ESAP Proceedings

Participatory Innovation and Research: Lessons for Livestock Development

Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 12-14, 2004

Ethiopian Society of Animal Production
P.O. Box 80019, Addis Ababa, Ethiopia

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Welcome Address

Tesfaye Kumsa

President, Ethiopian Society of Animal Production (ESAP)

Your Excellency Ato Getachew T/Medhin,

Minister D'Etat, Ministry of Agriculture and Rural Development

Distinguished Invited Guests,

Dear ESAP Members and

Ladies and Gentlemen,

It is an honor and, in deed, a particular privilege for me to welcome you all to this majestic gathering of our 12th Annual Conference on behalf of the executive committee of the Ethiopian Society of animal Production (ESAP). To this conference we invited over 330 ESAP members, representative of seven agricultural-related professional societies, 37 different governmental and non-governmental organizations and nine private entrepreneurs that produce, sell or import various livestock products and /or inputs in the country. It is anticipated that ---plenary and ---- technical papers would be delivered and discussed in the conference.

Today about 1.3 billion people, one-fifth of the world's population, are considered to live on an income less than US $ 1 per day. Evidence shows the majority of these are women since they constitute 60 % of the world's poor and 70 % of the poorest of the poor. No doubt that our country shares a big chunk of this problem since it is placed among the top in the list of poor countries and in the year 2000 the proportion of our population under food poverty stood at 42 %.

In fact the extent of food insecurity has become alarming in Ethiopia because as much as 45% of the population is affected in drought years and this chronic situation is frequently aggravated by unexpected shocks. On average, over five million people are commonly enlisted for daily relief food year after year even in years when weather and market conditions appear to be favorable. A combination of factors has contributed to the seriously growing problem of food insecurity in the country. Adverse climate coupled with high human population pressure, environmental degradation, decreasing per capita land holding, technological and institutional factors and policy induced stagnation of agricultural development have all been implicated for the rift between food demand and supply.

When we talk about lifting up the lives of the many poor people living in an abject poverty, we are essentially addressing the need to improving the performance of the agricultural sector. Evidences are amounting that agricultural development, as part of economic and social changes that give the poor greater power over the productive resources and the social factors that shape their livelihoods, is indispensable to the enhanced food security of the rural population and a more peaceful and stable political environment. Equitable growth and pro-poor policies are critical to prevent the outbreak of social conflicts. Food insecurity contributes to grievance and suffering of people that may eventually lead to conditions where violence may be inevitable.

The livestock sub-sector, as an essential component of the Ethiopian agriculture, holds a particular significance as a strategic tool to overcome the negative social and economic consequences of poverty. This sub-sector has positive effects on diets, health, incomes, financial security, sustainable crop yields, employment prospects and social status. Animal food products such as meat and milk are concentrated source of high quality protein and certain vitamins and minerals. When children consume even a modest amount, these products help alleviate poor growth, poor mental development and general ill health

Currently, the livestock sub-sector in the country is at a crossroad. Production, in the mixed crop/livestock system widely practiced in the highlands and mid-altitude agriculture, is virtually strangulated by an aggressive cropland expansion that has led to the total disappearance of grazing lands. During the cropping seasons animals in this system are confined to plot boundaries for grazing under comparatively favorable circumstances or are forced to cram fully on roads to rely on weeds scarcely thrown out to them from crop fields when situations get worse. The pastoral production system is stifled by ecological impediments, poor development of infrastructure, weak institutional support and lack of clear developmental visions.

Under such scenario, it would be imprudent to expect the sub-sector to furnish the above-indicated positive effects in the struggle for poverty reduction. It is, thus, incumbent on all stakeholders to deliberate on the best way forward to lead animal agriculture swiftly out of this dilemma and enable it to increase its contribution to poverty reduction. We are all now challenged more than any time in the past to come up with new lines of thinking and hold prospective visions for technological innovations that serve the best interest of smallholder and commercial farmers. We are urged to dialogue on the best alternative of linking up our efforts to realize the fastest possible mechanism of changing our deliberations in scientific forum to practical development efforts.

It was with this goal in mind that this year's conference theme was committed to "**Participatory Innovations and Research: Lessons For Livestock Development**". It is our conviction that the ten plenary session papers that are designed to address the various aspects of this issue will serve as a basis for provoking dialogue among participants to further develop the concept and understanding. Adoption of agricultural technologies by farmers in general and those related to livestock in particular is consistently low in Ethiopia. One, among the several responsible factors for this situation, is the relevance of technologies to the socio-economic circumstances of the smallholder farmers. Most case studies in the last twenty years indicate that more recognition of the indigenous knowledge and farmers as independent experimenters, which laid the foundation for the development of farmer participatory research, has been much more effective in spreading technology and increasing capacity than the conventionally followed extension system.

Your excellency, distinguished guests and dear participants

The executive committee of ESAP may not be certain how yet at this juncture, but definitely holds a strong feeling that there is an urgent need to see the annual conference of our society to move beyond serving as a mere forum for technical paper presentation and information data bank to an effective tool that spearheads the country's livestock development policy directions. This society is a huge congregation of available knowledge in the country that can make a change in the development of the livestock industry if committed unreservedly and tapped properly. All it requires is to stand firm not to see unjustifiably a weak sub-sector that we claim to represent, join hands in pooling our expertise, vision and effort to bringing about a change in the right course with a further commitment to getting prepared to confront every possible impediment that may stand in the way of our positive move in the interest of promoting this sub-sector.

If we care to open up our minds to look beyond the gloomy situation of our country in connection with progresses in the development of the livestock industry, we find lots of global buoyancies. Livestock production has been growing faster than any other agricultural sub-sector due to a rising population. It has been estimated that, worldwide, there will be an additional 2 billion consumers of livestock products by the year 2020, 97% of them in developing countries. Besides, as a result of rapid urbanization half the population of developing countries will live in cities by 2020 and people in cities consume more livestock products. Growing income in many developing countries is estimated to lead to a 2.1 % increase in mean annual per capita consumption of livestock products due to the high elasticity of these products. African Growth Opportunity Act (AGOA) of the Government of the United States of America that removes tariffs on goods exported to Africa, Everything But Arms Act of the European Union, which de-tariffs about 1000 products, Inter-African countries market free trade zones, East African countries geographical location comparative advantage to the Middle East huge markets, are all ample opportunities lying out there for our continent to explore for enhancing the development of its livestock industry. We are obliged to deliberate seriously on formulating an effective strategy that guides Ethiopia to overcome domestic and international barriers in order to reap benefits of its potential livestock industry.

Lastly, I would like to thank for their generous donations, the management of EARO for allowing us to utilize this hall with its facilities, the Ethiopian Science and Technology Commission for hosting our field trip and offering us their willingness to serve as a home-base for this year's conference.

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Opening Address

H.E. Ato Getachew Teklemedhin

State Minister, Ministry of Agriculture and Rural Development

Dear distinguished guests,

Participants,

Ladies and Gentlemen,

It gives me great pleasure and feel honoured to address the opening session of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP).

Attributed to her great physico-geographic diversity and highly variable macro- and micro-climatic conditions, Ethiopia is endowed with diverse ecosystems that are inhabited by amazingly great diversity of animal, plant and microbial genetic resources. The diversity of the country's farm animal genetic resources has further been enriched by her proximity to the historical entry point of many initially migratory livestock populations from Asia and wide ranges of production systems. At present, the country possesses huge population of livestock and the diversities of which is also embodied in the numerous breeds and strains that exist within each species. As the result, Ethiopia is known to be one of the centres of farm animal genetic diversities of the world.

Ladies and gentlemen,

Agriculture is the mainstay of Ethiopian economy employing about 85% of the population. It generates about 45% of the GDP, 90% of the total export earnings and 70% of raw material to the local industries. It is believed that agriculture, in Ethiopia, started 5000 years ago. However, it is still conducted in traditional way so that about 95% of the present total national agricultural output is generated by the smallholders to whom livestock are the backbones of their farming activities.

Dear conference participants,

Ethiopian livestock are constituted, largely, with indigenous breeds. They are sources of food, employment and income to millions of people. They are the only sources of draught power and manure for crop production. In some production systems, livestock are the only durable form of saving wealth and accumulating assets, insurance, which is particularly the case where there is no financial system for such functions. They provide co-lateral for loans and serve as buffer stocks when other income generating activities do not provide the expected returns. They also serve important social, cultural and security functions. Livestock are one of the input suppliers to the manufacturing sector of the country. Their contribution to the total agricultural GDP and national foreign currency earnings are about 30% and 16%, respectively.

Ladies and gentlemen,

As far as the size of livestock population is concerned, Ethiopia stands second to none in Africa. Despite the values and functions stated above, the contribution of the country's livestock to food security, poverty alleviation and overall national economic development is not comparable to their size. The present per caput milk, meat and eggs consumption of Ethiopians; which is 18.9 litres, 10.5 kgs and 1.1 kgs, respectively is much more lower than the Ethiopians were used to consume in 1970s. It also is much more lower than the sub Sahara-African average. The share of livestock to the total export values for years 1999, 2000, 2001 and 2002 were only 8.3, 10.85, 17.9 and 14.75, respectively.

It has increasingly become evident that production and productivity of our livestock have failed to keep in pace with human population growth, thus leaving the demand for livestock and livestock products increasingly unsatisfied, and if it were to continue at the present pace, then the trend will be even worse. Increase in annual milk and meat production of 2.6 and 1.4%, respectively that were achieved in years between 1995 and 2000, for example, are threading far behind the rate of human population growth of about 3%.

Ladies and gentlemen,

Research, extension and availability of effective market are some of the prerequisites to improve livestock production and productivity. In the western world, genetic research and breeding programs that were aimed at combined improvements in nutrition, farming systems, health and breeding that were conducted between 1945 and 80s have resulted in significant improvements in production and productivities of livestock the benefit to cost ratios of which were in the ranges of 5:1 to 50:1. Attributed to those efforts, for example, egg and milk production have increased 2.7 and 2.5 times, respectively. Because of those efforts, the number of cows in 1980s has been reduced by half compared to those that were required to produce the same amount of milk in 1945. Similarly, the duration of production cycle that was required to produce 1.7 kg broiler has been reduced from 14 weeks to seven weeks.

As has been mentioned above; in Ethiopia, agriculture has been conducted for about 50 centuries. As you all may be well aware of, the first introduction of exotic dairy cattle into the country dates back to the immediate post World- War-II era, i.e., 1947. Besides the longest history of agriculture in the country, it is believed that researches, extension and development works of various dimensions and scope have been and are still being conducted since, at least, the first introduction of the exotic cattle. Effected by multitudes of factors, however, the levels of successes enjoyed, except some in dairy and poultry, in those efforts of decades is not as high as the ones achieved in most of the other countries during the same time span. Due to this and similar other factors, about 45% of the country's population is living under poverty lines and the level of impoverishment is worse in the rural areas where about 85% of the total inhabitants dwell. Why has all these been so?

Dear conference participants,

We are aware of the fact that, on one hand, about 95% of the Ethiopian livestock are still reared under the low input system and about 88% of the country's rangelands are found in lowland areas, the areas that contribute about 20% of the draught power and significant number of cattle for fattening and crossbreeding required in the highland areas and over 90% of the country's export of live animals. On the other, the focuses of most of the previous researches, extension and other development efforts have concentrated to the relatively favoured areas and little were the attempts made to identify priorities to real potential areas of development and problems to be addressed. Similarly, the development approaches of those efforts were top to bottom types. They did not involve the farmers and pastoralists in decision making processes. Technologies generated for the smallholders and pastoralists did not consider the interests, social, cultural situation and traditional knowledge of the end-users and therefore, they were either capital and labour intensive or were too sophisticated. As you are well aware of, development entails mechanisation. Effected by the shortcomings of previous efforts, the majority of producers could not adopt the path of intensification due to none acceptability or high costs of the technologies or due to poor market and marketing infrastructures. As the result, smallholders and pastoralists have been forced to continue using their traditional knowledge and means, which they have been using for centuries. The continued use of the traditional way of production under worsening environmental conditions and ever increasing human population pressure has kept the production and productivity to remain stagnant or even decline in some cases and the latter has in turn forced them to live under worsening poverty, malnutrition, thus forcing to depend on aid.

Ladies and gentlemen,

In Ethiopia, about 47% of the population is under the age of 15 and those entering to the labour market in the next decade and half are already born while the birth continues at a rate of about 2.7% per annum. With this rate of birth, the Ethiopian population is expected to rise from the present 69.1 million to 84 and 106 million in years 2010 and 2020, respectively. This in turn is expected to cause explosive demand for livestock products.

Similarly, Ethiopia is one of the developing countries where urbanization is at its fastest. Currently 15% of the countries human population is estimated to be urban dweller and this proportion is expected to rise to 17.2 and 19.9% in 2010 and 2020, respectively. This increase in urbanization would among others, means increase in demand for food items and a shift in dietary preferences towards high quality foodstuff such as milk, meat and eggs. It is evident, however, that present level of productivity and production system of livestock and the way the smallholders and pastoralists use their resources can neither meet the projected food demand nor can it serve for genetic resources as well as environmental conservation. To meet this demand tremendous increase in productivity is required. To this end, appropriate technologies that could contribute directly to the farm earnings, general improvement in farm productivity and overall national economic development should be generated.

Ladies and gentlemen,

The government of the Federal Democratic Republic of Ethiopia has already issued several policies and regulations that are favourable to the overall national economic development and general well being of its citizens. The national economic development policy aims at ensuring food security, increasing production of sufficient export products, increasing supply of raw materials to the local industries and ensuring conservation based development of natural resources. In this regard, improved livestock marketing is viewed as an important livestock development strategy to increase both the rural income and export earnings.

Ladies and gentlemen,

Like any other agricultural sub-sectors, a success in livestock production is not like that of a simple factory that can be built overnight. Despite all the odds the development efforts of this sub-sector have gone through, it should be commenced with "it will work at the end". We should always bear in mind that from the gatherers of long a go to the modern agriculture of today, from a smallholder production to the agri-business the developed countries are enjoying today have been all the stories of food and agriculture and one of the trial and errors. Therefore, our future livestock development strategies should be viewed from the above perspectives. They should be based on the lessons that are drawn from the past success stories that have been achieved elsewhere. The setting of priority areas of development, generation of technologies, etc. should involve participation of local communities. It should also consider indigenous knowledge, socio-cultural and financial capabilities of the end-users. Moreover, it should take into account the medium and long term local and external market requirements. More importantly, such technologies should be those that can create ranges of job opportunities to the women and young of the area in particular and of the country in general. It is, therefore, timely and appropriate for the Ethiopian Society of Animal Production to choose the theme of this Conference to be "Participatory Innovations and Research: Lessons for Livestock Development".

Dear Conference participants,

As I can see from the program, this conference is expected to address some of the key issues on the theme in light of experiences from national and global environments.

I believe this gathering of researchers, academicians, development practitioners and policy makers will have successful deliberations on the issues in order that the current state of knowledge around the theme of the Conference can be brought together, synthesised and put forward to enable all stakeholders better prepared to handle the present and future challenges for the development of livestock of the country.

Finally, let me take this opportunity to congratulate the organizers and sponsors for making this Conference a reality and for choosing the theme. I would like to wish you every success in your deliberations.

Ladies and gentlemen,

It is now my pleasure to declare that the 12th annual conference of ESAP officially open.

I thank you all.

Keynote address

Commissioner Mulugeta Amha, Ethiopian Science & Technology Commission

Mr. Chairman,

Distinguished guests,

Conference participants,

Ladies and gentlemen;

As you all know, in Ethiopia livestock are critical element of both rural life and the economy in general and produce much more than food. Livestock and their products provide direct cash income; animals are living bank for many farmers and are critical to agricultural intensification via provision of power and manure for fertilizer and fuel. They are closely linked with the social and cultural lives of millions of Ethiopian farmers and pastorialists for whom livestock ensure varying degrees of sustainable farming and economic stability. Exports earn foreign exchange that adds to national reserves.

The complexities of livestock R&D integration with traditional knowledge and practice often lead to difficulties in predicting the effects of proposed development. Research organizations, institutes and centers have always worked hard to accumulate scientific knowledge and make progress. New techniques may be adopted and tested in research stations with great efficiency and control; however, for promising research results to reach the goal of economical applications by the farmers, the path is filled with difficulties and uncertainties. National research and extension programs have often found that farmers face practical constraints that make adoption of apparent improvements impossible. On station research results even when designed with the use of farm survey data, may still require on farm testing and integration with traditional knowledge and indigenous innovations. There is therefore, a pressing need to create a link in which formal researchers and extension workers can complement the informal age-old experiments of innovative farmers, pastoralists and rural communities.

Dear participants, Ladies and Gentlemen;

The concept of participatory innovation development and extension should be based on two way communication, farmer experimentation and strengthening of self-organizational capacities of rural communities. Active participation and dialogue among all actors, farmers, policy makers, extension workers and researchers should be the main stay. As an over all effect, the knowledge and understanding gained through these processes strengthens smallholder farmers and pastoralists confidence in their own solutions and increase their ability to choose technological options and to develop solutions for their specific ecological, economical and socio cultural conditions and circumstances.

As a goal the Government of the Federal Democratic Republic of Ethiopia is fully committed to promoting sustainable food self sufficiency and poverty reduction with agriculture being central in the overall economic development of the country and playing the determinant role in the national development objective. Current efforts and results are very encouraging, more and more farmers are improving their living standard and various indicators have shown that the overall production level has increased. Agriculture as whole has contributed 18.8% for the overall economic development growth of the nation that has been estimated at 11.6% for the past Ethiopian fiscal year.

Conference participants:

At the Ethiopian Science and Technology Commission we strongly believe that specific innovations developed with little or no participation of the end users are unlikely to spread effectively. The main limitation of such a patronizing approach, where farmers are treated as passive partners expected to accept rigid blanket recommendations in a top down manner, is that it hardly encourages dialogue; interactive learning, adapting of technologies and developing own solutions. To overcome these limitations in a bottom up approach Kebeles and Woredas need to be empowered and farmers encouraged to participate and dialogue in exercising new technologies. To un-lock the innovative power of the farmers and as a result induce self propelling sustainable development, the Ethiopian Government has put in place a forward looking and aspiring technical and vocational Education and Training (TVET) program with over two dozen agricultural colleges in different parts of the country envisaged to train development agents in tens of thousands every year. Young graduates of the TVETs are to work and live within the farming communities and contribute to empower the farmers to shape their destiny and development through sharing of mutual ideas and knowledge. However, it is widely known that it is difficult for formally educated professionals to accept farmers/pastoralists with their traditional and experience based knowledge system as equals and to learn from them. Therefore, attitudinal change of the new generation of development agents towards the farming community is a key determinant if they are to live up to the expectation of the Ethiopian people and government in changing rural Ethiopia.

At this juncture, Ladies and Gentlemen, I would like to introduce an innovative project in the area of livestock development and the opening up of the hostile but fertile virgin lands of southern, south-western and western low-lands of Ethiopia. This extensive fertile land is virtually inhabited or sparsely populated because of mosquitoes responsible for malaria and tse-tse fly which is responsible for trypanosomiasis or Gendi, the most important animal disease in the whole of Tropical Africa. Some authorities claim Africa is undeveloped because of these two vectors-mosquitoes and tse-tse flies, also responsible for the sleeping sickness disease in humans which is also a major killer in many African countries.

In Ethiopia alone the tse-tse infested area covers about 150,000 to 200,000^{2}Km of land. In Africa, the tse-tse belt is larger than the entire land area of the USA. But, encouraged by the initiative of countries like Ethiopia and Tanzania, managed to wipe out the disease and the vectors from the entire territory of the island of Zanzibar for once and for all, the Heads of states and Governments of Africa through the African Union (AU) have declared a war on the fly, to get the continent rid of the vector and the associated disease. This is going to be a commitment that would take several decades and few billion USD.

The Ethiopian Government has launched the biggest SIT project in Africa by the approval of the House of Representatives six years ago. The Southern Rift Valley Tsetse Eradication Project (STEP) that is estimated to cost about 300 million Br. over a period of ten years. The Project envisages to wipe out the fly and the disease from an area of about 25,000^{2}Km. This indeed is daunting venture, but can be done. It was done on a similar cattle disease in South America and most recently on tse-tse in Zanzibar of Africa. The technology is mature and has been implemented on the Mediterranean fruit flies since several years particularly in the USA. The same technology (SIT) was used to handle the screw-worm problem in Libya.

A central and determinant aspect of the STEP project is the Kaliti Insect Mass-rearing and Sterilization Center. This facility under construction at an estimated cost of over 20 Million Br. allocated from the Ethiopian Government is the biggest Insectary ever in Africa. The end products of this huge factory in the making are flies. These are male flies made infertile by exposing them to the right dose of radiation; so much so that they will be sterile but otherwise left healthy and sexually active so that they can compete with the wild males in the bush to service the female fly. When released in a ratio of nine sterile males to one wild male fly, due to shear statistics the fly population will collapse and vanish for good. Mr. Chairman, I would like to invite as courtesy from the ESTC, all participants here to visit the Kaliti site on Saturday morning. We will make all the necessary arrangements for the Visit.

Dear Conference participants; I am sure you appreciate the potential of eradicating tse-tse trypanosomiasis from Ethiopia for the development of the livestock sector and agriculture in general. It is simply immense. As a society that brings together professionals concerned with animal production ESAP has a serious stake in the success of this project. An early success of Ethiopia in the realization of tsetse-trypanosomiasis eradication obviously unfolds huge opportunities to Ethiopian professionals of Animal Production. I therefore, urge you to keep interest in the progress of this project and we at the ESTC are always more than eager to engage with you professionals in the various disciplines of studies related to animal production. Any professional support you may be able to provide STEP is welcome.

Thank you.

Participatory Innovation and Research: Lessons for Livestock Development

Local Innovation and Participatory Innovation Development: The concepts and their application in livestock-related research and development

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For decades, livestock-related research and development (R&D) in Africa have been strongly influenced by concepts and production systems in the industrialised countries. Smallholder and pastoral livestock-keeping was regarded as backward, unproductive and needing to be replaced. However, after many decades of R&D focused on "modern" livestock production, millions of people in developing countries are still practising indigenous forms of livestock-keeping. A review of livestock development projects by major donors (LID 1998) revealed little evidence of sustainable impact on the livelihoods of the poor. This was largely because animal scientists neglected the real-life production systems of the vast majority of livestock-keepers in Africa. Most researchers have given little attention to how improvements can be made in the indigenous systems.

Studies of indigenous livestock-keeping systems

This was despite the fact that, in the last 2–3 decades, some good research has been conducted into "traditional" livestock husbandry in developing countries. The earlier studies were made primarily by anthropologists and social scientists (e.g. Dahl & Hjort 1976, Galaty *et al* 1981), but then some animal scientists started to take a closer look at indigenous livestock-keeping systems. This research revealed that "traditional" livestock-keeping as practised by smallholders and pastoralists is not less rational than "modern" animal production, but the objectives differ. Whereas "modern" animal production is aimed at supplying markets with food and fibre, smallholder and pastoral animal husbandry pursues diverse goals including production for both household and market, building up capital, maintaining savings, buffering against risk and fulfilling social and cultural functions. The products include not only food and fibre, but also draught power, transport capacity and manure to be used as fertiliser or fuel while the animals continue to live, if only at survival level, and various products from the eventually slaughtered animal such as skins, bones and horns.

Also the efficiency of the indigenous systems in terms of using natural resources for production began to be recognised. Some animal scientists compared the productivity of indigenous and exotic breeds of cattle, sheep and goats. The weight of weaned offspring per dam was regarded as the best indicator for herd productivity. Even from this limited perspective, breed comparisons on station showed that – already under conditions of moderate stress (e.g. limited, low-quality feed and water; high ambient temperatures) – the performance of some indigenous breeds with respect to meat production could almost match that of exotic breeds. When the weight differences of the dams were taken into account and weaning weight per 100 kg of dam or per kg metabolic weight was calculated, many indigenous breeds performed as well as or better than exotic breeds (e.g. Buck *et al* 1982).

Research on mobile pastoral systems in the West African Sahel revealed that the livestock produced much more protein than did livestock on "modern" ranches in areas with similar natural conditions in the USA and Australia – if the nutrient content of all livestock products actually used was taken into account (Breman & de Wit 1983). When communal and ranching systems were compared in Botswana, taking all major products including draught power into account, the productivity per animal was similar in both systems and, on a per hectare basis, the traditional livestock-keeping system out-yielded the ranching system (Ridder & Wagenaar 1986). However, this comparison still did not give a value to other functions of livestock such as risk aversion or social security. Workneh (2000), comparing crossbred and local goats in Ethiopia, included not only meat, milk and manure but also quantifiable socio-economic data, i.e. financial and insurance (security) benefits. This study revealed that, although crossbred goats gave more milk and grew faster, they also lost weight faster than did the indigenous goats during the lean season and were therefore more at risk and had a lower "insurance value".

Local innovation: indigenous knowledge on the move

These and other studies (e.g. Galaty & Johnson 1990, McCorkle *et al* 1996, Niamir 1990, Niamir-Fuller 1999) allowed a better understanding of indigenous practices and recognition of the value of indigenous knowledge about the environment, herd management, ethno-veterinary medicine etc. However, most of them gave little attention to the dynamics in indigenous knowledge, to the innovations that livestock-keepers were themselves developing to adapt to change. The so-called "traditional" livestock-keeping systems have persisted, but they have not been static. Local experimentation and innovation by livestock-keepers and suppliers of inputs such as feed in the informal sector have led to changes that most animal scientists have overlooked.

Local innovation is the process through which individuals or groups discover or develop new and better ways of managing resources, building on and expanding the boundaries of their indigenous knowledge. The innovations – i.e. the results of this process – are not only of a technical but also of a socio-institutional nature. Especially in drier areas where livelihood systems are highly vulnerable to climatic risks and where livestock-keeping prevails, successful local innovations often involve new ways of gaining access to or regulating use of the natural resources, new ways of community organisation, or new ways of stakeholder interaction.

Local innovation through informal experimentation, without external support, has always been taking place in all parts of the world, but it is only recently that increased attention has been given to identifying and documenting the innovation process and the innovations. The purpose of identifying local innovations is not primarily to be able to disseminate these in a transfer-of-technology mode of extension – picking out what scientists consider to be the "best" solutions that can be widely applied. This approach is not suited for the highly diverse environments in which most resource-poor farmers live. Local innovations are locally developed to fit a particular biophysical and socio-economic setting and usually cannot be transferred in exactly the same form to other settings. However, the documentation and wider sharing of local innovations can provide ideas and inspiration for other farmers to do their own experimentation and to adapt new ideas to other settings.

Linking local and scientific knowledge in Participatory Innovation Development (PID)

Local innovations offer entry points for linking indigenous knowledge and formal scientific knowledge in joint R&D led by the local communities. Identifying local innovations in a first step towards engaging in "Participatory Innovation Development". PID is a more comprehensive term than "Participatory Technology Development" (PTD), an approach that especially NGOs have promoted for many years and that has become increasingly widespread. Basically, the activities involved in the PTD approach are:

- Getting started (getting to know each other)
- Joint analysis of the situation – the problems and opportunities
- Looking for things to try to improve the local situation
- Trying them out in community-led participatory experimentation
- Jointly analysing and sharing the results
- Strengthening the process, often through improving local organisation and linkages with other actors in R&D, so that the process of participatory R&D will continue.

As innovation in agriculture and natural resource management (NRM) goes far beyond "hard" technologies to "soft" innovations such as in farmer organisation, marketing arrangements and co-management mechanisms for resource use, the term PID is increasingly being used instead of PTD to embrace this broader understanding of participatory research and development.

Identifying local innovations is an entry point to PID that starts with "Looking for things to try" – and this by looking at what farmers are already trying, in their own efforts to solve problems or grasp opportunities they have already identified. This leads into a joint situation analysis by community members and outsiders that is based on these concrete examples. Local innovations become foci for community groups to examine opportunities, to plan joint experiments in order to explore the ideas further and to evaluate the results together. This is a very good way of "Getting started", because recognising local innovation and informal experimentation by farmers changes the way that scientists and development agents (DAs) regard farmers and interact with them.

This is quite different from the conventional "transfer-of-technology" (ToT) approach to research and extension. ToT is based on the assumption that knowledge is created by scientists, to be packaged and spread by extension services and to be received passively by farmer adopters. ToT denies and often suppresses local initiatives.

The Farmer Participatory Research (FPR) approach was a step forward, in that it gave farmers an opportunity to tests ideas coming from formal research before the new technologies were disseminated through the extension services. The PID approach goes one step further: by giving recognition to farmers' innovative capacities, it establishes a basis for more genuinely <u>participatory</u> R&D. It starts off the partnership on a completely different footing than approaches that start with bringing external technologies for farmers to test. In PID, from the outset, value is given to local people's knowledge and creativity. They are seen as partners with something to offer, not just to receive. A positive approach that starts from (but is not confined to) local ideas, that focuses on local people's achievements and strengths and explores the particular opportunities open to them – rather than dwelling on their problems and weaknesses – is key to stimulating innovation.

In very recent years, the Indigenous Soil and Water Conservation (ISWC) and the Promoting Farmer Innovation (PFI) projects worked with the PID approach in eight countries in Africa, including Ethiopia. Researchers, DAs and university staff discovered farmers' own efforts at informal experimentation and development. They sought ways to build on these initiatives, to develop the local innovations and complementary techniques further. This approach to improve the livelihoods of rural people and to strengthen their organisational and self-help capacities has been documented in *Farmer Innovation in Africa* (Reij & Waters-Bayer 2001). Several Ethiopian examples, mainly related to crop farming and NRM, are included in this book.

Local innovation by livestock-keepers

Here in this conference of the Ethiopian Society of Animal Production, it is important to note that not only crop farmers but also livestock-keepers have been innovating spontaneously – without the support of formal research and extension services – in order to deal with new problems or take advantage of new opportunities. As most of my work has been with pastoralists, most of my examples of innovation in different parts of Africa refer to pastoral systems. They include:

- ***Hay making and selling.*** In many Sahelian countries, crop farmers and city dwellers increasingly keep livestock and are prepared to pay for feed, especially in the dry season. Some pastoralists who recognised this market opportunity harvest standing hay, transport it to town and sell it;
- ***Capturing livestock market opportunities.*** In much of West Africa, small ruminants fetch higher prices than cattle per kilogram liveweight and they reproduce more quickly. Sheep have become several times more lucrative than cattle, and Sahelian pastoralists have changed the composition of their livestock holdings accordingly (Tyc 1995);
- ***Pasture enclosure.*** In many parts of Africa – also here in Ethiopia – pastoralists have spontaneously begun to enclose certain pasture areas (Behnke 1988, Fuller & Turner 1996, Graham 1988). Some do so as individuals; others as groups that manage the enclosures together (e.g. Alemayehu 1998, Yohannes & Waters-Bayer 2002);
- ***Water harvesting.*** Some pastoralists have developed water-harvesting innovations, such as the construction of *berkado* (in-ground tanks to store runoff rainwater) by the Somali; this innovation has spread rapidly without external support (Yohannes & Waters-Bayer 2002);
- ***Organisation of milk marketing.*** Pastoral women have been innovative in spheres of production where they have control: processing and marketing milk products (Waters-Bayer 1988). For example, some women in Ethiopia have formed rotating milk banks that allow each woman, in turn, to make and sell butter and cheese from cow's milk belonging to all women in the group, thus achieving economies of scale (Ayelew 2001).

These innovations indicate directions in which the livestock-keepers are seeking to develop their livelihood systems with the resources to which they already have access. Such innovative local people could benefit from collaboration with outsiders – with formal researchers and DAs – if the outsiders can bring promising new ideas or techniques to complement and improve what the local people are already trying to do. Participatory approaches to livestock-related R&D could thus enhance local innovation processes.

PID with livestock-keepers

Many examples of participatory R&D with livestock-keepers involve trying out a new management technique or way of regulating access to resources and comparing the situation before and after the change. The expanse and nature of the resources involved seldom allow for more conventional trials with treatment and controls. An early example was recorded in the mid-1970s, when pastoralists in Mali, with the support of extension agents and an external advisor, started experimenting on a small scale with reserving selected areas of range for collecting wild grasses for food and, later, for deferred grazing. In a series of facilitated meetings, the pastoralists drew lessons from their observations and adjusted the management regime, e.g. by changing the size of the reserved areas, the period of reservation or the way in which fines were imposed on herders who did not comply (Gentil & Marty 1979, Marty 1985).

More recent cases of R&D in collaboration with livestock-keepers include the work of the Forage for Smallholders Project in Southeast Asia (Horne *et al* 2000), the development of donkey-drawn ploughs in collaboration with local blacksmiths in Sudan (Majzoub 2003), and the support to joint experiments by crop farmers and mobile pastoralists to optimise overnight kraaling of animals for production of local cash crops in Cameroon (Tchawa *et al* 2001).

One of the few documented examples of participatory research with pastoral women comes from southern Ethiopia, where Borana women – with the support of scientists – experimented with early cutting of grass and conserving it as hay for dry-season feeding of calves, and examining effects on calf nutrition and seasonal distribution of women's workloads (Coppock 1991).

Participatory R&D has not been confined to so-called "developing countries". In New Zealand and Australia, for example, it has involved local monitoring of vegetation as a learning mechanism to assist livestock-keepers in decision-making for adaptive management of the grasslands. Management actions are regarded as deliberate experiments designed to generate better information for resource management (Bosch *et al* 1996, Burnside & Chamala 1994).

Little has been documented thus far on deliberate attempts to build PID on livestock-keepers' own innovations, but some promising work in this direction has been started. Examples from pastoral areas of Ethiopia include (Waters-Bayer 2003):

- comparing different methods of bush management in grazing areas, e.g. burning trials; testing debarking plus spraying a herbicide/diesel mix; making charcoal;
- testing the use of prickly pear cactus (*Opuntia*) for survival feeding of key classes of livestock.

Key elements in promoting local innovation by livestock-keepers

Based on the experience made thus far in promoting local innovation in livestock husbandry and NRM, the key elements in the approach can be summarised as follows:

- Identifying local innovators / innovating groups and their innovations
- Encouraging other livestock-keepers to assess these innovations
- Facilitating formation of groups of livestock-keepers interested in exploring innovations of their choice
- Organising study tours to compare similar technologies or initiatives
- Collaboration of livestock-keepers and supporting scientists / DAs in designing and implementing experiments to explore innovations of common interest
- Organising visits by other livestock-keepers to discuss and analyse the local experiments and their outcomes
- Supporting local experimenters to serve as trainers / advisors of other groups interested in taking a similar approach to innovation development.

These key elements are similar to those in promoting local innovation among crop farmers (van Veldhuizen *et al* 1997, Reij & Waters-Bayer 2001). However, some important differences in the case of livestock-keeping systems are:

- Many livestock-keepers, especially pastoralists, are more mobile and live in areas with poor road infrastructure and are therefore more difficult for scientists and DAs to reach;
- The drier areas in which livestock-keeping systems prevail are less densely populated than cropping areas, so information exchange between producers must cover longer distances, consumes more time and is more expensive;

- In the drier areas, there are more narrow limits to technological improvements that would be ecologically and economically sound;
- In the areas used by livestock-keepers, especially pastoral peoples, there is greater complexity with respect to rights of access to land, tree and water resources.

One major difference is that innovations in livestock-keeping systems – especially in pastoral settings – are more often of the "soft" type, such as:

- securing primary or secondary rights of access to land and other resources, often through forging new types of social relations with other rangeland users;
- organisational innovation such as involvement in multi-stakeholder platforms for negotiating use of resources or making arrangements for access to markets far from the sparsely-populated areas of production.

Creating favourable conditions for local innovation in livestock-keeping

In order to create a favourable institutional environment for PID in livestock-keeping systems, various institutional changes are needed:

- Research and development programmes need to be more process-oriented and open-ended, without preconceived interventions in terms of technologies to be developed or adopted, but rather starting with a phase of jointly analysing the current situation and trends as well as the local initiatives, innovations and visions, and then jointly planning subsequent activities on the basis of this analysis;
- Government services, including research, need to be decentralised. Vesting more responsibility for planning at the level of rural communities and local governments would allow more site-specific experimentation and development initiatives co-managed by the local people;
- Agricultural education and training needs to be oriented toward understanding and improving the livelihood systems of farming, including livestock-keeping, people. In the technical disciplines, attention needs to be given to indigenous knowledge and innovation. Training and practice are also needed in communication techniques, participatory R&D methodologies and process-facilitation skills.

Experiences in tackling these and many more challenges to institutional integration of PID in agricultural research, extension and education are presented and analysed in Lizares-Bodegan *et al* (2002) and Wettasinha *et al* (2003). These are available on the website of PROLINNOVA (www.prolinnova.net), an international platform for promoting local innovation in ecologically-oriented agriculture and natural resource management. Specific experiences with respect to creating favourable institutional environments to nurture the dynamics of indigenous knowledge in livestock-keeping systems are still to be documented – or may emerge during or as a result of this ESAP conference.

However, it is evident already from the examples given here that livestock-keepers and committed scientists and DAs <u>can</u> work together to discover better ways of using the local resources and improving rural livelihoods. An entry point into this collaboration is identifying the dynamics of indigenous knowledge as reflected in local innovation by men and women livestock-keepers. This entry-point activity not only indicates possibilities for joint experimentation and development but also helps break down the barriers of distrust and disrespect that exist between many smallholder and pastoral livestock-keepers, on the one hand, and scientists, on the other. It creates a basis for more genuine partnership and a bridge between the two realms of knowledge, offering a way toward developing innovations in rural livelihood systems that are appropriate in biophysical, socio-economic and cultural terms and – at the same time – give the farmers more influence over their future.

The call for PID does not deny the importance of more conventional disciplinary research under controlled conditions – on research stations, in laboratories etc. But there is a need for closer linkages between this component research, on the one hand, and – on the other – system-based research rooted in the current practice and initiatives of smallholders and pastoralists.

It needs to be emphasised, moreover, that PID is not only or even primarily an approach to research but rather an approach to development. Most of the PID that is happening today is being done by farmers together with DAs – usually without the involvement of scientists. This should be encouraged, as it will not be possible for formal research to work together with the millions of smallholder and pastoral livestock-keepers in remote, marginal and highly diverse areas throughout the world – also not here in Ethiopia. In such areas, "blanket" solutions cannot be applied. Local experimentation is necessary to see if new external ideas – whether from other farmers or from formal research – can fit the local setting. Moreover, conditions are constantly changing, so all farming communities need to be able to adjust to these changes. Therefore, local innovation by farmers must be a never-ending process. PID is intended to strengthen this process.

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Acronyms

DAs	Development Agents
ISWC	Indigenous Soil and Water Conservation
LID	Livestock in Development
NRM	Natural Resource Management
PFI	Promoting Farmer Innovation
PID	Participatory Innovation Development
PROLINNOVA	Promoting Local Innovation
PTD	Participatory Technology Development
R&D	Research and Development
ToT	Transfer of Technology

Interface between Indigenous and Modern Knowledge Systems

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Introduction

This paper tries to provide some theoretical background to the interface between indigenous knowledge and modern knowledge. Understanding this issue necessitates entering into an on going heated debate on the traditions of *science.* These are *positivist science*, *interpretive social science* and *critical social science*. More specifically, one needs to revisit the long-standing and growing claim of the Western culture for an exclusive ownership of foundation of knowledge, which some professionals call it as a colonization of mind (S.A. Marglin, 1990).

Nowadays, peoples' participation is one of the issues of high priorities. However, without a deliberate understanding of some philosophical departures, there can hardly be a genuine participation in development, which demands integration of indigenous knowledge into the development processes. This may occurs, on the one hand, when development agents and scientists who see *science* only from its most popular points of views, i.e., positivist science, at times, unintentionally fall back to their root when they try to understand indigenous knowledge in different spheres social of life. On the other hand, proponents of the interpretive and critical social sciences also go into the extreme-side of the positivist science, by denying the relevance of findings through positivist science.

In view of this, the paper first present an overview of the three traditions of science and then look at knowledge and related issues that is followed by a discussion on the interface of indigenous and modern knowledge systems. Finally, the paper concludes with brief suggestions on the strategy for effective knowledge interface.

An overview on three traditions of science

Science is commonly seen to mean the same thing for all scholars. However, debates that revolve around the nature of science and particularly social sciences has revealed three alternatives to social science in 1960 that resulted from over two centuries of debates on the question of "where is science in social science?" (Neuman, 1997).

In this section, I present an overview of three traditions of science, viz., positivist science, interpretative social science (ISS) and critical social science (CSS), which serves as a philosophical explanation for the difference among researchers on knowledge sources. The focus of the discussion is limited to only few issues that may help us to understand the nature of the interface between indigenous knowledge and modern knowledge.

Positivist science

Positivist science is the approach of natural science. It is the most popular among the three traditions of science. This has been reinforced by the educational programmes and curricula that hardly try to elicit these variates of science. Instead methods developed in the natural sciences were forced into the context of social science.

Positivism says, "There is only *one* logic of science, to which any intellectual activity aspiring to the title of 'science' must conform." Thus, the social science and the natural sciences must use the same method. In general, positivism sees social science as an organized method for combining deductive logic with precise empirical observations of individual behaviour in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity (Neuman, 1997).

The ontological view of positivism is the reality that exists "outside" human minds, in an orderly and regular manner. The task of scientists is then to discover this regularity overtime, which are assumed to be additive in nature. This view emanates from the assumption that mind exist in isolation from body and world. Positivists do not accept non-science as science, is the only path to truth. Moreover, they argue for a value-free science that is objective. By virtue of objectivity, scientific findings can be replicated to confirm their truth (Guba and Linchon, 1989).

Interpretative and critical social sciences

Interpretive and critical social sciences are alternative approaches to positivist science. These two approaches are commonly addressed as a *constructivist* perspective, even though they differ in some respects[1]. Interpretative social science is the systematic analysis of socially meaningful action through the direct detailed observation of people in natural settings in order to arrive at understanding and interpretations of how people create and maintain their social worlds. The critical social science goes even further by trying to uncover the real structure in the material world in order to help people change conditions and build a better world for themselves. To that extent, it is critical of the interpretative social science that limit itself to the level of understanding without making further attempt to change the statuesque in a social system (Neuman, 1997).

With respect to the ontological question, the interpretive approach sees social reality as an intentionally created from the purposeful actions of interacting social beings, the view that is in a polar opposite to positivist science and critical approach. For ISS, social reality is what the society perceives as a reality, i.e., the way it interprets it. Hence, social construction of meaning, which leads us to multiple reality of our environment rather than one and only one, law like explanation that is provided by the positivist science. ISS appreciates common sense as a valuable source of interpretation of what people observe in their 'life-world.' In asmuchas people give their own meaning to events around them, the meanings cannot be free from their values. While this is well accepted practice in constructivism, positivism strongly oppose to this view.

Knowledge Systems

Culture in its broadest sense is a key source of knowledge systems. Knowledge system refers to characteristics of four ways of knowing: *epistemology*, how do we know what we know?; *transmission*, how do we go about distributing and receiving knowledge?; *innovation*, how does the content of what we know get modified over time? and *power*, what are the relationships between members of a community who make use of the knowledge? And how does a particular knowledge community relate to other knowledge community? (S.A.Marglin,1990). These four characteristics are linked to one another in a *systemic* manner. Marglin, S.A (1990) illustrates these characteristics with Greek words, *techne* and *episteme*. As will be shown later, this distinction is useful to understand the interface between indigenous knowledge and modern (scientific) knowledge and reasons for the marginalization of the former by the latter.

According to Marglin, S.A. (1990) *episteme* is logical (based on self-evident axioms), analytical, articulate, universal, cerebral, theoretical, verifiable, impersonal, whereas *techne*[2] is intuitional,

[1] Critical social science resembles the positivist science in some respect, even though it opposes it in many ways. For instance, like positivists, it holds that social reality exists out there. However, unlike positivist, it claims that social reality is shaped by social, political, cultural and similar factors and therefore, changes overtime.

[2] Note Scott (1998) uses a term *metis* instead of *techne* and uses *techne* in the same way Marglin uses *episteme*. Scott prefers to use the term *metis* instead of indigenous technical knowledge (for more see Tesfaye

indecomposable, implicit, contextual, emotional, practical, discovery and personal. In terms of power, *episteme* is egalitarian internally whereas hierarchal externally. *Techne* reverses this power relations by being relatively hierarchical internally and pluralistic externally (see also Marglin and Marglin, 1996). The two forms of knowledge were widely used to distinguish between western-culture and the traditional societies, which is commonly called developing countries. This view is a fundamental reason for interventionism in the name of development aid and assistance, particularly after World War II. Moreover, the two concepts covey power differences between the western knowledge and non-western ways of knowing. This difference is rooted in the traditions of sciences that were discussed earlier. The epistemic culture is heavily founded on the positivist science. Interpretative and critical social sciences argue against the hegemony of one path of truth, in favour of multiple realities that appreciates the views of actors involved in the knowledge generation.

Even though these opposing features for *episteme* and *techne* have substantially influenced what is commonly known as science (of positivism), there was strong caution among classical philosophers such as Aristotle and Socrates not to see *techne* as an inferior form of knowledge compared to *episteme* (Marglin S.S., 1990). Nowadays, there is growing understanding and claim that the two forms of knowledge are interrelated rather than markedly differing (see Leeuwis, 1993, 2004; Marglin and Marglin, 1996; Scott, 1998; Millar and Curtis, 1999).

In spite of that the modern institutions such as education and research are still deeply rooted in the western-culture about the view of knowledge. This gap necessitates bringing the issue of knowledge generated outside modern institution into focus in order to seek ways to integrate it with that of the modern knowledge, when deemed necessary[3]. Therefore, a brief discussion on indigenous and modern knowledge system would be appropriate at this juncture before we go on to analyze the interface between them.

Indigenous knowledge versus modern knowledge

Indigenous knowledge is addressed in many terms. These include, local knowledge, traditional knowledge, rural people's knowledge, people's science, indigenous technical knowledge, ecological knowledge and ethno-ecology (for the basis of some of these terms and authorities, see Tesfaye, 2003). Among these terms, local knowledge (LK) is widely accepted among practitioners as it can also apply to any knowledge including scientific knowledge, whereas it does not require qualification for rural/urban, agriculturist/pasturalist or any other entity (WinklerPrins, 1999; Kothari, 2002).

Most of the literatures on indigenous knowledge do not go into the philosophical debates that underlie the place of local knowledge compared to the modern knowledge, or scientific knowledge. Their emphasis is on the presentation and description of the indigenous practices (WinklerPrins, 1999). In spite of growing volumes of literature and initiatives to promote indigenous knowledge in development processes, there is little progress in this front. In my view the reason for this setback is lack of transparency and open dialogue between the different stakeholders on the fundamental issues, which placed local knowledge in lower position compared to scientific knowledge.

Generally, the negative attitude towards local knowledge is one of the great barriers to the integration of local and modern knowledge. Global movements during the last two decades made it possible that many social scientists and few natural scientists change their attitudes in favour

Beshah (2003:55-56).

3 I am of the opinion that integration between indigenous knowledge and modern knowledge is not always necessary nor it would be possible as it might be limited by the interface between them.

of local people's knowledge. The establishment of a Center for Indigenous Knowledge for Agriculture and Rural Development (CIKARD) at Iowa, USA, with regional centers in Asia and Africa are steps in this direction (Warren, 1991). Similar attempts are underway in Ethiopia where a national network was established to coordinate indigenous knowledge. Much is needed to mobilize a critical mass that warrants wide implementation of alternative approaches to knowledge utilization, both at national and global levels, as shown below.

The dichotomy between the LK and modern knowledge originated from a view that is strongly held by the western science, which regards itself as superior to other sources of knowledge. This concept is spreading through modern institutions including those in the non-western societies (Tesfaye, 2003). The primary foci of this view are research and extensions organizations, health and education services. As a result, whenever policy-makers and other intellectuals talk about development, it means development that is based largely on the western science. If there is any thing that counts from the local people is their labour, not knowledge. This practice is pervasive especially among agricultural researchers and extensionist who encounter LK more than any other professionals. Supremacy of a scientific knowledge (SK) over the LK is being preached today as in the 1950s and 1960s.

Most of the criteria used in the previous section for *techne* are widely reflected in literature on indigenous knowledge. LK is regarded as merely practical knowledge, without explicit theoretical foundation. Of course, it is undeniable that indigenous knowledge is mostly generated as a result of man's struggle to adapt his environment. However, this should not be counted as weakness. Perhaps, it shows largely incompetence of scientific methods to understand how such knowledge were generated in the absence of a clear research design, which enables us to 'replicate' whenever required. Thompson and Scoones (1994, cited in Kothari, 2002), write:

"Knowledge, whether "indigenous" or "scientific" is inclusive in the sense that it is the result of a great many decisions and selective assimilations of previous beliefs, values, ideas and images, but at the same time exclusive of other possible frames of conceptualization and understanding."

Mushrooming farmers' innovations around the world are a good testimony to observation of Thompson and Scoones. Recently, what amounts to a book has been published on farmers' innovation (Reij and Waters-Bayer, 2001), with many examples from Ethiopia. Long (2001) firmly argues that there is no ontological difference between science and everyday knowledge. Richards (1985) shares the same view on knowledge.

LK is embedded in the local culture and biophysical contexts. This feature is likely to increase relevance of LK, unlike the SK, which often times lack relevance and misfit with the local context, whereas it maintains universality. LK is also interwoven with spiritual and religious system of a society. Certain local practices apply complicated magico-spiritual practices that are outside the realm of science, as this cannot be verified using the methods of science. The easier way for science so far is to relegate such knowledge to 'belief' as opposed to 'knowing' in its own right. To cite an example from Konso, southern Ethiopia, there is trinity between the spirit world (God-*Waaqua*), land and people (Waston, 1998, Tesfaye, 2003). There are numerous examples from Asia, Africa and Latin America, particularly on land, sprit, forest, water bodies and people.

Apart from knowledge held in few families, particularly in the area of human and livestock medicine, most of the LK is socially owned, as it is socially generated. These characteristics ensure that it is pluralistic at societal level, even though there is some degree of hierarchy internally (S.A. Marglin, 1990).

In spite of such visible benefits of LK, the place of science is still held high above that of LK. Even though most proponent of LK and few converted other scientists accept equal service of LK with that of SK in terms of classification of natural and social phenomena, science is believed to surpass local knowledge in explanation (theory) and predication, markedly in the latter (Howes, and Chambers, 1980). Subsequently, many positivist scientists profess in favour of science on many grounds, in addition to what has been presented above. For instance, 'openness' of science versus 'closedness' of LK; Kuhnian revolution in science (dynamic), unlike the static 'state' in LK; abstract presentation of 'reality' by science, unlike intuitive and empirical evidence in LK (Kothari, 2002).

At this juncture it can be safely said that earmarking knowledge domains in the form of IK/LK and SK proves counter productive for facilitation of interface among multiple knowledge that is generated by multiple actors. In this line, Agrawal (1995) strongly argued against the dichotomy between western/scientific and indigenous knowledge in favour of "multiple domains and types of knowledge, with differing logics and epistemologies."

On the whole, there is undeniable devaluation of the LK by the positivist epistemic culture. Despite many dichotomies between LK and SK, Kloppenburg (1991, cited in Kothari, 2002) rightfully argues, "both science and LK represents partial and distinct ways of understanding phenomena. Neither can elucidate alone what they can in "conversation." Each has its strengths and weakness, and to think that only LK complements science or that science has a virtual monopoly on "truth," is grossly fallacious." This view is consistent with a long standing plea by Howes and Chamber (1980) who claimed that the right direction for a proper utilization of LK for the generation and exploitation of technology to benefit rural population is by finding an optimum mix, and balance between LK and SK in the R& D processes rather than a choosing one over the other. It is only this kind of attitude that create the space for dialogue and help us to prudently utilize the available sources of knowledge to the best interest of mankind, both the present and the generation to come. With these backgrounds, I now turn to the interface issues between local and modern knowledge systems.

Interface between local and scientific knowledge systems

In the previous sections, I tried to present differences and similarities among the three traditions of science, systems of knowledge that is based on different traditions of science, the local knowledge and scientific knowledge that can be seen through the dichotomies of epistemic culture. I went into this schematic discussion for ease of presentation and hopefully simplifying rather complex discussion on knowledge. By way of opening a discussion on the main theme of this paper, I offer a definition on interface.

The interface concept I use here is different from its use in other fields such as electronics, where the term is used to indicate an intermediary device that connects two or more parts to ensure the function of the whole system. The concept of interface I used here is that of social interface which is borrowed from Long (2001).

"A social interface is a critical point of intersection between life-worlds, social fields or levels of social organization where social discontinuities, based upon discrepancies in value, interests, knowledge and power, are most likely to be located."

In the same essay Long indicates that interface involves conflicts in spite of its presupposition of some degree of interest. Conflicts may arise due to differences in interest and objectives or to unequal power relations. Long's definition reveals that interface is a venue whereby different ideologies come in contact with each other. This interaction facilitates generation of knowledge that results from a cross fertilization of different life-worlds. In his writing about linkage mechanisms, Roling (1988) writes that linkage between institutions takes place if the interface allows it. In this sense, he refers to the *force field* between the intervening institutions.

From the above observation, interface can be seen both as a *cause* and *consequence* of interaction between two or more life-worlds. It is a *cause* of interaction because; one can assume multiple interfaces in time and space, with different level of 'energy' or information flows in the force-field. When the flow of energy or information allows it or when it intensifies among different life-worlds, through communication processes, generation of [new] knowledge takes place by blending from relevant sources. In turn, these processes reinforce an interface as an *consequence* of interaction. Knowledge that is created through interface has a *shared* value and interest, which makes it different from knowledge generated by a single epistemic culture. Consequently, interface becomes a point of mediation, negotiation and conflict resolution among different life-worlds.

As indicated in the previous section, LK and SK are complementary. What is required from societal point of few is to nurture their interface. Interface between LK and SK can be created through *communication* process and conducive contexts. Positive outcomes of this process depends on the attitude of the interacting parties, namely, the agencies from LK and SK. Moreover, power differences among interacting parties, contested knowledge and values attached to respective knowledge sources, perception, expectation of the outcome, etc., should be considered seriously in order to influence the outcome of the *force-field* in a desirable direction. Without due concerns to these issues a genuine intention to "empower" the people to achieve a sustainable development through their participation is likely to fail. Consequently, what we call knowledge system or more specifically, National Agricultural Research System becomes a normative and hypothetical system without a functional synergy.

Development of appropriate technologies for sustainable development requires that scientists, policy-makers and other development agents practically accept people's perspective and knowledge and sharing space them. This approach is fundamental for negotiation, instead of involving people in the development projects created by outsiders with marginal participation of the 'clients.'

So far, both nationally and internationally, interface between LK and SK is weak in the sense that communication between them was not effective enough to enhance the innovation process through which [shared] knowledge could be created. The communication failed to take place because of the polarity between the LK and SK that is rooted in the *ontology* and *epistemology* of positivist science. Positivist scientists continue to emphasize the superiority of their knowledge, which is translated into action by development intervention that overtly neglect the LK in favour of science based knowledge.

The gap between LK and SK can be bridged if and only if the development practitioners prepare themselves to enter into everyday life of the very people they intend to serve. According to WinklerPrins (1999), this approach might create a 'third way of knowing', which results from knowledge interface (see below). The process in this approach would be different from the traditional approach whereby researchers force users to accept technological package designed without their involvement and a thorough understanding of their context. A package approach, which is common in 'transfer of technology' approach, precludes incorporation of users knowledge (cf. ontology of the positivist approach).

Understanding people's way of life facilitates mediation and negotiation over world-views. This understanding can be ensured only through effective communication. Meehan (1980) suggested to cross-map scientific concepts with that of ethno-scientific[4] one, which can be entertained by Long's interface concept (see also, Agrawal, 1995). In view of these, I prefer to use the term *knowledge interface,* as proposed by Long (2001), instead of interface between indigenous/local and scientific knowledge, in order to minimize the dichotomies and assume the multiplicity of actors in the process.

The school of ethno-science has long demonstrated the importance of local knowledge to technological change for the betterment of mankind. In this regard, it suffices it to mention abundant literature under titles such as ethno-veterinary, ethno-medicine, ethno-semantics, ethno-botany, ethno-ecology, ethno-agronomy and indigenous soil and water conservation (many authors in: Brokensha, *et al*, 1980; McCokle, *et al*, 1996; Reij, *et al.*, 1996). These works emphasize the embededness and embodiedness of knowledge in societies' cultural, religious, social, economic and institutional frameworks, which need to be accommodated for effective research for development rather than the traditional research and development (Pound*, et al.,* 2003). Moreover, it reveals that that traditional R&D process alone cannot ensure sustainable development, in the face of increasing complexity in the contemporary societies. Therefore, the interface concept provides a proper framework and concept to enhance the intermarriage between the LK and SK. This intermarriage, however, requires suitable strategies and approaches, some of which are highlighted below.

Strategies and approaches for effective knowledge interface

The discussion on interface addressed possibility to minimize the divide between western and indigenous knowledge, which served little purpose for holistic development. However, how to minimize this gap is not widely known among development institutions, nor there is any 'blue print' to follow. In conclusion, attempts are made to pinpoint some of the relevant strategies and communication approaches that facilitates knowledge interface.

The fundamental issue for scientific community, policy-makers and those associated with these parties is to avoid verification of indigenous knowledge using methods and standards of scientific research and readiness to learn with other stakeholders. More over, the possibilities that an interface fail[5] to support integration of different knowledge system should be appreciate by all as only one form of knowledge cold be best under some conditions. This can be achieved by institutionalizing indigenous knowledge through participatory research approaches. This approach is now evolving into participatory innovation development (PID) from FPR/PTD in 1990s (Servaes, *et al.*, 1996; Mook and Rhoades, 1992; Reij and Waters-Bayer, 2001; Pound, *et al.,* 2003; Pijnenburg, 2004).

PID should not be seen as yet another stage of participation continuum. I understand PID as a set of principles with respect to roles in research and development communication by different actors in R&D. The principles may include; importance of local innovation/knowledge for sustainable development, the need for integration of LK and SK to improve livelihood of diverse

[4] Refers to a set of concepts, propositions, and theories unique to each particular culture group in the world. According to this definition science is one of a number of types of ethno-science of culture groups throughout the world.

[5] Values attached to different knowledge may hinder communication that may facilitate an interface between different knowledge communities.

stakeholders, the need to understand different worldviews of stakeholders, importance of a holistic approach based on *soft system*[6] methodology, which also employ *hard system*[7] selectively, dynamic nature of *context* and actors involved, and the need for knowledge and skills to accommodate different needs and interests in this dynamic world.

PID can use range of tools and strategies to ensure effective knowledge interface not only in agriculture and rural development but also in urban setting. These include, *Rapid Appraisal of Agricultural Knowledge Systems* (RAAKS)[8] (Engle, 1997), *Social Learning*[9], *Negotiation* (Leeuwis, 2004). This volume cannot provide a sufficient space to do justice to these concepts. However, it is worth mentioning here that these concepts are consistent with the *ontological* and *epistemological* foundation of interpretative and critical social sciences discussed earlier, which foster knowledge interface because of their openness to multiple world-views.

RAAKS is a participatory action research methodology, unlike some tools such as PRA, which by and large focus on data collection and presentation (see Tesfaye, 1999). RAAKS, through its soft system thinking facilitates social learning. The latter is learning that takes place in a social context. Such learning is applicable to both individuals and society for the purpose of survival and development (Tesfaye, 2003). Learning at societal level requires negotiation to accommodate multiple interests and different world-views. It is a voluntary process among stakeholders. Its aim is to reach at a mutually acceptable solution on the issues of difference. Therefore, negotiation is part of a solution in case of conflict or differences of any degree in the learning processes (Leeuwis, 2004).

The worth of these strategies to an effective knowledge interface is in the methodological departure. They de-emphasize, if not neglect, rigid survey and experimental approaches to research. They instead employ open and discovery oriented approaches in data collection and analysis. The latter approach improves understanding of people's way of life, which is one of the crucial elements in bridging the gaps between researchers' knowledge and that of the user's communities.

To sum up, knowledge interface can flourish or diminish or even remain uninitiated mainly because of the attitude of key stakeholders. Of course, context within which stakeholders operate, play a great role to facilitate its creation. Given the growing complexity with many facets, it is high time to rethink about the reign of 'scientific knowledge' and allow alternative world-views, with the purpose to create a basket of choice rather than a fixed menu, as coined by Chambers and his associates (1989). Therefore, an interface concept offers a fresh perspective and possibilities for social learning towards this end. It is my sincere belief that forums such as ESAP are instrumental in promoting knowledge interface among actors in R & D.

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6 A soft system methodology creates a process of inquiry as a system that facilitates understanding of 'reality' through a purposeful action, which involves negotiation, consensus, and accommodation. This methodology is consistent with interpretive and critical social sciences.

7 A hard system is the methodology of the positivist science. It postulates the world to be systemic and construct models to represent the world, whereby improvement in the perceived problematic world's situation is sought through the improvement of the constructed model, guided by the goal set when the model was perceived.

8 For details unpack the RAAKS tool kit, which provided many flexible windows for range of contexts.

9 See Leeuwis and Pyburn, 2002 for more resources on the subject

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Participatory forage technology development in Southeast Asia

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Introduction

Despite Asia's economic boom in the early nineties, many agricultural households have remained poor. In 2000, 849 million people in Asia still lived in poverty, 158 million of which in the Southeast Asian region (Gryseels et al., 1997). Poverty is often concentrated in the remote upland areas, where investments in infrastructure and government services have lacked behind. The upland areas are also the homes for many different indigenous peoples, living their ethnic traditional lives. One thing the upland farming communities have in common is the importance they attach to livestock. Although milk consumption is relatively uncommon in Southeast Asia, livestock provide manure for the low external input farming system, traction, and a source of capital accumulation which can provide income at times when needed. Livestock is a pathway out of poverty; when livestock rearing is successful enabling mature offspring to be sold, capital is often invested in other opportunistic businesses that provide a high rate of return. Rearing of ruminants such as cattle and buffaloes is traditionally time consuming. Many hours are spent herding, or collecting local forages to carry home. Grazing areas are scarce, and if at all available, consist of low quality grass such as *Imperata cylindrica*.

National and international research programmes in the past have generated a range of improved forage and feed technologies with the aim to increase livestock production in the tropics. These technologies have proved productive on research institution's farms, but have not had much impact on feeding practices by smallholder farmers in SE Asia. One of the reasons for this lack of adoption has been the absence of research facilitation to adapt the innovations to something that would suit the smallholder farm conditions and household dynamics.

The regional initiative called the Forages for Smallholders Project (FSP[1]) realised that the only way to increase adoption of improved forage technologies was to involve end-users in the innovation process. This paper describes how farmers' participation in experimentation evolved during the project . Results are described in terms of technologies tailored within diverse conditions, and impacts on livelihoods. The second phase of the project focused on dissemination. The active role of partners and farmers are eluded in this paper. The paper concludes with generic and technical lessons learned.

Evolution of research approaches within the Forages for Smallholders Project

From 1992 to 1994, CIAT and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) evaluated more than 500 forage species and varieties for adaptation to climate, soils, pests and diseases, in a few representative sites in SE Asia. Conventional methods

[1] FSP was convened by CIAT, and funded by AUSAid from 1995-1999 and Asian Development Bank from 2000-2003.

for screening forages in nurseries were used, and farmers' land was sometimes rented (Table 1). Only after the number of candidate species and varieties were reduced to a manageable size, farmers' involvement became feasible. FSP started regional evaluations of selected species and varieties on communal sites, and asked farmers to rate their performances in terms of growth characteristics and pest and disease resistance. Gradually, experimentation shifted from communal sites to individual farmers' plots, and methods were developed to facilitate appropriate farmer participatory research (FPR). FPR is an iterative process, going through various stages and providing opportunities for feedback. Horne et al. (2000) developed a diagram which proved very useful for clarifying the research concept to various stakeholders (Fig.1.).

Facilitation of FPR as portrayed in Fig 1. was an essential aspect of the project, but in order to increase impact beyond pilot communities, a more holistic approach was needed. During the second phase of the project, a strategy was developed for selection of sites to scale out, selection and training of partners, facilitation of knowledge flows, development of skills for farmers, and methods for monitoring and evaluation. Fig. 2 shows the various steps in the process. The first step was to gather secondary information and to carry out a rapid rural appraisal with a wide range of stakeholders in a particular area. Officers and field workers of agricultural extension authorities would be trained in forage agronomy, participatory research, and gender analysis. During these courses, the more active and motivated field workers were identified (step 2). The selected extension workers were assisted in their first participatory diagnosis and planning exercises with their communities (step 3). Forage options that would complement existing feed resources were discussed and selected (steps 4 and 5). Within a new community, a key farmers would be delegated for a cross-visit to champion farmers at other experienced sites (step 6). New farmers would normally follow a pattern of expansion within their own farms; they would start with small plots of new forage species and varieties, often only a few m^2 per species. They would evaluate the new forages using a variety of criteria, ranging from agronomic performance to ease of harvesting. Expansion would normally occur in an opportunistic way, when planting conditions were favourable. At this stage, enough forage would be available to compare palatability of forage species for animals, and evaluate grazing persistence. After about 1 year, farmers would start to perceive effects on animal productivity, soil fertility, or erosion control (steps 7 to 11). The broken arrows at the right indicate links to strategic research, the broken arrows on the left indicate the scaling out process.

Development and diversity of forage systems

Results of early nursery and regional forage variety evaluations in Hainan (China), Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam were published in proceedings of a workshop held in Indonesia (Stür, 1998). In this section I analyse what has happened since then in terms of forage technology development at two locations: Malitbog, Philippines, and Tuyen Quang, Vietnam.

Malitbog is situated at 8° N latitude, 700 m above sea level, with an annual rainfall of 1830 mm, 10 wet months (more than 50 mm), and a soil pH between 6 and 6.5. The farming system is based on maize, rice, banana, coconut and a variety of root and vegetable crops. Cattle are traditionally kept grazing or tethered on steep degraded hills covered by *Imperata cylindrica*. Based on performance in nursery and regional forage evaluations (Stür, 1998), 30 accessions of grasses, herbaceous and shrub legumes were recommended for use by farmers. Results from participatory diagnosis (PD) showed that major issues in animal production were lack of feed during the dry season or during planting season, and labour requirements for finding enough feed. After PD and planning exercises with farmer groups were held, farmers started small plot evaluations in their own farms. A few more years of collaborative and collegial farmer experimentation and expansion on farm resulted in significant areas covered with forages for multiple uses. Table 2 shows the varieties that most farmers were growing in 2002, how they integrated them in their farms, and the main uses. The collaborative and collegial research has provided us with several unique findings. First of all, although the initial recommended list of forages were mostly legumes, the five most appreciated and widely cultivated forage types in Malitbog are grass species. Secondly, early adoption of forages occurred at plot level, but these grasses are now mostly grown in lines along steep slopes, intercropped with food crops. Forages in general were very much appreciated for their effect on reduced soil and water run off. The combination of high biomass productivity of grasses for feed and their capacity to contain soil has been a major factor for adaptation and adoption. *Setaria sphacelata* has been cultivated by the largest number of farmers, because they value its very dense root system, resulting in dramatic natural terrace formation. These forage soil conservation structures have also saved farmers money in terms of reduced fertiliser wash off. Although it was initially feared by scientists that Setaria would not produce well enough during the dry season, this has been no important constraint for farmers, perhaps due to improved water infiltration as a result of the particular innovation.

Tuyen Quang is situated at 21° N latitude, 40 m above sea level, with an average annual rainfall of 1640 mm, 7 wet months (more than 50 mm), and a soil pH of 5-6. The mixed faming system consists of wetland rice and fish ponds in the lowlands; fruit trees, vegetables and tea near the homes, and forest plots on the hill tops. Cattle and buffalo are kept for meat (sale) and draft power, and fed on natural vegetation from the forest plots. Pigs are intensively raised and fed. Fifteen grass, herbaceous- and shrub legumes were recommended for use by farmers based on nursery evaluations at four sites in Vietnam. PD with farmers in Tuyen Quang indicated four major problems related to livestock production: Lack of good animal breeds, animal diseases, feed shortages especially during the dry cold season, and lack of cheap feeds for fish and pigs. The results after subsequent participatory research with farmers in terms of forage systems adopted are presented in Table 3. The participatory process in Tuyen Quang also yielded some important findings. The mostly grown and appreciated forage was *Panicum maximum* for the feeding of fish. This grass has some characteristics that make it ideal for this purpose; it has smooth, soft leaves and it floats on the water for the carp to feed on. It is also high yielding and stays green during the cool dry season. *Paspalum atratum* did not perform as well as other grasses in nursery and regional evaluations in Vietnam in terms of yield potential, persistence and seed production, but it has been highly appreciated by farmers because of its growth form, ease of propagation by tuft splits, smoothness, staying green during the cold dry season, and good on-farm yields. *Stylosanthes guianensis* has mainly been appreciated for its suitability as pig feed. Since all forages were only used for cut and carry, the tall growth form of *Brachiaria brizantha* has been found preferable to the more spreading and lower other *Brachiaria* spp. which were identified in the earlier evaluations. In contrast with the Malitbog experience, forages were grown in fodder banks rather than contour lines, and intercropped with fruit trees.

Most farms in Tuyen Quang consist of a forest plot on top of the hill, which is not supposed to be used for logging or cultivation, but which is exploited for other purposes such as grazing, browsing and collection of other forest products. FSP in collaboration with Thai Nguyen University carried out a study to assess farmers' use and perception of fodder resources from these forests. Local fodder plants traditionally provide the biggest bulk of cattle and buffalo feed. Indigenous grasses such as *Thysanolaena maxima, Narenga Fallax*, and *Saccharum* *arundinaceum*; and indigenous trees such as *Ficus heterophylla*, *F. lacor, Strebulus asper* and *Brousonettia papyrifera* were found superior to other indigenous plants in terms of providing green forage during the cold dry season (Ta Thi Thu Thuy et al., unpub.). Initial laboratory analysis revealed promising nutritive value for the tree species in particular. The community and researchers have been encouraged to experiment on management practices to optimise seasonal fodder production from these species, and on propagation methods.

Impacts

In 2001 and 2002, impacts studies were carried out in several countries and sites, using a combination of participatory methods and conventional surveys (e.g. Bosma et al., 2003). In the Philippines, the project had a significant effect on the quantity and quality of available forage; farmers who were growing forages derived 67% of the feed resources from improved cultivated forages, whereas before the project this amount was negligible.

Farmers mentioned several benefits from these forages: improved body condition and overall health of animals; increased quantity and quality of work by draught animals; larger amounts of collectable manure due to reduced herding-time and increased numbers of offspring.

Estimated amount of time saved due to new forages ranged between 30 minutes and 2 hours per day in southern Philippines. Life became more relaxed as it was easier to plan activities when animals were not grazing. Involvement of women and children in tasks like herding and collecting local forages diminished, and men became increasingly responsible for livestock tasks. The reduction or disappearance of tethering and herding also resulted in less destruction of crops. Consequently, the production of maize, banana and vegetables, and the income from animals' work outside the farm, increased. Net yearly income per household from animal production increased from $54 to $157 in the farming community at Malitbog. Planting forages in contour lines increased crop production slightly and contributed another $22.50 to yearly income. The reduction in labour requirements allowed households to make $36 per year from other activities. Most farm households expanded their herd size after joining the project, and consequently the time available for off-farm work decreased, offsetting partially increased income from livestock.

In Tuyen Quang, Vietnam, farmers reported higher yields of forages compared to native grass. The high yields of new forages allowed farmers to keep more animals or to keep animals in zero grazing feeding systems. Improved forages enabled other farmers to start keeping animals, as they were able to produce sufficient fodder from their small plots. The average estimated contribution of new forages to animals' diets was 53% during summer and 32% during winter. Ruminant productivity increased in terms of faster growth of animals, higher price received for the animals at the market due to better body condition, increased working capacity of draught animals, and increased amounts of manure. The productivity of fish increased as the period until marketing was reduced from 11 months to 9 months.

As was the case in the Philippines, saved time was an important benefit for most farmers keeping ruminants. The number of labour days per year required for raising large ruminants was 258 for farmers *without* forages versus 149 for farmers *with* forages. The mean number of saved days for fish production was 30 days per year, which corresponds to approximately 40 minutes per day. Women and children benefited most from the reduction in time spent cutting, carrying and herding. They used this extra time for other farm activities, and educational and cultural activities. Forages had a positive effect on other crops due to soil conservation and manure availability.

In Vietnam, improved forage systems also had a pronounced effect on income levels and welfare. Net income from ruminant-fish production systems increased from $99 to $199 per year. The time saved allowed households to increase their income from other, mainly agricultural activities, resulting in an additional yearly income of $52 per household. Farmers were grouped in four income classes; the majority were in the class that earned between US$301 and US$736 per year per household. An increase of $152 from the livestock system therefore corresponds, on average, to an increase in total household income of 29%. Poorer farmers who depended more on livestock due to small land areas, benefited the most from the improved forages. Other positive effects on rural development included a reduction in the number of farming conflicts, rehabilitation of barren land, and reduced use of pesticides.

Scaling out and up

Scaling out is geographical spread to cover more people and communities, and involves expansion within the same sector or stakeholder group (IIRR, 2000). Within the complex smallholder farming systems and diversity of local cultures and practices, aims to replicate forage systems without an adaptation process would result in low adoption, in a similar way as top down strategies of the past didn't work. On the other hand, there is also the wish to make the process more time and capital efficient, i.e. to avoid elaborate interactions with every new farmer. The FSP did find such a compromise. The selection of new areas and new communities would still require relatively high investments in terms of time for rapid rural appraisals (several days) in a new region and PD and planning with communities (1-2 mornings). Staff time was saved though in terms of facilitating the research process. Very often he research would be collegial or completely farmer led, the emphasis of facilitation time being only in monitoring and evaluation. The facilitation of cross visits by champion farmers from old sites would partially replace staff time. Table 4 shows how the aggregated numbers of PD and other activities in six FSP countries in SE Asia led to numbers of new farmers planting forages. On average, about 18 farmers would participate per PD. Many of these farmers were encouraged by what they saw and heard during the following cross visit and about three-quarters of participating farmers would start planting forages. As a result, a total of 4,155 new farmers have started to grow and experiment with forages from 2000 - 2002.

Scaling out implies a need of increased numbers of staff to facilitate the research and development process. The selection process for fieldworker trainees has been described earlier. It is emphasised that training courses need to be multi-faceted; new knowledge, skills and attitudes are equally important.

Lessons learned

General

- The myth that 'participatory research is easy and anyone can do it' is not true. There are people who are naturally gifted with abilities to listen, show respect, have interest in others, be flexible, or be able to enjoy or bear field conditions. At the other side of the scale, people find it very hard to acquire these skills. In a similar way, not everyone excels in conventional research. Participatory research done wrongly can waste farmer's time, damage community trust and willingness to collaborate. There is a need to screen facilitators.
- Practice makes perfect. Training alone in participatory approaches is not very effective unless it is followed by field work with mentoring opportunities.
- Reporting and analysing qualitative data and information remains a challenge for many field

workers and scientists. Training and practice remains to be required. Qualitative data are often collected and accumulated in ad hoc ways, without thinking much in advance on what to do with the information. Careful planning of the qualitative data collection process helps analysis and interpretation.

- Anecdotal or unexpected information can add tremendous value to a project or even change its course significantly. Many important farmer innovations have resulted from it. Facilitators need to develop a sixth sense for this phenomenon.
- There is usually no reporting language that fits all. Reporting needs to be done in a language for the most appropriate user, be it donor, institution, field workers, or community. Translation might be needed into one or more other languages, either simultaneously during meetings, or written in reports. Considerations need to be made to serve international public goods versus development and empowerment of communities. Careful targeting of time and capital resources for translation is needed.
- Situations are dynamic and participatory diagnoses don't reflect the truth forever. Revisiting PD is essential about every two years. Planning and implementation of research need to be adjusted accordingly.
- Capacity building or advocacy of participatory approaches are necessary at various levels, not only for field workers. Scaling up[1] of approaches will facilitate scaling out.
- Confrontational methods during advocacy of participatory approaches often result in adverse effects. In adverse conventional environments, working in the margin yields more progress in terms of acceptance and institutionalisation.
- It is difficult to develop sincere relations with communities for participatory research in the shadow of livestock dispersal programmes or other projects that supply substantial agricultural inputs free or on loan. Individual or communal objectives for participation remain obscure, due to wishful expectations. This often results in strenuous planning and implementing community based research.
- Memoranda of understanding and research agreements with key partner institutions have been very instrumental for successful project implementation.
- Initially there is a strong demand for formal research procedures by all stakeholders. The formal type of research is increasingly replaced by more informal research. For many researchers and field workers this complicates matters. Skills for collecting, reporting, analysing and interpreting qualitative data are required. The shift to more informal research methods, however, indicates increased community ownership of the process and a development phase of innovations.
- Many research and development projects have the following words in their goal statement: improvement of livelihoods, increased equity and sustainable natural resources management. The pathways of reaching the goal need to be flexible. As end-user environments are dynamic, local priorities change, new opportunities for innovations arise, hence flexible outputs and activities can result in higher efficiency and impact. Imperfect community problem diagnosis at the start is more common than not, and doesn't need to be disastrous.

Technical

- Non availability of forage seed in rural areas is a major bottleneck to adoption of forages. In

[1] **Vertical scaling up** is moving higher up the ladder. It is institutional in nature and involves other sectors/ stakeholder groups in the process of expansion – from the level of grass-roots organizations to policymakers, donors, development institutions, and investors at international levels. Vertical scaling up includes **institutionalisation** (often referred to as 'mainstreaming', especially in the participatory literature). This implies getting institutions to accept and internalise the underlying principles of an innovation so that these will remain as guiding principles of practice even after the initial innovative project or program has come to an end (IIRR, 2000).

many humid regions decentralised local seed production has been difficult or impossible, but vegetative multiplication of planting materials appeared a practical alterative. Many farmers have become skilled and efficient in vegetative multiplication systems, serving many other clients. Subsidies for local production of seed or panting material are useful initially, but should be phased out soon after.

- Within the nation as a whole, there are often large variations in climate and soil type providing suitable niches for forage seed production. Centralisation of seed production is preferable in this regard, taking advantage of optimal niches. Import and export of large quantities of seeds are impractical due to strict regulations and extremely lengthy procedures in most developing countries. Grass seeds loose viability during bad storage in the process.
- FSP results in SE Asia show that grass based technologies are preferred over legume based technologies for livestock production. Grasses generally have the following advantages: they produce more biomass, they establish faster, they are easy to propagate vegetatively, cattle and buffaloes traditionally feed on them. Legumes on the other hand serve special niches, multi-purposes and certain animal categories. The potential of tree legumes is very much under-utilised due to some practical agronomic problems for farmers, such as lengthy establishment phase, which could be overcome.
- Diversity of forage options is essential, as these options suit the diversity of farming systems, niches, topography, fertility, microclimates, livestock, labour availability, customs, farm size, etc.
- In smallholder systems, improved grass and legume forages are rarely the sole feed resource for livestock. The impact of improved forages have been in systems where they serve a strategic supplementary role with existing basic feed resources.

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Table 1. Formal and informal stages of forage evaluation (adapted from Roothaert et al., 2003).

Stage of evaluation	Number of species and accessions	Number of locations	Management	Type of farmer participation
1. Nursery, 1992-1997	Many (>50)	Few	Researchers manage	Contractual
2. Regional evaluation, 1995-1999	Few (<20)	Many	Farmers manage	Consultative
3. Formal farmer evaluation, 1997-2001	Few (6-8)	Many	Farmers manage and evaluate	Collaborative
4. Informal farmer evaluation, 1999-2003	Few (2-6)	Many	Farmers make decisions, manage and evaluate	Collegial

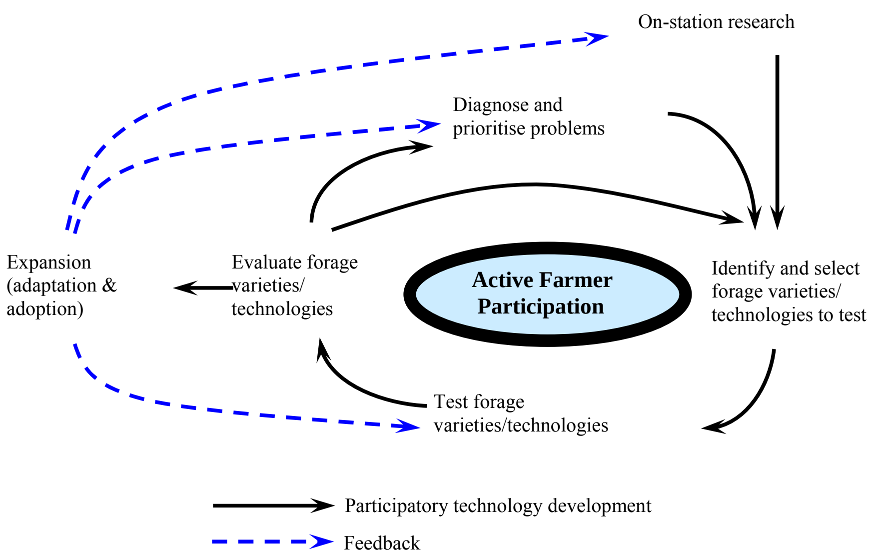

Figure 1. Diagram of the iterative research process for forage technology development (Horne et al., 2000).

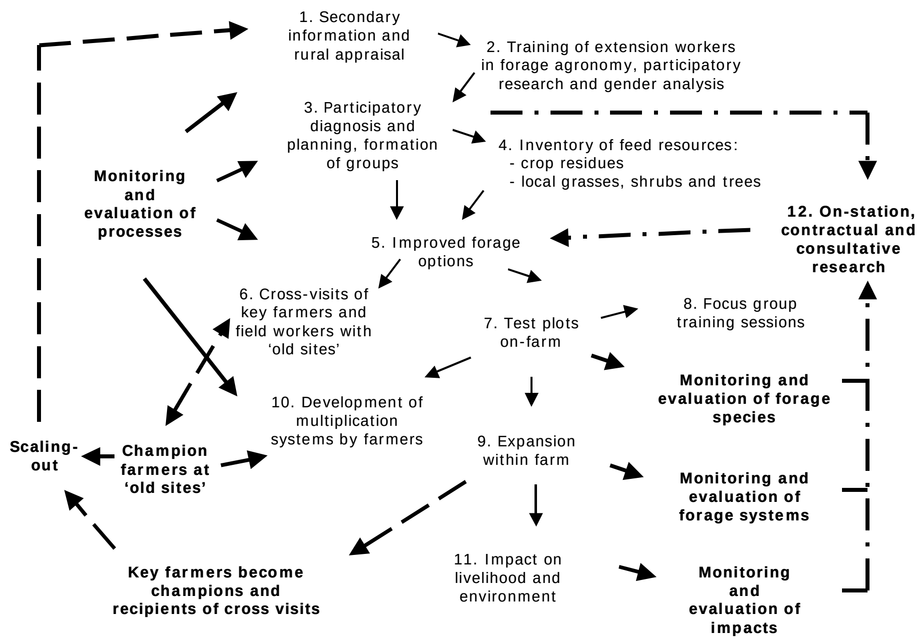

Figure 2. Strategy for scaling out the research process (Roothaert and Kerridge, 2002)

Table 2. Forage systems adopted in Malitbog, Philippines, 2002.

Species (ranked in order of number of farmers growing them)	Planting and harvesting system	Type of animal fed to (in order of importance) and other uses.
Setaria sphacelata var. Splendida and cv. Nandi	Contour lines along steep slopes, cut and carry from lines and plots. Grazing.	Feed for cattle, goats, pigs, horses[1] and carabao. Planting materials. Soil and water conservation.
Pennisetum purpureum ex-Xavier[2]	Contour lines along steep slopes, cut and carry from lines and plots.	Feed for cattle, goats, horses and carabao. Planting materials. Soil and water conservation.
Paspalum atratum	Contour lines along steep slopes, cut and carry from lines and plots.	Feed for cattle, goats, horses and carabao. Planting materials. Soil and water conservation.
Panicum maximum CIAT 6299 (Tobiata) and T58 (Simuang)	Contour lines along steep slopes for T58 only. Cut and carry from lines and plots. Grazing of contour lines after harvest of maize.	Feed for goats, cattle, carabao, horses. Planting materials. Soil and water conservation.
Brachiaria ruziziensis	Contour lines along steep slopes, cut and carry from lines and plots.	Feed for cattle, goats, carabao and horses. Planting materials. Soil and water conservation.
Arachis pintoi	Plots for cut and carry or for grazing. Little is planted along contours or as cover crop.	Feed for goats, cattle, carabao and horses. Planting materials. Soil and water conservation. Soil fertility improvement.
Flemingia macrophylla	Plots, contour lines along steep slopes and hedges. All for cut and carry.	Feed for cattle, goats, and carabao. Planting materials. Soil and water conservation. Soil fertility improvement.
Gliricidia sepium var. Retalhuleo	Plots and hedges. All for cut and carry.	Feed for cattle, and goats. Planting materials. Soil and water conservation.

[1] Setaria is toxic to horses only when fed in big amounts.

[2] This variety was obtained from Xavier University, Cagayan de Oro, in the early nineties. The plants are tall, broad leaved, and non-hairy. It distinguishes itself from other many other *P. purpureum* varieties in a characteristic of being glabrous at the upper side of the leave blades. In appearance it compares to King grass from Indonesia and to Pennisetum hybrid cv. Merker.

Table 3. Adopted forage systems in Tuyen Quang, Vietnam, 2002.

Species (ranked in order of number of farmers growing them)	Planting and harvesting system	Type of animal fed to (in order of importance) and other uses.
Panicum maximum *T58*	Cut and carry from fodder banks. Intercropped with fruit trees.	Fed to fish, buffaloes, cattle and pigs. Erosion control. Sale of planting materials and seeds.
Paspalum atratum	Cut and carry from fodder banks. Intercropped with fruit trees.	Fed to buffaloes and cattle. Sale of planting materials and seeds.
Pennisetum purpureum	Cut and carry from fodder banks.	Fed to buffaloes and cattle.
Stylosanthes guianensis *CIAT 184*	*Cut and carry from fodder banks. Intercropped with fruit trees. Some contour hedgerows.*	*Fed to pigs and cattle. Soil fertility improvement. Erosion control.*
Brachiaria brizantha	*Cut and carry from fodder banks.*	*Fed to buffaloes and cattle.*
Boehmeria nivea	*Cut and carry from fodder banks, intercropped in fruit trees.*	*Fed to pigs, fish, buffaloes and cattle.*
Trichantera gigantea	*Cut and carry from fodder banks.*	*Fed to buffaloes and pigs.*
Leucaena leucocephala	*Cut and carry from live fences. Contour hedgerows.*	*Fed to buffaloes and cattle.*
Gliricidia sepium	*Live fences.*	*Fencing.*

Table 4. Scaling out activities and number of new farmers experimenting with forages.

Year	No. of participatory diagnoses (PD) conducted	No. of farmers who participated in the PD	No. of new groups	No. of cross visits organised	No. of farmers participating in cross visits	No. of new farmers planting forages
2000	45	1087	52			748
2001	151	2173	179	187	1330	1537
2002	101	2148	52	141	1833	1870
Total	297	5408				4155

The Concept and Application of Farmer Field Schools for Livestock Research and Development

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Abstract

This paper presents adaptation and testing of Farmer Field School (FFS) as an extension approach among smallholder dairy households in Kenya. Overall the results indicate that FFS contributed to the building of farmers and extension agents' capacity to critically reflect on management practices for improved livestock extension. The results of implementing the approach suggest that gender, education, access to non-farm income and group building dynamics influence effectiveness of the approach. While adoption of new forages varied by location. However better understanding of local social capital and marketing issues would provide additional information in adapting FFS widely.

Keywords*:* Farmer, Field, School, capacity, building,

Introduction

Research and development partners working to alleviate poverty through livestock are seeking new approaches to realize technical impacts on production systems of small-scale farmers (Mungunieri *et al.,* 2002). Previous studies have indicated that lack of information constrains the productivity of the smallholder dairying systems in Kenya (Schreiber, 2002).

The traditional extension system in Africa, based on a top down approach, rarely delivers in an integrated manner the necessary information (Nyambo & Kimani 1998). Failures in the traditional methods of research and extension include lack of focus on farmers' priority issues, or giving recommendations that were inappropriate or with no immediate tangible benefits (Hefferman & Misturelli, 2000). In addition farmers were not sufficiently involved in identification of their problems, or in selecting, testing and evaluating the possible solutions.

Specifically in Kenya, the department of veterinary services has historically not undertaken extension advisory work (Leonard *et al.,* 1993). It has instead focused on provision of emergency healthcare services (Barton *et al.,* 1996). Meanwhile extension service by livestock and crop development staff lacks the philosophy of target group participation and motivated staff. Inadequate research and technology transfer and information services are also the result of low priority to adaptive /applied research (GoK 2001). But, farmers operate animal health and production systems that are complex with varying levels of resources and risks to animal diseases that threaten the livelihood assets of the poor (Perry *et al.,* 2003).

They have poor road infrastructure, poor access to production resources including adequate information and capital. Under such situations farmers' information and capacity building needs can be unclear to outsiders.

In a recent study in Central and Rift Valley Provinces of Kenya, approximately 90% of rural households were agricultural and of these 73% had dairy cattle (Staal. *et al.,* 2002). In the DFID bilaterally funded Smallholder Dairy Project (SDP) characterization and longitudinal monitoring of smallholder dairy farms has confirmed that in Rift Valley Province, smallholder farmers

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consider endemic diseases, particularly tick-borne diseases (TBD), and inadequate supplies of feed resources the major constraints to increased dairy production (Omore 1999).

Current approaches for development and delivery of technologies have to recognize the importance of involving the end-user at all stages. A diverse set of tools and methods are promoted, such as the 'farmer-to-farmer' model; farmers' agricultural networks; farmers' research committees; and farmer field schools (FFSs) (Anandajayasekeram *et al.,* 2002). The underlying need for a paradigm shift is to facilitate better learning, communication and organisation capacity among farmers and between farmers, extension agents and researchers.

Farmer Field Schools (FFS) are an innovative, participatory and interactive learning approach, developed by the FAO in South East Asia, which lays emphasis on strengthening farmers skills to test, learn, adapt and seek out more information (Simpson. *et al.*, 2001). FFS was originally developed as a way for small-scale rice farmers to investigate and learn for themselves the skills required for and the benefits possible from, adopting integrated pest management (IPM) practices in their paddy fields. The hypotheses was that, knowledge of principles and concepts in an intervention can enable farmers to adapt existing or new technologies (Khisa 2002, Asiabaka and James 1999). The FFS methodology has been successfully adapted to improve farmers' participation in adapting IPM, soil management and poultry production knowledge gaps. However it needed to be developed for the more complex animal health and production systems where responses to interventions may not be as fast.

Forging for institutional collaboration

Although at inception of the project FAO, ILRI and the Ministry were already working together it was important to start by building partnerships at field level. FAO were already working in the region using FFS to address IPM and soil fertility issues. Although many farmers were requesting livestock FFS (which is referred to as LFFS in the rest of this paper) there was no expertise available to adapt the methodology to the more complex animal production systems. FAO and ILRI started to work together with local partners building on existing local networks of experts in training of trainers in the basic LFFS concepts. Links to the ministry staff in the field were established through the DFID bilaterally funded Smallholder Dairy Project (SDP), led by the Ministry of Agriculture Research & Development in collaboration with the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI). Since the FAO-FFS had already established a set of basic principles the project aimed to bring these principles to LFFS and to follow the same norms and regulations to ensure a harmonious working relationship and avoid setting precedents, which could not be maintained.

The ILRI/DFID-AHP/FAO Project

This LFFS project set out to adapt and develop the methodology specifically for livestock starting in 2002.Ten pilot LFFS were set in 2001 in five agro-ecological zones in Central and Rift Valley Provinces, where two-thirds of households own dairy cattle. LFFS approach was adapted to facilitate the understanding of the impact of animal health on productivity and how to control diseases. The LFFS addressed an integrated approach to control vector-borne diseases and helminth infections and to improve the efficiency of utilization of available feed resources and the management of nutrients within the crop-dairy system. A series of structured activities were implemented in this process of adapting and testing the LFFS methodology (Minjauw *et al.,* 2002).

All facilitators were trained during a 2-week training of trainers (TOT) course, run as a learning workshop. The participants learned and used the basic principles of the LFFS to develop specific examples of activities, tools and techniques suitable for the smallholder dairy production systems. Facilitators thus trained in LFFS approaches then worked with established groups to prioritize the main constraints to improved efficiency of milk production. Issues highlighted for all groups were similar and, in order of priority included 1) Feeding strategies; 2) Fodder establishment and conservation; 3) Calf rearing and mortality; 4) Diseases (tick-borne and mastitis) 5) Water management and breeding (equal priority given). Based on the results of this exercise, individual grant proposals were prepared by each group including a detailed work plan with a corresponding budget.

A grant of US$600 was deposited in an account controlled by elected members of the LFFS group to cover the cost of field activities and facilitation, i.e. transport and lunch allowances to enable the extension worker to visit. Management of this budget empowered the farmers to demand and control activities covered by the LFFS and ensured that the extension services offered responded to farmers' actual priority problems and needs. LFFS groups met on a weekly basis but some varied their frequency to fortnightly. The principle components of the LFFS on smallholder dairying are adapted from the Integrated Pest Management (IPM) FFS approach .It consists of; participatory tools applied to analyze animal health and production issues; agro-ecological system analysis (AESA) and participatory technology development (PTD). These participatory tools were adapted to suit the specific needs of learning about livestock issues.

How the LFFS concept is made operational

One common element that the LFFS shares with other group approaches is targeting clients as groups with a common interest. However, through a combination of features outlined in the table below the LFFS lays emphasis to farmer empowerment through learning analytical skill.

Table 1: Non—negotiable principles in FFS

Feature	How it is realized
Ownership	Target group of participants have common constraints and interest
	Recruitment is by self volunteering
	Group by-laws by group members
	LFFS name, objectives, leaders selected by participants
Empowerment	Grants given directly to group bank account
	Committee pays facilitators allowance
	Organisation of functions and dissemination of technical information learned during field days, graduation organised by farmers themselves
	Education principles
	skill, not technical information, is the goal
	Learning by discovery
	Learning by doing
	Systems approach
	Science-based
	Experimental and/or problem-based learning
	Experimentation and study plot
	Non-formal education process
Group discovery learning	LFFS observational activities rotated to select individual homes
	Joint experimentation plot is staged at the host farmer
Life education	Linkage to other resource persons
	Linkage to other organisations

Feature	How it is realized
Self-help and Self-propelling	Group income-generating activity initiated Linkage to other more permanent, local organisations
Competent facilitators	TOT handled at the start by recognised master trainers Routine mentoring during monitoring and evaluation visits by LFFS expert Systematic training process Observation Group discussion and analysis Conclusion and action plan (s) Agro-ecosystem analysis Regular and frequent meetings (weekly/ fortnightly)
Curriculum development:	Curriculum developed by participants Topics should be chosen by the community Training based on farmer's limited knowledge Training based on basics needs of farmers

Adapting a participatory process

Tools for problem diagnosis

Participatory methods were used to carry out in-depth problem diagnosis and develop a common understanding between the facilitator and farmers on animal production and health issues that were to be addressed. Understanding of existing farmer knowledge, local factors and the broad variation in practices between members of the group provided the basis for subsequent learning activities. Common participatory tools used in participatory rural appraisal (PRAs), ethno-veterinary surveys and qualitative epidemiology (Mariner 2001) were adapted for use in LFFS, building on the participatory epidemiology approach as described by Conroy (2002).

Improving observational and analytical skills - Agro-eco-system analysis (AESA)

The AESA exercise helps to establish, through a process of structured observation, the interaction between livestock and other biotic and abiotic factors co-existing in the field. The exercise is used to improve farmers decision making skills by developing a system whereby regular observations of the livestock and their environment are used as a basis for identifying problems, deciding on improvements and monitoring change.

At each LFFS meeting farmers were divided into sub-groups who visited other participants farms. Data was collected through observation of a single animal and its interaction with the environment. Suggestions on interventions to improve the health and nutrition of the animal with a view to optimizing farming objectives are made and the conclusions presented back to the whole group for analysis.

Livestock Participatory Technology development (PTD)

PTDs are implemented to empower participants (both farmers and facilitators) with analytical skills to investigate cause and effect relationships of problems in farming practices. Since the main objective of the PTD is to develop farmers learning skills rather than just increase knowledge of a particular technical aspect, record keeping and accurate observation are an important component. AESA technique is thus an integral component of the PTDs and is used to record and observe the results of the experiments.

Establishment of PTD is one of the biggest challenges for LFFS. Indeed, while it is relatively easy to design comparative studies for crop integrated pest management, the high economical value of cattle does not allow any experiment involving risk or even short-term productivity losses of the animal. Therefore, one of the objectives of the LFFS project is to establish the type of PTDs that can be performed without any risk or detrimental effect to the animal. However such PTDs should give farmers confidence to experiment with new technologies.

Case study:

Livestock Farmers Field School approach and factors that affect its application and impact.

According to Simpson (2000), the FFS model of extension is receiving consideration for wide application in Sub Saharan Africa (SSA). However evaluation of how it has improved participation and learning by farmers, in relation to their socio-cultural and economic circumstances is lacking. This case study was therefore undertaken to evaluate the above factors among smallholder dairy farmers in Nakuru and Nyandarua districts.

Methodology

Quantitative and qualitative methods were combined so as to produce complementary data sets allowing both statistical rigour and comprehensive understanding of the results.

Facilitators opinion using semi-structure interviews

Using semi-structured questionnaire information in which open-ended questions were asked and answers post-coded, was collected on the perceptions of seven (5 male and 2 female) livestock Farmer Field School facilitators on the suitability of LFFS methodology as an extension approach.

Farmer opinion from group sessions using participatory approaches

A one-day farmers' workshop for each of the eight Farmer Field School from two high potential dairying provinces in Kenya, was held to obtain their perceptions on the LFFS. During the workshop, participatory evaluation techniques were used to gather information from farmers. Some of the participatory evaluation techniques used include:

- Focus group discussions and subgroup presentations on special topics covered during the LFFS for smallholder dairying process. A total of 28 subgroups (14 from Nakuru and 14 from Nyandarua district) gave presentations. This was done in order to evaluate the extent to which farmers internalized the skills they acquired during the one-year LFFS for smallholder dairying training.
- "T-Chart": Used to evaluate the content of the areas that farmers were taught during the LFFS for smallholder dairying sessions. Farmers' assessment grouped the topics in accordance with those that "Need to be improved" and those that were adequately facilitated hence grouped as " good". This way we were able to capture what farmers thought about the evolving LFFS for smallholder dairying curriculum. For the special topics that needed to be improved they offered suggestions on how they could be improved during focused group discussions.
- Pictorial self-assessment: Farmers drew pictures depicting their lives before and after LFFS. They then presented these pictures to the rest of the group and explained what their individual drawings meant in relation to having been in the field school.
- Proportional piling matrix: Was done by farmers to assess the LFFS for smallholder dairying by weighing and ranking various activities that formed the structure and style of the field school. This activity evaluated commitment to regulations set (school attendance, contributions), sub-group activities for group observation analysis and recording (AESA) etc

Household survey: FFS participants and non-participants

The last step was to select LFFS participants for individual interviews. Selection was by secret ballot amongst FFS sub-groups. Each FFS had at least 5-6 sub-groups which generally represented groups of farmers living close by each other. Each sub-group was asked to vote for 1 or 2 members to represent them giving a total of 50 farmers. A further 44 farmers owning at least 1 cow were nominated by FFS members as 'non Livestock FFS participants (NLFFS).

Semi-structured questionnaires were used with the 94 farmers. The questionnaire was used to collect information characterizing the farmer (age, education, gender) and farm resources (area under forage, income sources) as well as whether or not farmers were testing some practices covered in the FFS including calf housing, correct spraying routines, correct mixing ratios used in preparation of acaricides, use of weighing bands and diversification of forage types. Regression analysis was carried to determine the effect of involvement in FFS and some farm/farmer characteristics on whether farmers tested practices on their own farms.

Statistical analysis

SPSS computer programme was used to analyze both the survey data and some data from participatory methods. Descriptive statistics were applied to summarize the data, and enable an understanding of preliminary change in technology use and the participants' circumstances as factors affecting technology use. Logistic regression models were used with the household survey data to evaluate factors that influence participants' willingness to adapt technology at household level, with willingness defined as being whether or not a farmer was testing or using a particular practice on their farms.

Results

The results from the study covered three areas of interest namely facilitators and participants opinion about the approach, the impact of LFFS and the household factors that influenced use of FFS learnt technologies.

Evaluation of LFFS approach by facilitators

Evaluating the methodology using semi structured interviews

According to extension staff interviewed LFFS is cost-effective and has potential to be self-sustaining. Tables 2 and 3 below give facilitators views of the LFFS. In comparing LFFS and other extension approaches they identified a number of appealing and unique features (see table 4).

Identification of advantages and disadvantages (see table 7) indicated that there were many novel of aspects of LFFS that would require them to adapt to its application.

Table 2: Assessing LFFS effectiveness

Issues of effectiveness	Percentage
Facilitators reach many farmers within a short time	71.4
Farmers fully participate and respond very fast	57.1
Extension messages spread very fast due to farmer-to-farmer	42.9
Farmers are trained according to their needs	42.9
Close working relationship between farmers and facilitators	14.3

Table 3: Assessing sustainability of LFFS

Sustainability issues	Percentage
Social learning and peer pressure will encourage farmers to continue with LFFS	71.4
Trained farmers are willing to be facilitators	57.1
Farmers are already making contributions	42.9
Promoted technologies are based on farmer needs	14.3
It is demand driven extension/private extension	14.3

Table 4: Factors that distinguish the LFFS as an extension approach

The most striking aspect of LFFS as an extension approach	Percentage
Interaction among farmers encourages social learning	71.4
Results are realized almost immediately	42.9
Farmers are well targeted	28.6
Encourages cohesiveness among farmers	28.6
Courses are tailored to the farmer needs	28.6
Going back to books is quite refreshing	14.3

Table 5: Advantages and disadvantages of LFFS as perceived by the facilitators

Advantages	Disadvantages
Increases community cohesiveness	Quite committing to the facilitator
Farmer-to-farmer extension enhances technology dissemination	Limited budget, forcing facilitators to use their own money
Enhances social learning and peer group influence due to interaction	Culture/norms hinders LFFS activities
Learning is enhanced by farmer-extension interaction	Doesn't allow for leave
Farmers are well targeted i.e. you get them when you need them	Lack of classrooms
Empowering in decision making and gender equality	Farmer perceptions is a hindrance
Quite cost effective	Does not cover other important topics such as marketing
Flexible learning process	

Evaluating factors that affect participant mobilization using semi-structured interviews with the facilitators

There are socio-cultural adjustments that a farmer has to consider to participate effectively in the LFFS. On average about 5 participants would drop out of during the active period of each FFS. Gender related issues i.e. permission from husband, other commitments are the main challenges facing mobilization in LFFS as an extension methodology. The study identified the following reasons as the possible factors leading to dropouts.

1. Failed expectations such as material/financial benefit from LFFS
2. Following a weekly routine of going to school was found difficult
3. Got a job in other sectors
4. Inability to follow the laid down by-laws by LFFS participants
5. Gender issues/increased responsibility for women
6. Sickness/old age
7. Milk marketing problems

8. Disagreement with other participants

Evaluation of the LFFS approach by participants

Evaluation the LFFS approach using proportional piling

Participants of LFFS found the approach to be different and new. The results of their assessment of new participatory activities that can be applied to build observational analytical and organizational capacities are given in table 6. Farmers were given 36 maize seeds. They were asked to place any number of seeds based on how they thought the activity was doing .The activity that was doing very well they allocated to it a maximum of six seeds. The ones that did very poorly could get low number of seeds or none. Agro-ecological Systems Analysis (AESA) was ranked highest followed by special topics, and sub-group activities were third. Farmers mentioned that they like AESA and special topics because they have learnt a lot from these activities. Activities that were doing poorly were individual financial contributions towards LFFS and group dynamics.

Table 6: Farmers evaluation of LFFS activities

Activity	Scores
Agro Eco Systems Analysis (AESA)	1
Special Topic	2
Sub-group Activities	3
Group Dynamics	4
Field Day	4
Individual monthly Contributions	5

Evaluating the facilitation styles using T-charts

Farmers also assessed the facilitation styles for various livestock topics that evolved in LFFS. The T-chart results identified dairy cow disease, calf rearing, breeding and selection, homemade rations and milk marketing as topics that were not adequately covered in the LFFS curriculum. They suggested that teaching of these topics needs to be backed -up with more practical lessons, technical handouts and/or booklets particularly on clinical signs of the common diseases.

Evaluating self development using special topic presentation

FFS sub-groups assessed ability of group to recall and present adequate information on technical issues. 28 subgroups (14 from Nakuru and 14 from Nyandarua district) made special topic presentations. This was done in order to evaluate the extent to which farmers internalized the information and skills they acquired during the one-year LFFS. Fodder establishment; calf rearing and cow diseases are the topics that farmers frequently and spontaneously made presentation on for peer review.

The FFS then evaluated each presentation by sub-groups and awarded marks expressed as a percentage. The marks ranged from 50-90%. In awarding the marks, farmers looked at the level of coverage of the topic during the presentation, but also self-confidence of the presenter. Farmers stated that self-confidence and ability to address a gathering are some of the skills they acquired in LFFS.

Evaluating use technology learnt

Evaluating technology use by household surveys

It also found that farmers had started practicing new technologies and a considerable increase in the application of previously known technologies. See table 7 below.

Table 7: Frequency of change in technology use.

Technologies	Current practice (%)	Past practice (%)	After LFFS (%)
Establishing Napier grass	97.8	78.3	19.5
Establishing Fodder Sorghum	22.0	7.0	15.0
Establishing Kaw kandy*	28.0	1.0	27.0
Establishing Lucerne	80.4	7.0	73.4
Establishing Desmodium*	20.0	0.0	20.0
Home made ration*	19.0	0.0	19.0
Hay making	8.0	13.0	-5.0
Oats	28.0	20.0	8.0
Silage making*	13.0	5.0	8.0
Correct spraying/dipping interval	84.8	21.7	63.1
Right amounts of acaricide	87.0	17.4	69.6
Deworming	91.3	23.9	67.4
Weighing a cow*	67.4	0.0	67.4
Calf housing	43.5	3.0	40.5
Calf feeding regime	60.9	6.0	54.9

*New technologies introduced at LFFSs

Evaluating impacts and household factors those household factors that influenced use of FFS learnt technologies.

Participants evaluation of impacts using pictorial self- assessment

When farmers were invited to present their perceptions of the impacts of the LFFS experience, acquiring knowledge and better farm management skills were reported as main immediate benefits. See results of pictorial self-assessment below in Table 8.

Table 8: LFFS perceived outcomes

Illustration	Implied outcome	Percentage
Sun/stars/darkness	Knowledge	99.2
Farm /animal farm structures	Resource allocation	92.6
Milk cans /size of fruits on a crop	Yield	86.9
Self drawing and dressing code	Attitude/confidence	86.9
Animal size and body condition	Livestock health	83.0
Self drawing	Personal well being	51.0
A fruits which is bitter or sweet tasting	Relationship in community	35.2

Farmers and extension agents perceived that the LFFS was effective in imparting new knowledge, building their observational skills and confidence to adapt and use technologies.

Perceptions by non-participants of impacts of FFS

Areas and extent of changes in technology use at community level, as observed by non-LFFS farmers interviewed appear to have similar results as those obtained from the interviews with

LFFS members (see table 9 below). They reported change in fodder production, improved access to information and renewed interest in livestock farming in the community.

Table 9: Perceived outcomes at community level.

Perceived outcome	By LFFS %	By NLFFS %
Increased fodder establishment in village members ‘plots	68.2	60
Renewed interest in dairy farming	53.9	23.6
Increased milk output	24.0	
Better income for LFFS participants		25
Free information		55

Two main sources of information and technical advice that were mentioned by NLFFS farmers were Ministry of Agriculture extension agent (65.8%) and LLFFS participants (38.0%). The results indicated that the LFFS has become a key source of timely information in the community.

Table 10: Source of advice on farming practices for non-participants

Source of advise	Total (%)
MOA extension agent	29 (65.8)
NGO/CBO	3 (6.4)
LFFS participants	17 (38.0)
Non-LFFS participants	5 (10.0)
Other	4 (9.0)
Co-operative society	4 (9.8)

Household factors that affect use technologies learnt in LFFS.

There are perception held to the effect that FFS do not include the socio-economically dis-advantaged farmers. Owning a dairy cow and adopting associated technologies is capital intensive, therefore participating in LFFS as opposed to crop FFS is assumed to require more resources. The study revealed that Over 80% of the farmers who participated in FFS were literate as seen in table 11 below and in table 12 below over 80% of households in the study did not have off farm sources of income.

Table 11: Educational levels for household heads

Education level	Non-participant	Participants	Overall
None	22.7	20.5	43.2
Primary	38.6	38.8	37.9
Secondary	22.7	28.6	27.4
Post-secondary	15.9	14.3	14.7

Table 12: Proportion of farmers with off farm income

Off farm income	Non-participant (%)	Participants (%)	Overall (%)
No	81.8	91.8	87.4
Yes	18.2	8.2	12.6

Household level analysis of factors that influence use of technologies learnt

Chi-square tests to give significance of participation in FFS on technologies on disease control feed diversification or improved management skills were carried out. Participation in FFS was significant at $p < 2$ % for influencing application of disease control measures (correct application of acaricide) and at $p < 3\%$ for farmers practicing improved livestock husbandry skills (weighing the animals, calf housing). This suggests that knowledge and skills acquired through FFS participation enabled farmers to try these technologies. Using novel forages in diversification of fodder technologies was not significant at $p > 5\%$ by FFS participation but was weakly significant at ($p > 5.5\%$) for farmers with off-farm income. This suggests that information on feed production technologies were available from other sources, or that it is more easily shared, but that cash flow could be a constraint. Using linear regression factors found to have a significant relationship between farmers testing practices was, gender, off-farm income and district as well as participation in the FFS. Education of FFS participant was significant at $p > 2\%$ for disease control measures. Participation of female-headed households was significant at $P < 5\%$ for using calf-housing technology.

Discussion

Results of the impact study show that LFFS facilitators perceive the LFFS approach as a novel, effective and sustainable methodology. It provides them with tools that allow them to have better farmer participation in generating and sharing information. It improves the aspect extension -to- farmer contact with many farmers being reached at a time. It has a built in mechanism of enhanced information and technology dissemination, by the peer pressure and social learning it attracts. The results of statistical analysis also show that female-headed household showed significant use of management skills associated with reduced calf mortality.

According to participants evaluation LFFS increases diversity of information sources in the community. Farmers' major reasons for joining the LFFS were to obtain knowledge and skills for disease control and to improve the efficiency of utilization of available feed resources. However farmers still require more information on the issues of dairy cow disease, calf rearing, breeding and selection, homemade rations and milk marketing. The participants were largely literate.

The study could not yet measure success by uptake of technologies but rather by how well it facilitated access to information, technology and the building of farmer's confidence and analytical skills for technical changes. The results the survey and semi structured interviews showed that after one year of project implementation, farmers were more confident in farming as demonstrated by self-pictorial assessments and their willingness to assist their neighbours on simple animal husbandry techniques. Participating farmers showed improved farm and animal management practices. They paid better attention to calf health and reported reduced calf mortality. Participating farmers have also formed support groups to undertake labor and skill intensive technologies such as making like silage for feed conservation.

Conclusion

FFS demonstrate the potential to make farmers more enthusiastic participate in research and development initiatives .It encourages farmers to test technologies not only at the FFS site but to be willing to try new technologies at household level. The simple comparative experiments at household level are a great opportunity for generating local relevant analytical indicators of livestock performance. They encourage collective, reflections and hence faster decisions to adopt, adapt or reject technology.

The LFFS provides R & D initiatives in livestock development with a process of taking farmers' resource constraints and risks into account during technology transfer. LFFS process recognizes the fact that farmers are interested in the delivery of animal health services, which provides them with a chance to adapt technologies (Minjauw, *et al* 2002). As a possible recommendation to extension and research services, use of tools that ensure farmers learn by discovery such as AESA and PTD activities should be in-built in any extension approach. Farmers rated the AESA, as the most useful activity in the LFFS. LFFS has the potential to stimulate self - reflection and assessment of long-held perceptions and attitudes toward technological changes.

If scientific research is to achieve real impact on livestock productivity and livelihoods of the poor, participatory approaches that focus on building farmers observational and analytical skills should be widely used.

The major challenges in setting up LFFSs are experienced in group mobilization to ensure that the participants have a common interest and needs. Understanding the local structures especially the social affiliations that act, as a form of social capital is important. Participatory technology development activities rely on willingness of individuals to mobilizes resources and share information. Such a collective effort would facilitate comparison of new and existing practices in the communities. There is need for further studies to assess the contribution of the LFFS in enhancing access to markets for animal products and livestock health care services.

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Promotion of Farmer Innovation and Experimentation in Ethiopia [PROFIEET] : "A newly emerging Multi-stakeholder platform to link local innovations with research and development "

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Introduction

It is becoming increasingly necessary for actors involved in public services to join hands and speak with a louder voice to bring about desirable socio-economic changes in Ethiopia. No single organisation can achieve its goals unless it reaches out in all directions and learns more from others about the realities outside its own domain. Similarly, no single organisation has perfect knowledge and complete understanding about the complex reality of this world and of the unpredictable social and environmental changes that are taking place within it. Therefore, platforms need to be established to facilitate learning through the building of effective partnerships. Platforms create a common ground where all constituents have equal footing and equal rights in decision-making. It accommodates multiple perspectives and interests, without submerging differences that emerge in the process. Diversity is beauty, provided that there is a common understanding and an acceptable level of consensus among the constituents on the basic concepts, principles and goals of the platform. On the other hand, it is waste of time and resources if conflicts of interest leading to undemocratic and unfair decisions become day-to-day phenomena in the platform.

The issues of reducing poverty and attaining sustainable livelihoods are central to the agenda of many institutions involved in development activities in Ethiopia. Both governmental organizations (GOs) and non-governmental organisations (NGOs) are making tremendous efforts to change the present-day picture of poverty in the country. Most agree that "agriculture"[15], with due emphasis to environmental concerns, should be the strategic focus in order to bring about rapid economic and social transformation. Nevertheless, poverty reduction through a focus on agricultural development cannot be achieved in the short term and requires the attention of more than only the public institutions. The process of reducing poverty is complicated and demands lots of resources and the attention of a wide array of actors in research and development. This calls for the coalition of the relevant stakeholders in the agricultural sector.

This paper is a document prepared to introduce Promotion of Farmer Innovation and Experimentation in Ethiopia [PROFIEET], which is a platform established by multiple state and non-state actors that have a mandate and great concern in the area of agricultural research and development in Ethiopia. Over the past year, agencies that developed interest in Promotion of Farmer Innovation and farmer participatory research have started to build up the PROFIEET platform.

Background to the building up of the PROFIEET platform

A few organisations in Ethiopia are already in the midst of Farmer Participatory Research (FPR), Participatory Technology Development (PTD) and similar forms of development-oriented research that regard farmers as the main actors in the innovation process. There is very high interest among various other development practitioners – particularly those concerned with food security – to become more familiar with and skilled in participatory research and extension approaches. Many formal researchers and field practitioners are also very keen to see live, on-the-ground cases of innovations that have been developed under the leadership or active participation of farmers.

In January 2002, Agri Service Ethiopia (ASE) – a national NGO implementing food-security programmes in three regional states of Ethiopia – and Mekelle University – the lead agency for the second phase of the Netherlands-funded Indigenous Soil and Water Conservation Project (ISWC-2) – organised a national familiarisation workshop on the concepts of PROFIEET for regional policymakers in all Bureaux of Agriculture in Ethiopia. ASE, Mekelle University and FARM-Africa – an NGO that has been promoting FPR in the Southern Region of Ethiopia for several years – presented their experiences with farmer innovators and FPR / PTD. The workshop participants showed great interest in this work and asked the workshop organisers to continue organising educational fora on PROFIEET. Some even requested the establishment of a national network that could provide backstopping to them while they implement and – in the process – learn more about the concepts of farmer innovation and experimentation.

The organising committee of the January 2002 workshop took the comments and requests of the participants on board and began to consider opportunities and possibilities to bring together the Ethiopian experiences in farmer innovation and experimentation and to allow all relevant actors to learn from each other. It was at this point in time that our international partners – ETC Ecoculture based in the Netherlands – expressed willingness to solicit funds for a national workshop that would aim at scaling up the approach of participatory research and development, building on farmer innovation and experimentation.

ASE entered into formal contacts with ETC Ecoculture and made an institutional commitment to work as secretariat and facilitator of multi-stakeholder interaction in designing a PROFIEET platform and programme, and to administer the funds made available by IFAD (International Fund for Agricultural Development) through ETC Ecoculture for this initial design phase. A Steering Committee was established to oversee the process of preparing and carrying out the PROFIEET National Workshop. It was composed of both GOs and NGOs: the Ministry of Agriculture (MoA), the Commission for Science and Technology (CST), the Ethiopian Agricultural Research Organisation (EARO), Mekelle University, Debub University, FARM-Africa, SOS-Sahel and ASE. The major activities of the Steering Committee were to organise an inventory and analysis of relevant experiences in Ethiopia and to bring these together in a national workshop which would presumably lead to a collective commitment by all relevant stakeholders and a plan of action to scale up the approach.

ETC Ecoculture has been catalysing and supporting similar processes in other countries in an initiative to build up a global programme called PROLINNOVA (PROmoting Local INNOVAtion in ecologically-oriented agriculture and natural resource management). A global platform for PROLINNOVA is growing as movements similar to PROFIEET emerge in several countries and show an interest to come together for synergy and mutual support, as well as for policy influence at international level. The PROFIEET initiative can thus contribute to the formation and strengthening of the global network and would share experiences and receive support from the constituents of PROLINNOVA.

The concept

Core agenda of the initiative

It is to create space in which formal researchers and extension workers can support the informal experiments of innovative farmers and rural communities. The whole idea is to help farmers come up with cost-effective and ecologically friendly innovation that fit their own realities. This is, indeed, a process of empowering farmers and rural communities. Because, the approach gives farmers more opportunity and self-confidence to make their own decisions about research and development.

In this approach, outsiders [researchers, extension workers, experts etc] respects the proposals, ideas, theories and decisions of farmers not only for the sake of moral reasoning but because the knowledge base of innovator farmers is very powerful and realistic. Of course, outsiders have an extremely important role to play in providing relevant information, methodological support and other forms of assistance for local experimentation, without jeopardising the local innovation processes. This approach does not deny the necessity of basic research. Indeed, there is no intention of replacing the current research and extension approaches in the country. However, it introduces a new dimension of thinking that complements existing approaches and links them with farmers' realities. This approach can be easily accommodated within the framework of current agricultural research and extension systems, without bringing conflicts of interest into the system. Making a logical link and striking a balance between the knowledge worlds of innovative farmers and formally educated experts is central to this initiative.

Paradigm shift in research and extension approach

Almost since the invention of extension science, the Transfer of Technology [ToT] model has been the dominant research and extension approach in the developing world. It is still used extensively in many parts of the world including Ethiopia. This model implies: scientists generate new or improved technologies, which are then transferred by extension agents to farmers. It considers farmers as legitimate receivers of technologies coming from outside. It also considers that most of the smallholder farmers and pastoralists are illiterate, poor and helpless, who deserves the attention of experts /outsiders in order to improve their livelihood. However many of the technologies generated and promoted in this way are too expensive for millions of small scale farmers who can not afford to invest in the packages of required inputs, such as introduced seeds, genetically improved breeds, fertilizers etc. Moreover these packages are standardize and promoted country wide with out regarding to agro ecological differences and poorly suited to diverse and variable conditions. Some times farmers appear to be reluctant to adopt the technologies offered by the conventional research and extension.

On the other hand there is immense potential within the farming community and it has to be remembered that, centuries back farmers were the ones who have managed to identify, select and domesticate thousands of plant and animal species, quite long before the institutionalization of modern sciences. Nevertheless, local knowledge and innovation have been ignored in the process of technology development by the formal researchers and this has been one of the reasons for creating gaps between the real needs of the smallholder farmers and the technologies, the social norms and economic capacity of farmers and cost and suitability of the technologies etc.

Innovation is a broad terminology that can refer to the discovery of a completely new way of doing something or to modifications of existing technologies. Farmer innovation is therefore refers to a new idea/ practice that has been started within the lifetime of the farmer, and not inherited from the parents and grand parents. Traditional knowledge, that is inherited from ancestors and indigenous knowledge, which is a generic term used to refer all bodies of knowledge that emanate from the indigenous people, are often the sources of most of the local innovation of farmers. Farmer innovators are always adding values on the indigenous knowledge they already acquire and they try to make it more relevant, workable, effective, efficient, environment sound and user friendly. Some times they may come up with completely new way of doing things, and this may perhaps mislead that it has nothing to do with indigenous knowledge. Nevertheless it is very difficult to make a hard line distinction between indigenous knowledge and any form of farmer innovation.

Farmer innovators do conduct informal experiments. They in fact start with a problem analysis, formulation of a hypothesis, test their proposals and finally adopt the new finding as long as it is found worth doing. This precisely shows that farmer innovators are following the same procedure like the modern sciences do. However we cannot conclude that the farmer innovators have adopted this procedure from the modern science. It is in fact otherwise true that the modern science has learned quite a lot from the traditional way of technology development. Farmers are often reluctant to tell outsiders that they are conducting experiments. They don't even recognize them selves as farmer researchers, even though they are doing spectacular works in technology generation activities. Outsiders may not also rightly recognize that farmers could conduct experiments in their own domain. But, in reality, in order to cope up with the ever-changing environmental, ecological, policy, market etc situation, many farmers are under persistent innovation process. Some innovative farmers are indeed doing more feasible works and it is up to the outsiders to identify those innovative farmers, appreciate their works and begin to work with them for better results.

There are ample opportunities for cross-fertilization of indigenous and formal knowledge in development. It is these characteristics that draw the attention of development practitioners to the use of indigenous knowledge in development. Lack of this focus in the past has led to the failure of numerous projects. During the last decades, particularly in the l990s the role of indigenous knowledge is recognized in the International Agricultural research centers and multilateral agencies such as the World Bank and the United Nations agencies.

From real life experiences we have learnt that there are some thinkers who take the concept of indigenous knowledge too far and assume that IK could provide answers to every single problem of farmers. On the contrary there are scientists who believe that the role of farmers in technology development process have to be limited to "providing relevant information", when ever they are asked by the researchers. They may not put this statement bluntly but it appears to be the governing attitude of those scientists who are not well informed about the role of IK in development. Theses two extremists' views are not basically the premises of the founders of PROFIEET. PID is in fact collaboration of farmers, development agents and scientists [formal researchers] for technology development with a logical mix of the knowledge and skills of farmers with the collaborating stakeholders. The approach therefore seeks to strengthen the existing experimentation capacity of farmers.

Basic assumption of the approach

The basic assumption behind this approach is that in a given innovation process there is something perfectly known or understood by farmers and not by Scientists; something perfectly understood by scientists and not by farmers and something which is completely not known both by scientists and farmers or fully understood by same. This frame of knowledge analysis tells that there is strong need of facilitating collaborative researches with farmers, particularly with the innovative ones. Innovative farmers are not necessarily "model" or contact farmers; rather S/he creates or tries out new ideas without their having been recommended by extension workers or any development worker. Experiences of Mekele university shows that, in most cases innovative farmers are old age and experienced farmers and most often the poor farmers tend to be more innovative than the other farmers who could afford baying modern technologies. One of the possible reasons behind this fact is that poor farmers are always striving to overcome problem situations by their own, because they may think that it is not as such easy for them to address the problem situation by importing technological innovations from the science world.

Innovative farmers often are not easily traceable because most of may not even recognize for them selves that they are doing something new and fascinating. Some of them are also in most cases out of the formal contact of the government extension services because they might think of trying things differently as that they cannot afford baying the packages. Therefore innovative farmers are in many cases those who are running informal experiments or those who have already achieved something new out of their own informal experiments and yet are not easily traceable unless a well-organized systematic and purposeful survey is conducted. Ones these innovative farmers are identified, the outsiders should start thinking of what value can they add in order to make the process more complete. This implies that formal researchers should not always think of going to the farmers with established research agendas because in the case of innovative farmers they already set the research agenda.

On the other hand there are cases where the agendas are set by the researchers and there by farmers are given the opportunity to comment, modify or change the original topic so that to make it more responsive to the local realities. This also applies true to the extension activities that farmers will be in a position to accept as it is, modify, make substantial changes or reject what ever is provided by the extension services. The process of changing, modifying and then adoption are still considered as process of innovation.

Some more remarks

- The idea of farmer innovation and PID brings about lots of recognition and empowerment to farmers and extension workers who are involved in the process. Because, they are officially assuming a new role which could provide them chances to release their potentials. On the other hand it tends to reduce the role of the formal researchers in the process of innovation development and this may cause frustration and socio psychological problems for those scientists who are not ready to accept the new configuration and power relationship of actors in PID.
- The role of researchers and scientists in the PID process is indeed indispensable if reasonable changes have to come in short period of time and quicker expansion of the approach and the innovation is desired. Winning the confidence of researchers/scientists and causing desirable changes in the research and extension systems of the relevant institutions is one of the goals of PROFIEET
- The concepts of PID is not only applicable to research activities but also extension. PID is Indeed a tool that is being used to participatory research and development. Some of the futures of PID as an extension tool can be explained as, on the one hand what ever the a new technology is coming from any source, farmers involved in PID will have the capacity and the right attitude to test, modify and then adopt or reject the newly coming technology as the case

may be. Secondly there are cases where some of the farmer innovation could be directly taken to promotion or extension with out a serious need of considering further research or securitization. This could be done through using the farmer to farmer extension approach, where farmers are playing a key role in the extension undertaking. Moreover it has to be remembered that the natural process of PID is a farmer led learning phenomena and thus any one who come across the process have something to learn and something to contribute.

- The most fundamental and desired impact of PID/PTD is empowerment of farmers, in a sense that decision making of farmers on the research agenda and process will be highly improved and access and ownership of information ensured. The empowerment of farmers however has to be exercised and extended until farmers make sure that they are actively involved in making decisions on the public money that is dedicated for research and agricultural development activities as well as formulation and reform of policies that are relevant to their priority needs. Indeed one can see PID/PTD from the angle of human right issue, which specifically refers to the article which emphasizes the right to get involved in development works. Hence it explains a feature of right based development approach.

More elaborations on key terminologies

- **Farmer Innovation - Approach** - is an approach that helps to explore farmers who are involved in innovation processes through conducting informal experimentations to over come problem situations or learn new way of doing thing.
- **Participatory Technology Development [PTD]** is an Approach that helps to improve the linkage of innovative farmers, researchers, extension workers and other stakeholders in the process of technology development.
- **Participatory Innovation Development [PID}** a synonym for PTD with more border usage of the term "innovation" instead of restricting the process to hard-core technologies. New way of marketing, land use planning, getting organized, networking, learning etc are all innovations that may not be adequately explained by being a "technology". PID is therefore the most recent and comprehensive expression of PTD.
- **Farmer led participatory research :** -A type of PID in which case the research agenda is set by the farmers and the innovation process is mainly managed and controlled by the farmer researchers. The participation of outsiders is often through building the capacity of farmer researchers & providing technical and methodological information, which is believed to be unknown by the farmer and yet relevant for the innovation process.
- **Expert led participatory research :** is another type of PID in which the experts/scientists set the agenda and the process is mainly controlled by same. Farmers are invited to participate at different stages of the innovation process.
- **Farmers Field School** - An approach, which provide farmers the opportunity to learn from local knowledge and experiences in the open field. It also encourages farmers do researches to improve the proposed indigenous technological interventions or generate new ones. Educational curriculum is designed in the beginning of the activity and the entry point of the learning process is the one indicated in the curriculum.
- **Innovator farmers**: Farmers who are conducting informal experiments using their own wisdom, knowledge and experiences, with the aim of overcoming problem situation or discovering new learning dimensions.
- **Farmer Innovation** - value addition on Indigenous knowledge or scientific knowledge bodies through conducting self initiated informal experiments of farmers. Up with improving

efficiency, effectiveness, management, workability or understanding (generation of new Information)

Rationales for using the approach

- Ethiopia is a country of historic and diverse ethnic groups that have survived several types of crisis, including, drought, famine environmental changes, epidemic livestock and human diseases etc. Survivals have therefore immense knowledge on how to mitigate crisis.
- The present day expert/researcher - Farmer relationship is based on the assumption that the experts group feels that it is the only responsible body to come-up with technologies and new ideas so that to help farmers get out of poverty situations. However the reality is that farmers have also immense indigenous knowledge that have been on use for many years and yet neither tapped properly nor linked with the modern science. Thus understanding farmers and encouraging them to explore their own way out through developing local innovation and hybridizing with outsiders knowledge the best approach to respond to the diverse, specific and complex reality of farmers.
- In the course of technology/innovation development the degree of participation may be understood by examining some basic indicators like who set the research agenda, who make decisions on the major events of the study, who control the research process, who owns the information etc. The higher the involvement of farmers in the innovation process the more the result will be precise, sustainable, affordable and responsive to real life situation.

The PROFIEET Founding Workshop in brief

The national workshop to design a PROFIEET plan of action was conducted on 25–27 August 2003 in the Debre Zeit Management Institute southeast of Addis Ababa. Representatives from research organisations, experimenting farmers, NGOs, Ministry and Bureaux of Agriculture, universities and the Commission for Science and Technology took part.

A total of 51 participants, including 7 farmers, attended the workshop. Eight papers on experiences of GOs and NGOs in farmer participatory research and development were presented. The presentations provided ample opportunity to share practical experiences and learning points, and to raise the level of awareness of all participants.

The workshop participants identified gaps and challenges in participatory approaches to research and development based on farmer innovation and experimentation. The groups were formed on the basis of institutional affiliation (policymakers, research, extension, NGOs, farmers). This helped them to make critical self-evaluation of their own formal or informal institutions in connection with participatory research and extension. The gaps and challenges as presented by the groups were discussed in the plenary. A small team was then formed to summarise the group findings during the evening, for presentation the following morning on the final day of the workshop. The summary report listed the most important gaps / challenges as being:

- Lack of awareness on FPR at all levels
- Challenge to institutionalise the approach
- Absence of proper linkages between the relevant stakeholders
- Limited information flow on issues of farmer research
- Frequently changing institutional structure of the government.

New groups were then formed on the basis of interest in these topics, so that each group could work on how to deal with the different gaps / challenges. For ease of analysis and to have better balance in group size, the gaps / challenges were combined into three major ones:

- Awareness issues
- Institutionalisation
- Linkages

During the subsequent plenary session, each group presented objectives, strategies and major activities to address these three major gaps / challenges.

Finally, the possible institutional arrangement to implement the activities was discussed. The two main options were:

- to endorse the existing Steering Committee as a multi-stakeholder PROFIEET platform, with the addition of some other important stakeholders; or
- to hand over the activities of the Steering Committee to the recently formed National Research and Extension Council.

After much discussion about the pros and cons, agreement was eventually reached that the Steering Committee should continue working for some years, with the addition of three more members: Alemaya University, the Institute for Sustainable Development (ISD) and the Pastoral Forum Ethiopia (PFE). During the workshop, it was not yet possible to decide how the voices of the highland smallholder farmers, in addition to those of pastoralists, could be brought into the platform. The PROFIEET Steering Committee should have a strategic plan to hand over the activities to the National Research and Extension Council – and, in the case of regional platforms, to the regional Research and Extension Advisory Councils – assuming that PROFIEET will be able to contribute to strengthening these Councils and helping to make them fully operational in all parts of the country. The workshop participants decided that the PROFIEET Steering Committee would continue to be chaired by EARO, with ASE serving as Secretariat.

Vision

PROFIEET aspires to see a radical attitudinal and behavioural changes among researchers, extension workers, farmers and policymakers in terms of recognising and encouraging the conscious use of indigenous knowledge and local innovation in research and extension by promoting participatory processes that build on and enrich local knowledge systems and local innovation capacities.

Mission

To integrate PROFIEET – i.e. participatory approaches to research and development that builds on and enriches local innovation processes – within all relevant research institutions, extension organisations, NGOs and institutions of higher learning in order to contribute to reducing poverty and attaining sustainable livelihoods.

Strategic goals

Build the capacity of farmers, development practitioners and researchers to promote local innovation processes and farmer participatory research

Lobby policymakers to create an enabling environment for promoting farmer-led innovation and experimentation through their processes of policy formulation and revision.

Ensure the scaling up of farmer-led participatory research on the ground s of the relevant institutions and facilitate learning from experiences.

Facilitate learning from and sharing own experiences with other countries by strengthening linkages with PROLINNOVA and other international networks.

Strategies

Building capacities of researchers, extension workers and farmers to support local innovation and undertake participatory research

Advocacy and lobbing for an enabling policy environment in research and extension organisations and institutions of higher learning

Scaling up and enhancing farmer-led participatory research within member organisations and in collaboration with local and international universities

Networking with like-minded organisations, having a special linkage with the global platform established for promoting local innovation in ecologically oriented agriculture and natural resource management [PROLINNOVA]

Availing small grants to promote projects of farmer-led participatory research

Establishing a resource centre on promoting farmer innovation and experimentation (database, reference books, audio-visual materials etc)

Working closely with the National Research and Extension Council and facilitating the handing over of PROFIEET activities to the Council over time

Raising funds from internal sources and from outside donors

PROFIEET indicative plans

Establishing rulls, procedurs and systems for profieet

- Developing and signing MoU by members of profieet.
- Developing tor for the overall institution and different units of the platform.
- Setting a system for having a full time or parttime coordinator of profieet.
- Developing a phasing out plan in line of handing over the activities to the national counciel for research and extension.

Awareness raising/capacity building

- training of farmers researchers & extension workers at different levels.
- conducting panal discussions and interviews with innovative farmers and counter parts through buying radio & televesion time in the national programs.
- presenting the idea of pid in meetings of other forums, networks, professional association, and policy discussion forums etc.

Data base and resource center establishment

- Inventorize and document works of innovative farmers.
- Inventorize and document works of organizations and individuals dealing with innovative farmers.
- Establishing a computer based data base system and make it available for users.
- Establishing a resource center with books, journals, megazens etc relevant to farmer

innovation and participatory research.

- Designing a web sight and posting all relevantdocuments of profieet on the web.

Enhancing farmer led participatory research

1. Pilot case

- Identifying four agro eco systemes and social settings
- (enset area, coffee growing, typical ethiopian highlands and pastoralist area)
- Identifying farmer innovators in these areas.
- Conducting joint planning and training workshops with innovative farmers and researchers/experts.
- Conducting annual conferenses to learn more about the out comes of these researchs.
- Conduct different works with in0vative farmers in this program for 4 - 5 years.
- Cconduct a national write-shop and produce a book on "ethiopian experiences on farmer innovation and participatory researchs".

2. Encouraging member i institutions work on PID

- Establishing a small grant system for pid.
- Providing grants to innovative and sound poposals of profieet member institutions.
- Working with universities through providing research funds to graduate school students who would like to work on the concept of pid.
- Searching for PhD program scholarships for those who would like to work on PID, partnership for PID, institutionalization of PID etc.

Creating enabling environment through policy lobbing

- Working closely with decision makers of the universities to include PID in the curriculum of higher learning institution and colleges.
- Working closely with the governance of EARO & regional research institutes for policy reform (creating enabling policy environment for those researchers who would like to work on PID).
- Working with decision makers of the ministry of agriculture and lobby for the inclusion of PID as an alternative approach to extension.
- Encourage NGOs working on rural development create a space in their oms for PID (open position, allocate budget, making it part of the organizational mission etc).
- Work hard to start a national journal (annual) on PID and lobby for its recognition in the university and research systems.
- Influencing the Ethiopian science and technology commission to include works of innovative farmers in the national award system and patent right regulations.
- Encourage other institutions to have their own award system at local level for innovative farmers and staff working with innovative farmers.

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Farmers' practices in the management of Trypanosomosis in the Ghibe Valley, Southwestern Ethiopia.

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Abstract

Sound scientific research and development in developing countries like Ethiopia need to be based on due recognition of level of knowledge and traditional practices of farmers, if these are to achieve real impact on livestock productivity and livelihoods of the poor. This paper puts together what is known about farmers' knowledge of trypanosomosis and practices in its management in the Ghibe valley. Practically all farmers in the Ghibe valley recognize trypanosomosis as the major animal health problem and associate the disease with heavy losses through mortality and lowered animal performance. They have learned a lot about the control and prevention of trypanosomosis through the two decades of research by ILCA and then ILRI and its collaborators. However, knowledge on biology of the parasite and the tsetse fly is still very limited, particularly on the risk of misuse of trypanocidal drugs and insecticides. This compounded by the limited access to good quality veterinary services has exposed farmers to trypanocidal drug abuse and to some extent continued application of erroneous traditional disease control measures. In recognition of these, specific interventions have been tested, including participatory disease and vector control research programs by ILRI and partners; organizing farmers in to self-help input/output marketing cooperatives; promoting village-level selective breeding for trypanotolerance and investigation of drug resistance. There are also plans to test dissemination of proven trypanotolerant cattle, and provision of support for better performance of micro-financing services and markets.

Keywords: Trypanosomisis; Ghibe valley; farmers'practices; cattle.

Background

Animal diseases severely compromise Ethiopia's ability to improve food security. In particular, trypanosomosis, arguably the single most important constraint to animal production in Africa – causing losses of over US$1 billion per year, is particularly important in Ethiopia where about 14 million cattle and an equivalent number of small ruminants, equines and camels are at risk of contracting the disease (Longridge, 1976; FAO, 1994). Transmitted by several species of the tsetse fly (*Glossina spp*.), the disease causes high mortality, poor growth, weight loss, decreased reproductive performance, low milk yield and reduced work capacity for cultivation and other farm operations. The disease renders some 150 to 200 thousand square kilometers of fertile arable land (13-17.5% of total arable land in the country) in the west and southwest of the country under-utilised for agricultural production. Trypanosomosis is therefore a major bottleneck to food security in these otherwise fertile areas.

The severity of this bottleneck can be appreciated from the fact that, in 1975, the Ethiopian government introduced a policy to lessen the population pressure on highland areas by promoting resettlement in low-lying areas, such as Ghibe and Tolley. However, by the early 1980s, trypanosomosis had become prevalent in the area, devastating livestock numbers and resulting in a 70% reduction of the area under cultivation. Increased land pressure and drought in other parts of Ethiopia have nevertheless continued to result in increasing immigration and cultivation in the valley despite the fact that without curative and preventive measures, livestock mortality losses from this disease can reach 100%. New settlement areas are currently reporting the deaths of their government-distributed oxen and requesting further assistance.

The Ghibe valley is located some 185-230 km southwest of Addis Ababa; it lies between 1050 and 1600masl and receives 900 to1000mm of uni-modal rainfall between June and September. It has a warm climate with maximum temperature of 30 to 37°C and minimum of 10 to 15°C. These and its fertile soils make the valley a high potential agricultural area. Farmers practice mixed crop-livestock production, with maize, sorghum, Teff, red peper and sesame being the major crops and cattle as the predominant livestock species, with goats, sheep, donkeys present in significant numbers.

The need to mitigate the impact of trypanosomosis on food security has, since 1986, led the Ministry of Agriculture and the International Livestock Research Institute (ILRI) to conduct on-farm research to test the efficacy of various trypanosomosis and tsetse control and prevention measures, including the monitoring of animal response to natural challenges of the disease.

Results of this participatory action research reveal that attempts to contain trypanosomosis through conventional methods of parasite and vector control have been very successful, but their sustainability has very low. Vaccine development is still at an early stage. Biological control has so far been limited due to the non-specificity of biological enemies, while the Sterile Insect Technique (SIT) has high costs and requires significant external support. The most widely used method is one based on the use of trypanocidal drugs. However, its application is limited by the inadequate supply and the emergence of drug-resistance. The high cost of trypanocidal drugs is also a limiting factor; both curative and preventive imported drug treatments can cost the owner of an average size herd (10-15 head of cattle) approximately Birr 1,000 per annum (about US$ 120) - a figure similar to Ethiopian GDP per capita or the equivalent of the market value of a cow or an ox in the area.

The prevalence of trypanosomosis in the Ghibe valley is as high as 35%. *Trypanosoma congolense* was found to be the most important (85%), the other being *T. vivax and T. brucei*. The vectors involved are *Glossina pallidipes* (up to 1990) and *G.morsitans submorsitans* (since 1990); *G.fuscipes* is the least important vector. Attempts to contain trypanosomosis through the conventional methods of parasite and vector control in the Ghibe valley have produced encouraging results: it was possible to reduce the prevalence of trypanosomosis by 63%, and in so doing the number of curative trypanocidal treatments per animal declined by 50%, and both abortion rate and calf mortality were reduced by 50%. However, these achievements could not be sustained because of technical and institutional constraints of delivering proven disease control and prevention measures.

What do farmers know about the disease?

Sound scientific research and development in developing countries like Ethiopia need to be based on due recognition of level of knowledge and traditional practices of farmers, if these are to achieve real impact on livestock productivity and livelihoods of the poor. Practically all farmers in the Ghibe valley recognize trypanosomosis as the major animal health problem and associate the disease with heavy losses through mortality and lowered animal performance. However, until recently many of them have not been aware of the disease as a vector-borne problem, and that the tsetse fly is the major biological carrier of the parasite. To date farmers try as much as possible to avoid higher tsetse challenge areas (grazing lands, watering points) of the parasite. However, farmers are not well aware of biology of the parasite either in the fly or the infected animal. Research work by ILRI in the Ghibe valley over recent years has extensively demonstrated the application of insecticide impregnated targets and application of pour-on insecticide for effective vector control.

An on-going research in the Ghibe valley by the authors on identification of relative trypanotolerance in cattle has revealed that by the beginning of 2004 only a quarter of the sample households across the valley (with marked differences between villages) were aware of the genetic basis of trypanotolerance (i.e. that it is heritable), and hence this trait is largely not considered in any selection for breeding animals. In small herds like these, availability of breeding males is a critical constraint for reproduction, and even more so for genetic improvement. About 57% of the adult male cattle in the sample herds were found castrated, or effectively outside of the breeding process, and 12% of these were identified by their owners as requiring little of no trypanocidal drug treatments.

Four-fifths of the sample herds, including breeding bulls, graze on communal pastures. Only 12% of the households could relate paternal sires to the calves in their herds, with the rest being the result of unknown matings. More importantly, only 11% of households reported that they actively select breeding bulls for mating with their cows and heifers, although up to 40% of them do have at least one bull in their herds. Multiple bulls are maintained by only about a third of the households.

Many farmers reported that use of trypanocidal drugs is the only affordable means for them for control of trypanosomosis. Four sources of trypanocidal drugs were identified: village vendors (62%), unlicensed practitioners (28%), NGOs (5.5%) and the veterinary service of the Ministry of Agriculture (4.5%). The farmers themselves administer drugs that they procure from village drug vendors. When these farmers were asked how and when they would administer such drugs, only 30% of them said their decision is based on a tentative diagnosis of the disease, as judged by the common clinical signs; the rest administer drugs when they 'suspect' that animals have trypanosomosis, i.e. before these animal show clear clinical signs of the disease.

Nine monthly rounds of blood sample examinations in the same study revealed that about 84% of the 386 animals identified by the households as requiring little or no trypanocidal drug treatments did not have any of the four trypanosome parasites in their blood samples, and when any parasite was detected their PCV levels were slightly higher than that of trypanosusceptible animals (although the difference was not statistically significant ($p=0.22$)). This indicates that there is indeed some measurable variation in relative trypanotolerance within the sample herds.

Data from semi-structured questionnaires showed that over 97% of the households expressed interest in taking part in the planned community-level intervention related to the use of identified trypanotolerant animals, and nearly all of these households would like to purchase such animals. This research project has facilitated series of community-level workshops in which the community explored ways of maximizing use of trypanotolerant cattle in the valley. Identified measures include: 1) delaying castration of trypanotolerant bulls to use them for breeding purposes, 2) facilitating extensive use of identified bulls for breeding purposes, and 3) retaining as much as possible trypanotolerant cattle for breeding purposes, by minimizing their disposal by way of sales and slaughter.

Overall farmers in the Ghibe valley have come to learn a lot about the control and prevention of trypanosomosis through the two decades of research by ILCA and then ILRI and collaborators. However, knowledge on biology of the parasite and the tsetse fly is very limited, particularly on the risk of misuse of trypanocidal drugs. This compounded by the limited access to good quality veterinary services has exposed farmers to trypanocidal drug abuse and to some extent continued application of erroneous traditional disease control measures.

The need for documentation of farmers' practices

The documentation of farmers' practices in the management of trypanosomosis is the first step in the enlightening of many other farmers in similar environments on effective farmers' innovations to provide them ideas and inspiration for them to do their own experimentation and to adapt new ideas to other settings (Waters-Bayer, 2005). It also provides a realistic platform for scientific research to be conducted based on felt needs and aspirations of communities. Farmers' indigenous innovations emerge from, and are part of, the traditional farmers' practices in dealing with routine animal husbandry problems, and as such, they relate to the local culture and biophysical environment, which typically means poor road infrastructure, poor access to production resources and low availability of financial resources. Innovations are established technical and socio-institutional processes through which individuals or groups discover or develop new and better ways of managing resources, building on and expanding the boundaries of their indigenous knowledge (Waters-Bayer, 2005). Indigenous innovations are known to occur within a context of structured relationships, networks, infrastructure and in a wider social and economic context. Many important farmer innovations have resulted from anecdotal or unexpected information, which can add tremendous value to conventionally held notions (Roothaert *et al.*, 2005). Best innovations are discovered from exceptions or best practices; outcomes resulting from the applications of innovative ideas almost always arise from interaction with many other factors.

In spite of growing volumes of literature and initiatives to promote indigenous knowledge in development processes (Tesfaye, 2005), there is little documented information on indigenous innovations, and it is only recently that increased attention has been given to identifying and documenting the innovation process and the innovations (Waters-Bayer, 2005). Tesfaye (2005) also argues that there is lack of transparency and open dialogue between the different stakeholders on the notion that local knowledge is always in a lower position compared to scientific knowledge. But open dialogue on the attributes of indigenous knowledge makes it possible to identify and understand wrong perceptions and practices in traditional systems that hinder even scientific knowledge.

Following is a listing of major traditional practices and level of knowledge on critical issues in the management of trypanosomosis in the Ghibe valley:

Knowledge of disease diagnosis:

Farmers in the Ghibe valley do not have proven ways of diagnosing trypanosomosis in their animals. They rely on their judgment of gross clinical signs. These include poor appetite, sudden weight loss, drastic fall in traction performance, rough hair coat, hair break up and unthrifty stature. Unusually dry manure and blood-tinted milk are also believed to be associated with trypanosomosis. Too often they decide to treat their animals with trypanocidal drugs following early signs of ill-health that do not necessarily relate to trypanosomosis. This is what is called the fear factor. Obviously, these practices contribute to misuse of drugs and, as a consequence of this, the build up of drug resistance. The farmers in Ghibe do not have access to proper clinical diagnosis, except the one done only by the ILRI/EARO research team; the veterinary services of the Ministry of Agriculture do not have the minimum facilities in the Ghibe valley to undertake blood examination for parasite detection and estimation of PCV on regular or on-demand basis. This situation leaves the farmers to try to diagnose the disease in their own traditional ways.

Selective use of limited drugs:

In the face of scarcity of drugs and limited cash at their disposal, farmers traditionally have a priority list of sick animals to treat with trypanocidal drugs. In line with the critical role of plough oxen in the predominant crop agriculture, farmers give priority to working and newly recruited oxen. These are then followed by pregnant cows, lactating cows and other adult cattle. This is certainly a rational decision for use of limited resources. Farmers give more space than recommended in the application of pour-on insecticides; however, such spacing could compromise the long-term efficacy of the drug.

Limited selection of appropriate trypanocidal drugs and their doses:

Farmers do not have full knowledge on efficacy of available drugs and their limitations. They learn about available drugs from their colleagues and as they are made available for sale. As discussed earlier, drugs come from four sources unlicensed village drug vendors (62%), unlicensed practitioners (28%), NGOs (5.5%) and the veterinary service of the Ministry of Agriculture (4.5%). It is a rare practice to provide a range of drugs for the farmers to choose from; they usually take what is offered in the limited market. The farmers' practice of taking what is offered is driven by inadequate supply of drugs as well as limited knowledge on proper drug use, which can be rectified through specific interventions.

Use of expired and fake drugs:

Farmers are unlikely to check the authenticity and expiry of the drugs offered; on accounts of the farmers in the Ghibe valley, it is not uncommon to encounter delivery and administration of fake drugs (e.g. fluids of Coca Cola, Fanta, Instant Caffee). The established legal frameworks for dealing with such abuses are not enforced in rural settings like the Ghibe valley. Many farmers in the Ghibe valley are literate; nevertheless their command of the English language is very low. Hence they lack the minimum skill needed to check authentic labels and expiry dates of common drugs written in English, which could easily be improved through community consultations and specific training. In the absence of such a support, farmers rely on traditional ways of acquiring knowledge on these issues. Application of wrong drugs (e.g spraying of malathion, drenching of unknown herb extracts) has also been common until recently.

Under dosage of drugs:

Another major constraint is deliberate under dosage of the drugs. Lack of knowledge on the consequences and financial limitations lead farmers to administering too low doses of the drugs, and even wrong and unhygienic administration, when they handle drug administration themselves. Farmers also suspect that unlicensed private veterinary service practitioners often apply too low dosage of drugs. Without formal training or advice, farmers have to rely on their own experiences to deal with this problem. These difficulties can be related to the frequent complaint of farmers that sick animals do not respond to trypanocidal drug treatments.

Wrong use of targets:

The nature of the disease and its vector require that some community-level actions are needed for effective disease control and prevention, like use of insecticide impregnated targets around high tsetse challenge areas. The effectiveness of these applications depends on common understanding and sharing of responsibility among members of the affected communities, which are not always easy to secure even after some level of public awareness created. Some farmer take away mounted insect traps and insecticide impregnated targets and set them around their homestead. This is explained by lack of knowledge on the merit of community-level action and the role and responsibility of individuals in protecting community interests. Certainly more public awareness is necessary on these wrong practices.

Consequences of weak management of trypanosomosis

The obvious consequences of weak disease management practices by farmers are the following:

1. Expansion of illicit trade in trypanocidal drugs
2. Unlicensed veterinary service practitioners continue to operate in the area in the absence of adequate veterinary service delivery.
3. Farmers themselves are forced to administer the available drugs without proper knowledge of the limitations and risks of erroneous administration of drugs, including use of wrong drugs in wrong ways.
4. Use of expired drugs by farmers and other service providers.
5. All these could lead to the build up of resistance by the trypanosomes to available drugs. In fact all 12 trypanosome isolates from the Ghibe valley were found to be resistant to available trypanocidal drugs (Codjia *et al.,* 1993).
6. These are reflected in increased cost of trypanocidal treatments, greater losses through mortality and morbidity and hence worsening difficulties of the smallholder farmers in the area.

Against this background, ILRI, EARO and other partners have been promoting specific interventions to help deal with some of these difficulties.

Interventions to improve management of trypanosomosis in the Ghibe valley

1. Participatory disease and vector control research programs by ILRI and partners:

There has been a monthly monitoring of parasitaemia and vectors in sample cattle herds in the Ghibe valley. This study is used to inform decision making in the participatory control of trypanosomosis in the valley. Complementary to this is the monthly application of pour-on insecticide (Ectopor/cypermethrin) on cost-recovery basis to voluntary study herds. This systematic use of pour-on insecticide is expected to continue after community takes over management of veterinary service delivery as envisaged by this research program (see next section).**2. Organize farmers in to self-help input/output marketing cooperatives:**

As part of the long-term effort in the control of trypanosomosis in the Ghibe valley, ILRI is assisting selected communities to organize themselves into self-help input/output marketing cooperatives and secure legal registration. Such cooperatives with legal entities will facilitate direct functional linkages between farmers (demanders) and suppliers of veterinary products (Pour-on, trypanocidal drugs) at village level. Over time the cooperatives could build up the necessary capacity to negotiate service delivery for regular and on-demand monitoring of parasitaemia and PCV in their cattle herds. They can also explore opportunities for handling of other agricultural inputs and services at village level.

3. Village-level selective breeding for trypanotolerance:

Until recently, the farming community in the Ghibe valley had little knowledge on the natural attribute of some cattle breeds and populations for trypanotolerance, and even less on the genetic basis of trypanotolerance, i.e. the fact that trypanotolerance is passed on to succeeding generations with fair level of inheritance (e.g. Trail *et al.,* 1991a,b; Mulugeta *et al.,* 1997) reported heritability of PCV as high as 0.64. ILRI in collaboration with the national Animal Health Research Centre (NAHRC) at Sebeta of EARO have conduced a small community action-learning research to facilitate participatory screening of relatively trypanotolerant animals from traditional cattle herds in the Ghibe valley. In this project, community awareness on the genetic basis of trypanotolerance has been enhanced through consultative workshops and training sessions. Relative trypanotolerance was measured by the least number of curative treatments in sample cattle herds combined with measures of Parasitaemia and PCV. The identified animals with verified superior trypanotolerance were promoted for enhanced reproduction. Specific training was given to community members on improved reproduction and better breeding of these animals.

4. Dissemination of trypanotolerant cattle:

A potentially cost-effective and sustainable option for control of trypanosomosis is exploitation of the natural phenomenon known as trypanotolerance exhibited by certain livestock breeds that are indigenous to areas in which the disease is endemic. These breeds, like the N'Dama cattle of West Africa, have the capacity to survive and produce under tsetse and trypanosomosis challenge (ILCA, 1993). These animals are also known to respond better to trypanocidal drug treatment than susceptible animals, thereby help to reduce the use of drugs and chemical insecticides. Some Ethiopian indigenous cattle, like the Sheko, Abigar, Mursi and to some extent the Horro, inhabit areas of the country with heavy challenge of tsetse flies and high risk of trypanosomosis, suggesting that they may have some level of trypanotolerance. The fact that these breeds have good milk production potential in these areas (Alberro and Hailemariam, 1982) provides another preliminary evidence for their ability to survive and produce under the disease challenge.

The identification and use of indigenous trypanotolerant breeds, therefore, provides opportunities for sustainable genetic improvement of these natural attributes in the long term. An on-going NAHRC - ILRI collaborative research project is designed to explore the existence and quantify the level of trypanotolerance in some Ethiopian indigenous cattle breeds, and pave the way for their conservation, sustainable use and improvement with the view of primarily assisting smallholder farming communities which have to find ways of managing continuous challenges of the disease in their cattle populations.

The most promising breeding stock out of this research will be disseminated to participating communities. The proven trypanotolerant breeding animals can either be directly distributed to selected participating farmers for natural mating, or the AI technology could be used for wider dissemination of genes from superior bulls.

In the same way, the on-going QTL experiment by ILRI in Kenya on cattle trypanotolerance is very promising; the identified superior trypanotolerant genes could be disseminated through AI as well as natural mating. This option might appear to be remote for the realities of Ghibe now; however, it certainly holds promise for the future.

5. Investigation of drug resistance:

Isolated cases of trypanocidal drug resistance by *Trypanosoma congolense* have been reported in Ethiopia first by Scott and Pegram (1974) from western Ethiopia. Subsequently, multi-drug resistance was reported from the Ghibe valley based on a trial conducted on 12 trypanosome isolates, in which all were found to be resistant to available trypanocidal drugs (Codjia *et al*., 1993). To date anecdotal information from across the country suggests growing prevalence of drug resistance in all trypanosomosis-endemic areas of the country. There is therefore a strong need to systematically investigate this problem as part of the effort to making large tracts of trypanosomosis-endemic agricultural areas of the country more productive and enhance their capacity to support human livelihood. NAHRC of EARO and ILRI have jointly initiated a research project to specifically evaluate trypanocidal drug resistance in three major trypanosomosis-endemic areas of the country: the Ghibe valley, the Dedessa valley and Arba Minch area. The results of this study are expected to systematically address this problem and confirm or reject existence of drug resistance in these areas. Confirmation of drug resistance will lead to recommendation of alternative therapeutic treatments. As a collaborative research between NAHRC of EARO and ILRI, this study complements the on-going on-farm and on-station research on control of trypansomosis in the country

6. Support for functioning of micro-financing services and markets:

Access to financing services and markets has always been a serious limitation for remote rural places like the Ghibe valley. The relatively better farm produce (grain, livestock) needs more organized access to large central markets; middlemen and traveling merchants are taking advantage of the loose linkages. The high fluctuations of farm-gate prices reflect this reality. Specific interventions need to be designed and implemented to enhance the functioning of markets, through marketing cooperatives, market information and infrastructure. The same is true with formal credit and insurance services, which are either virtually limited to urban centers or unattractive to the farmers in the Ghibe valley.

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Innovative ICT Approaches for Pastoral Livestock Development: A New Proposal for a Unified Livestock Information System in Ethiopia:

Abdi Jama, Jerry Stuth, Robert Kaitho, Belachew Hurissa

Abstract

In this article we examine the recent advances in setting up a unified livestock market information system for Ethiopia led by the Livestock and Fishery Marketing Department of the Ministry of Agriculture and Rural Development;(LFMD) and the Livestock Information Network and Knowledge System of the Global Livestock Collaborative Research Support Program. (LINKS-GLCRSP) Improved overall performance of the livestock sector is required to enhance food security situation. A reliable Livestock Market Information System (LMIS) can assist pastoralists to reduce the risks associated with marketing, decide when and where to sell livestock and enhance the bargaining power of the pastoralists. Issues related to the type of data collected, data entry, analysis and dissemination tools are discussed in detail.

Introduction

The urgency to address the needs of pastoral communities in Eastern Africa has risen dramatically in the past few years, forcing national governments, NGOs, and international donors to explore high impact interventions for these neglected people. Given the high dependency by pastoral family livelihood on cash income from the sale of livestock and livestock products, institutional focus has been directed toward improving livestock market information, infrastructure and efficiency. An extensive review of the wide array of livestock market development activities in Eastern Africa has revealed a lack of viable livestock market information systems to support decision making of traders, pastoralists and policy makers.

Electronic means of communication are becoming increasingly more important in information exchange. Electronic information and knowledge systems are currently very limited in almost all sectors of the Ethiopia economy. The livestock industry is no exception. The global revolution in information and telecommunication technologies has created an opportunity to develop a livestock information system to remedy the situation and to assist livestock producers, development practitioners, researchers and policy makers.

Livestock marketing information is needed in Ethiopia to improve decision making at all levels in the livestock industry and the competitive position of the Ethiopian livestock industry in international markets. The Livestock Early Warning System subproject in the USAID Global Livestock CRSP project has demonstrated that information technology can be designed to deliver near real-time information on forage conditions for the region to decision makers at multiple levels. Information on emerging forage supplies and deviations from long-term averages, as it impacts decisions to sell or move animals, provides food relief interventions, or anticipate potential conflict, is valuable to decision makers. However, forage information alone fails to provide a rich picture of the likelihood of disease outbreaks, excessive livestock mortality, anticipated patterns of movement, and information on livestock market prices.

The LEWS research program has evolved toward a broader handling of livestock information and analysis needs through the use of Information and Communication Technology (ICT) for livestock marketing systems culminating in a new project called Livestock Information Network and Knowledge System (LINKS). The main goal of LINKS is to increase the household income of pastoral communities in Eastern Africa by improving livestock marketing efficiency, strengthening institutional market policy, and increasing livestock off-take during the emergence of drought, through the implementation of an integrated livestock marketing information system. The central theme of the LINKS is to create equitable livestock information and communications systems that provide monitoring and analysis technology to foster strategic partnerships between pastoral communities, markets, and policy makers through a broader application of the emerging ICT and improved geographical monitoring and analysis systems to serve the livestock sector of Eastern Africa. The strategic intervention of a livestock information network and knowledge system at this time is expected to significantly strengthen the existing activities that are designed to improve livestock markets and trade in Eastern Africa. The system will serve key institutions and pastoral communities in Ethiopia, Kenya, Somalia, Djibouti, and northern Tanzania.

LINKS project lead by Texas A&M University in the Global Livestock CRSP is collaborating with key institutions in Eastern Africa (Ethiopia, Kenya, Tanzania and Somaliland to develop a new regional information and communication technology to provide livestock price/volume data, assessments of forage conditions, disease, conflict and water supply on a regular basis to wide array of users in the Eastern Africa region. LINKS provides a regional forum for the adoption of a common livestock market information system in the region. This paper focuses on Livestock Market Information System (Price/volume), which is being developed jointly by LINKS and LFMD of the Ministry of Agriculture and Rural Development.

Design of the Livestock Market Information System

The livelihood of pastoralists in east Africa is highly dependent on the cash income from livestock and livestock products. Therefore, the establishment of reliable and timely national and regional market information to traders and pastoralists are vital for the development of the country. Livestock marketing information provides a basis for livestock producers and traders to make marketing decisions. Livestock market price monitoring system proposed here is a mechanism through which collection; analysis and dissemination of information needed to help producers in making marketing decisions are organized and systematized. Moreover, market information has become a necessary part of many Early Warning Systems in Africa to identify potentially critical food shortage trends.

Market information is crucial to producers, wholesalers and consumers to help them make decisions on what and whether to buy and sell. This is more so for the pastoralists/producers who have little to guide them both on domestic and overseas livestock prices when negotiating with more informed middlemen and traders. The key issue in the design of the LMIS in Ethiopia is to develop a standard, flexible and sustainable system that meets the commercial needs of both traders and producers with minimum field and desk work to produce accurate, timely and relevant information. Various communication tools and techniques have been explored to acquire reported and disseminate information (Figure 1).

Market Data collection method

Livestock market data is collected from selected markets in key areas of the pastoral regions of Ethiopia (Figure 2).

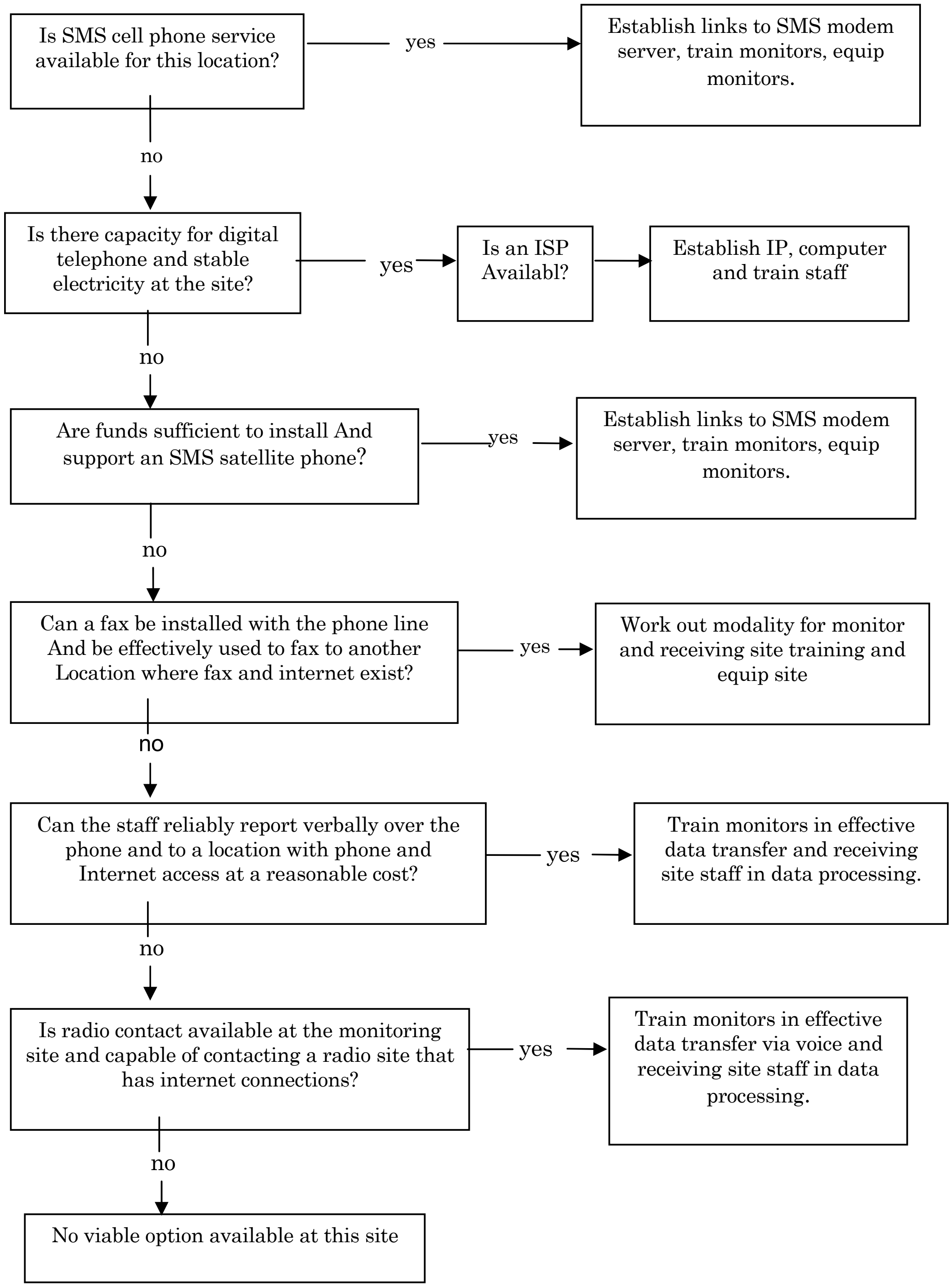

Figure 1. Livestock market communication decision tree

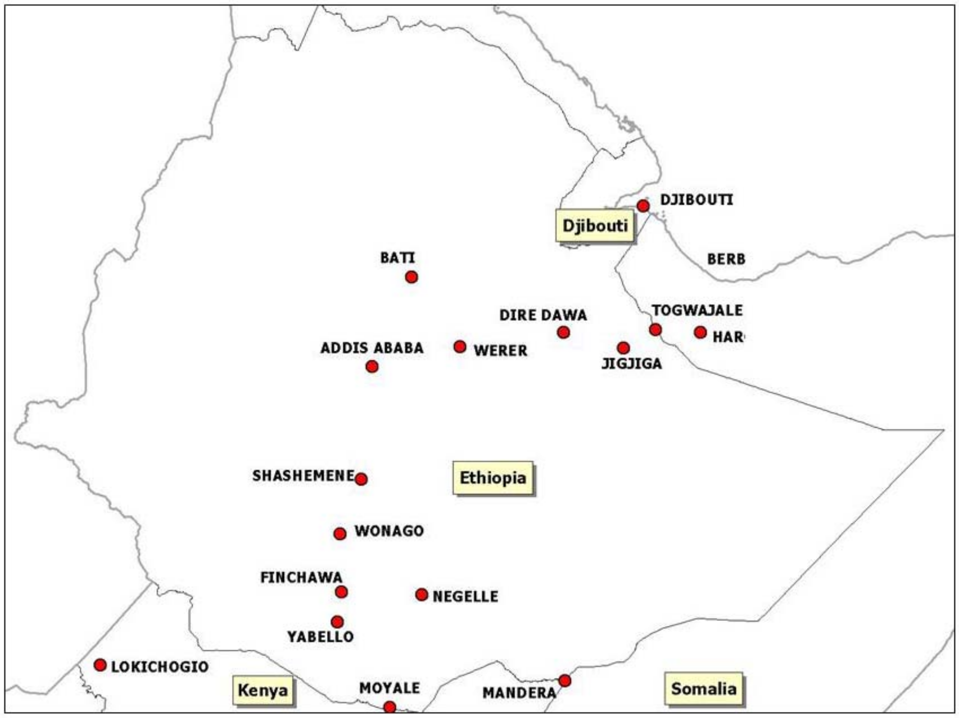

Figure 2. Livestock Markets Monitored in Ethiopia

Livestock market data collected currently consists of livestock prices and volumes. Livestock price data is gathered through interviews with traders during peak market for the livestock sold and is recorded on a data sheet. Price ranges (highest–lowest) or average prices are collected on a weekly basis for each of the selected markets by animal kind, breed, class and grade for the animals that are already sold and a midpoint/average is calculated dynamically upon entry into a database. The numbers of animals offered by animal kind are counted and percentages by classes for each kind are estimated during peak market period. Subsequently, the numbers of animals by class for each animal kind are also calculated dynamically from the estimated percentages for animal classes.

The livestock price data collection sheet has the following elements: Name of the country, name of the market, name of the monitor, date of data collection, animal kind, class, breed, grade and price range (lowest - highest) or average. The same data sheet has also columns for recording livestock volume by animal kind and estimate of the percentage of these animal kinds by classes (Table 1).

Presently, the most common breeds of the major livestock kinds (cattle, camel, sheep and goats); and classes for selected markets are monitored (Table 2). However, the system accommodates almost any type of livestock that is of economic interest to the users of the system. The system allows for the addition of any type of livestock.

Table 1. Livestock market information collection format

Country		Market	Monitor	Date	
				Price Range	
Kind	Class	Breed	Grade	Lowest	Highest
Cattle	Mature male (>= 4 years)		1		
			2		
			3		
			4		
Cattle	Young male (>2 < 4 years)		1		
			2		
			3		
			4		
Cattle	Immature Male (< 2years)		1		
			2		
			3		
			4		
Cattle	Mature Female (>= 4 years)		1		
			2		
			3		
			4		
Cattle	Young Female (>2 < 4 years)		1		
			2		
			3		
			4		
Cattle	Immature Female (< 2years)		1		
			2		
			3		
			4		

Percent estimates of volume by kind and class				
Type/Kind	Class	Percentage	Animal Type	Volume (No. offered)
Cattle	Mature male		Cattle	
	Mature female		Sheep	
	Young male		Goats	
	Young female		Camel	
	Immature all			

Table 2: Animal Kinds, Classes and Codes

Animal kind	Codes
Cattle	C
Sheep	S
Goat	G
Camel	CA
Donkey	D
Mule	M
Horse	H

Animal Classes	Codes
Immature all	IA
Immature male	IM
Immature castrate	IC
Immature female	IF
Young all	YA
Young male	YM
Young castrate	YC
Young female	YF
Mature all	MA
Mature Male	MM
Mature castrate	MC
Mature female	MF

Livestock are usually bought and sold through visual appraisal of the animal's condition and through touching and feeling of certain parts of their body. In essence grading is a combination of visual assessment of fatness relative to the frame characteristics of a given breed and class. Grading is used in this case as a practical system for separating livestock into more uniform groups to reduce heterogeneity within classes. This is to reflect expected differences in demand due to quality for the different grades which again might results in differences in price. A livestock grading system on a scale of 1 to 4 based on visual assessment of the body condition of the animals was adopted (Table 3). The grading system is a compressed version of the body scoring system developed by Nicholson and Butterworth (1986) for zebu cattle.

Table 3. Animal Grades and Related Body Condition Scores

Grade	Condition	Body Condition Score *	Descriptions
1	Fat	> 7	This grade ranges from animals that are smooth and well covered, but fat deposits are not marked where dorsal spines can be felt with firm pressure and transverse processes cannot be seen or felt to animals with heavy deposits of fat clearly visible on tail-head, brisket with dorsal spines, ribs, hooks and pins fully covered and cannot be felt even with firm pressure.
2	Moderate	5 - 7	This grades ranges from animals with ribs usually visible, little fat cover, dorsal spines barely visible to animals with smooth and well covered; dorsal spines cannot be seen, but are easily felt.
3	Thin	3- 4.9	These grades ranges from animals with individual dorsal spines pointed to the touch; hips, pins, tail-head and ribs are prominent to animals with transverse processes visible, usually individually. Ribs, hips and pins clearly visible. Muscle mass between hooks and pins slightly concave
4	Emaciated	< 3	Marked emaciation with Transverse processes projecting prominently and where neural spines appear sharply.

Adapted and modified from Nicholson and Butterworth (1986)

It is important to note that a coding system has been designed for all of the key variables in livestock price reporting (animal kind, breed, and class) to minimize field work and to speed up data transmission. The coding system enables the use of short messaging service (SMS) where the service can be provided through the use of mobile phones to send and receive livestock market information. This approach has been demonstrated in other parts of eastern Africa (Kenya) for livestock and for grain prices in Uganda (Ulrich Kleih and Isaiah Imaita, 2002)). The SMS text messaging allows 160 characters per single message which could be between mobile phones as well as between computers and e-mail to mobile phones. This system is being implemented in the eastern Africa region by LINKS where market monitors send data from the field through the use of SMS of mobile phones. The coded data is parsed and goes automatically into a central database that is accessible not only by other SMS cell phones but through the internet via a webage. Consequently, market prices can be accessed in near real time using these two sources.

Data entry Methods

Data entry is currently done using various means depending on what is feasible in each market locality. In some areas the data collected is entered into a computer and faxed or e-mailed to a central location for entry into database system. In other places where Internet is available, the data entry person would login to a secured webpage with a pre-approved login identification and password to input data on-line. In the on-line data entry, all of the markets included in the monitoring system, the common livestock kinds, breeds and classes are already set up and arranged in dropdown menus in the webpage for the person to choose from for each data record to report price. The system is in place also for direct SMS text entry, although this is not implemented in Ethiopia yet. In this case, the market monitor sends the livestock price data directly through a mobile phone provided by the project into a central database. Efforts are underway to implement e-mail direct data input into the database.

Information Processing and Data Analysis Methods

Presently, once data is entered into the central database system, the user can utilize the reporting function built into the webpage system where he or she has the ability to generate his or her own report in table format. The user chooses from a drop down menu in the webpage on whether he or she wants the report for a single market, single animal kind, single breed, and single class or for all of the above (Table 4).

Table 4. A Sample of Livestock Market Report

Market	Date	Animal	Animal Breed	Animal Class	Grade	Average Price	Minimum Price	Maximum Price
Jijiga	2/2/2004	Sheep	Black head Persian	Mature Male	2	280	270	290
Jijiga	2/2/2004	Sheep	Black head Persian	Mature Male	3	190	175	205
Jijiga	2/2/2004	Sheep	Black head Persian	Young Male	2	150	145	155
Jijiga	2/2/2004	Sheep	Black head Persian	Young Male	3	110	95	125
Jijiga	2/2/2004	Sheep	Black head Persian	Immature Male	2	90	85	105
Jijiga	2/2/2004	Sheep	Black head Persian	Immature Male	3	80	75	85
Jijiga	2/2/2004	Sheep	Black head Persian	Mature Female	2	250	230	270
Jijiga	2/2/2004	Sheep	Black head Persian	Mature Female	3	190	185	195
Jijiga	2/2/2004	Sheep	Black head Persian	Young Female	2	130	120	140
Jijiga	2/2/2004	Sheep	Black head Persian	Young Female	3	120	115	125
Jijiga	2/2/2004	Sheep	Black head Persian	Immature Female	2	90	80	100
Jijiga	2/2/2004	Sheep	Black head Persian	Immature Female	3	80	70	90
Jijiga	2/9/2004	Sheep	Black head Persian	Mature Male	2	280	275	285
Jijiga	2/9/2004	Sheep	Black head Persian	Mature Male	3	190	180	200
Jijiga	2/9/2004	Sheep	Black head Persian	Young Male	2	160	150	170
Jijiga	2/9/2004	Sheep	Black head Persian	Young Male	3	120	105	135
Jijiga	2/9/2004	Sheep	Black head Persian	Immature Male	2	100	90	110
Jijiga	2/9/2004	Sheep	Black head Persian	Immature Male	3	90	85	95
Jijiga	2/9/2004	Sheep	Black head Persian	Mature Female	2	250	240	260
Jijiga	2/9/2004	Sheep	Black head Persian	Mature Female	3	190	185	195
Jijiga	2/9/2004	Sheep	Black head Persian	Young Female	2	130	120	140
Jijiga	2/9/2004	Sheep	Black head Persian	Young Female	3	110	95	125
Jijiga	2/9/2004	Sheep	Black head Persian	Immature Female	2	100	85	115
Jijiga	2/9/2004	Sheep	Black head Persian	Immature Female	3	90	75	105

Emaciated = 1

Thin = 2

Moderate = 3

Fat = 4

Graphic functions are also being built into the system which will allow the user to display comparisons between different markets, examine the livestock supply (volume) and market trends over short or long term as the system matures. Certain reports will be generated automatically once a consensus is reached among all partners. Customized reports could be generated as need arises. Presently, only the current livestock market price reports are provided, however, historical market information will also be provided as more data is collected. The process of generating report will be automated once a consensus is reached with the beneficiaries of the system

Reporting and Dissemination Methods

An improved communication flow will augment the traditional word of mouth for a wider dissemination of market information. Various information and communications media are being examined depending on the level of ICT infrastructure for each location including: faxes, monthly/quarterly/annual bulletins or newsletters, radio and television. There are new technologies such as WorldSpace satellite radios, e–mail, Internet Websites, and cellular (mobile) telephones. Currently, the voice media is being used on a limited scale due to excessive cost demanded by their relative institutions. However, an attempt is being made to mobilize the communities of the potential beneficiaries to lobby for the access of the television service for a reasonable price as a public good particularly through the public owned media.

Implementation and Institutional Arrangements

The primary functions of market information services are to collect and analyze market data systematically and continuously, and to ensure delivery of information on a timely basis to all market participants. When properly implemented, the collection procedures should ensure that the data collected is of uniform quality throughout the system and to allow for the comparison of data from one market to the next and from one time period to the next.

Market monitors are typically drawn from district agricultural offices for each market location. Market monitors are adequately trained in the use of livestock market price monitoring formats and were given guidance on the proper ways of approaching sellers, brokers and traders to collect the data in an efficient way. Weekly market data is collected on livestock prices and volume of livestock on offer (supply). All of the above information is recorded by field officers or enumerators from the selected markets on their predetermined specific market days on a weekly basis. The data collected is submitted to a central agency (LINKS/LFMD) for analysis, which is immediately relayed back to the market agents for dissemination using various media outlets.

Livestock and Fishery Marketing Department of the Ministry of Agriculture and Rural Development is currently the home of LMIS in the Ethiopia. LINKS project teams and allied NGOs are working with LFMD to incorporate experiences from the field into the system and to alleviate some of the challenges faced by the department to make LMIS work for pastoralists, brokers and traders. These efforts include: training to help build the human capacity with the required expertise to run the system; software and database improvement, working with the regional collaborators to promote willingness on the part of some key regional institutions to support the national LMIS and to create the ICT infrastructure for increased ground data collection to meet the needs of the country and foster national consensus and ownership of the system. This program also provides many opportunities for the involvement of graduate students within the national universities in research and outreach in the livestock marketing issues to help create future custodians of the system.

The LINKS GLCRSP at Texas A&M University adopted a model of collaboration where it acts as a catalyst by helping in research and development of information and communication technology (ICT) in Eastern Africa. The access to that technology for relevant host country organizations is stabilized by maintaining it within the University system initially until that organization has the personnel and institutional commitment to transfer the technology. This allows for the developing countries to focus on outreach activities to accelerate the impact of the technology until a critical mass is attained in terms of government or institutional commitment. The key ingredient to making this approach work is the concept of fully automated ICT where a computer middleware is designed in such a way that it can monitor and acquires data on a prescheduled basis, checks the quality of the data and conducts basic analysis for display in a webpage which is available wherever there is Internet access. The use of the automation technique, allows Texas A&M University's LINKS/GLCRSP team to deliver the technology for a long time at minimal costs to the institution. The other key ingredient is building strong networks of organizations that report data that are stable in terms of fiscal support and human resources. The goal is to lower the upfront burden of the technology, develop low maintenance, automated systems for advanced organizations to support emerging skills and capabilities in developing countries. This will allow developing countries to focus on high impact outreach initially and then eventually grow into the technology where institutional and human commitment emerges.

Information and Communications Architecture

The LINKS livestock market information system consists of data collection, analysis, and an information delivery platform. As is illustrated in Figure 3, the system is mainly composed of two parts: regional servers and central data exchange server.

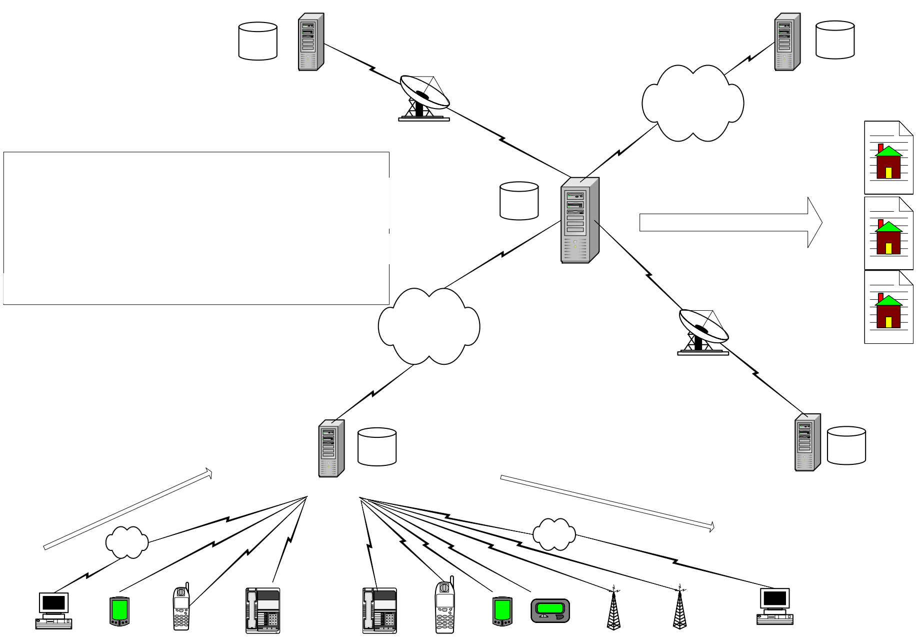

Figure 3. ICT Architecture of LINKS-LFMD

The regional servers are located at different countries including Ethiopia and are responsible for local data collection and information delivery. To support global data exchange and decision making, the central server collects the regional data from the different regional servers. The collected data is analyzed, synthesized, and delivered to global users.

Each regional server provides two kinds of services for that region: data collection service and information delivery service. The data collection part supports different reporting methods including online (web), email, cell phone and SMS message reporting systems. All of the reported data are stored in the local database. The data delivery service is responsible for sharing the data with local users. A regional user can query these data through the web interface (normal web browser and WAP on cell phones), emails, cell phone SMS messages, or landline phones.

The central data server acquires data from the regional through a web interface provided by the regional servers. The collected data is then stored in a central database. Global users can query these data through web interface, Email, or SMS messages.

The communication link between each regional server and the central server could be of different types. If the regional server has direct access to the global Internet, a communication link can be established directly through the internet. If such a capability is not available, then satellite connection to the central servers could be used.

The current system is implemented on Windows platforms. For the regional server, an access database is used to store the regional data. The web interface is developed on windows IIS (Internet Information Server), and the SMS and Email interface is developed based on a commercial SMS/Email server plug-in. For the central server, a Mysql database is used for data storage. The web interface on the central server is developed on Windows IIS server.

Conclusion and Recommendations

Reliable livestock price information is important for facilitating effective marketing and de-stocking of animals from drought areas. The linkages between the Department of Livestock and Fisheries Marketing and the other agencies with which it must collaborate should also be examined and strengthened. Eventually an integration of the livestock and grain marketing system in the country would need to be explored.

Using state-of-the-art telecommunication technologies, LINKS project and the Department of Livestock and Fishery Marketing are working on the development of a comprehensive information system resource for livestock that integrates market prices, forage situation, disease information, conflicts and water issues.

Given the recent advances in IT in Ethiopia, the time is right for the establishment of an *Ethiopian Livestock Information Network (ELIN)* and to create a web-based, comprehensive knowledge resource for livestock in Ethiopia aimed at expanding the current livestock databases, literature and accumulate all related information systems in the country to make that information accessible and openly available nationwide and worldwide. This process could be a collaborative effort between Ethiopian Society of Animal Production, Universities (both National and International), line government ministries, NGOs and donor agencies. A good way to start this would be to dedicate one of the upcoming conferences of the Ethiopian Society of Animal Production on assessment of the status of the availability and accessibility of information related to livestock and how to tap on the recent ICT advances.

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Mobility, Herd dynamics and Species composition of Pastoralists: Indigenous Innovations towards Coping Mechanism During Crisis

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Introduction

Diversity and mobility characterize the pastoral production systems. Pastoral production systems are diverse in order to minimize risk in unpredictable conditions. Pastoralists engage in multi-resource economies and usually maintain large, varied herds. Livestock products are, of course, the base of subsistence, providing such goods as dairy products, meat, live animals for trade, wool, manure, fuel, and labor. Therefore, Pastoralists are people who are highly dependent on livestock for their basic needs, such as food, cash income and social needs. Pastoral production systems have normally developed in arid lands, where climatic uncertainty/unreliability and the nature of soil affects spatial as well as temporal variations in the availability of crucial natural resources, notably pasture and water(Focus,2001). Livestock represent the main asset while mobility patterns, is the key strategy to cope with these conditions.

Mobility is normally based on an integrated multiple-choice system; where major determinants are rainfall, range resources access, animal disease, marketing options, political insecurity (war) and natural disaster (flood, drought, earth quake etc). Pastoralists reduce their risk by combining the animal species in their herds and flocks; female stock make up the larger half of the herd in order to enhance production and reproduction options(Kahsaye,2002). Choosing which animal to herd depends mainly on ecological factors, combined with social values and market factors. Recent investigations report that, in response to market incentives and in order to maximize potential, there has been a gradual shift in herd composition towards less drought resilient species in specific areas (Desta,2000).

Due to drought and diseases there is a change in herd dynamics. The change depends on wealth classes, as rich pastoralists suffer greater loss in absolute terms, but such losses were lower in proportion to their holdings. The wealthy classes however, react more quickly during recovery phase, while the poor experienced either a long period of adjustment or an ejection from the pastoral system(Kahasaye,2002).

Therefore, the objectives of this paper to review some aspects of mobility, species composition and herd dynamics of pastoralist and discus factors that affecting this coping mechanisms.

Herd Dynamics

Herd dynamics are a reflection of all the events that affected herd numbers (births, sales, purchases, slaughter and mortality) over time.

Herd size

Ndikumana et al, (2000) and Zinash et al (2000) reported that during pre-drought period the herd size of cattle in south Ethiopia was 31 and that of south Kenya was 149, following 1995-97 drought the herd size was reduced to 7 and 98, respectively, which means 78 % reduction for south Ethiopia and 35 % reduction for South Kenya. Kahasye, 2002 indicated the over all mean reductions for large stock following 1999/2000-drought period was 31.7 percent. In the analysis of the Magnitude of reduction across wealth classes (Kahasye, 2002), rich pastoralists suffered grater losses in absolute terms, but such losses were lower in proportion to their holding. The reverse was true for the poor households, in which the absolute figures for losses were lower but with a significant proportional change. The wealthy classes, though suffering a considerable loss, reacted more quickly during the recovery phase, while the poor experienced either a long period of adjustment or an ejection from the pastoral system. The most important contributing factor for quick herd restructuring in the case of rich households was their assets, which able them to purchase kids and calves.

The small ruminant herd size as described by Ndikumana et al (2000) shows that the pure pastoralists had more small ruminants than agro-pastoralists of East African countries (average of 125 and 60 animal /household, respectively) This trend was the opposite of that for cattle ownership, where in general, agropastoralists owned slightly more cattle than pure pastoralists. The mean herd structure ratios indicate that, in general, there were three ewes to a ram and five does to a buck, thus females dominated the herds. Moreover, there were generally more goats in the herds than sheep. These observations are in line with the known prolific nature of goats, and the hardiness and adaptability of their physiological make-up, which make them suitable for the highly heterogeneous and harsh conditions of the eastern African rangelands. During the drought, small ruminant herd size decreased greatly, with a reduction across the countries of Eastern Africa, where Southern Ethiopia recorded the larges reduction (83%) from pre-drought herd size.

Camels were valued both as beasts of burden and sources of food (milk and meat). Through the drought of 1995-97, minor rains and El Nino phases, number of camels per herd decreased from pre-drought period. Herd size has shown some recovery after drought.

Herd structure

Herd structure in pastoral production systems in Africa show that herd design is a major form of adaptive response by pastoral population. The response by pastoralists to changes in the environment very much depends on level of primary productivity, plant structure, its water resources and frequency of perturbation(Dyson-Mudson,1980).

In a survey carried out in Eastern African pastoral areas (Ndikumana et al 2000), the mean composition of the cattle herds by category showed as a ratio of 1:4:1:1 for bulls: cows: heifers: calves, respectively. Herds in pastoral area were female dominated, a similar herd structure was reported pastoral areas of Eritrea, too (Kahsaye, 2002). Under the same survey reported above in East African Pastoral area for small ruminants the mean herd structure ratios indicate that, in general, there were three ewes to a ram and five does to a buck; thus female dominated the herds.

In a study conducted on herd structure of afar Pastoral(Belete, 1997) the male to female ratio for cattle is 79:21. Out of the 79% female population 41 were young female stock.. From 21 % male population consisted 1% bulls for breeding , 17 % mature young males and 3% castrated. In terms of herd size for Afar cattle 38% consisted fewer than 100 heads of cattle, 22% 101-200 and the remaining 40% consisted above 201 heads of cattle. The flock size of sheep and goat showed that 25% were on flock size of 51-100 heads of shoats, 45% for 101-200 heads and 17% for 201 and above heads of shoats. The ratio of male to female to sheep is 27:73. Out of the 73% female population mature females (over 18 months of age) constitute 90 % of the flock. The general flock size of shoats ranges between 33 and 238 animals, with an average flock size of 119. The flock compromises 82% sheep and 13 % goats.

Moreover, there were generally more goats in the herd than sheep. These observations are in line with the known prolific nature of goats, and the hardiness and adaptability of their physiological make-up, which make them suitable for the highly heterogeneous and harsh conditions of the eastern African rangelands.

Overall agropastoralists and pastoralists kept similar ratios of sheep categories; however, there were pronounced differences in the ratios of goat categories (Coppock, 1994). In general, agropastoralists areas had more goats per herd than pastoralists and more bucks to does, which is in agreement with the findings of Nigatu (1994), with one buck to every three does. For instance the male to female ratio in a flock of goats under pastoral management were 1:19 as compared to 3:7 in the highland goats, which attributes for uncontrolled mating and hence a high coefficient of variation within a flock than among the flocks of highland goats (Nigatu, 1994).

Birth rates

Breeding to ensure the perpetuation of herd numbers, is a key management goal of pastoralists; it ensure survival of a breeding stock and thus promotion of the mainstay of their livelihood. Coppock (1994) noted that season, a determinant of nutritional status, affects pattern of cattle breeding. For instance, in the Boran Region of Ethiopia, most calves (70%) are born during the long rains, their arrival coinciding with optimal environmental and nutritional conditions for calf growth and recovery of the cows at the time of their greatest nutritional demands.

Birth rate was the number of births expressed as a percentage of the number of cows. In the East African Pastoral survey (Ndikumana, et al 2000) birth rate during pre-drought period was 12.9. During drought birth rate increased to 20.3 % and the rate increases in post drought period to level of 24.5%. Birth rate for small ruminants is expressed as the number of births to a percentage of the number of ewes or does. Small ruminants birth rates were generally higher than those of cattle during pre-drought, drought and post drought; with 19.3 %, 28.8% and 34.3%; respectively (Ndikumana, et al. 2000). Similar birth rates were reported for camels and small ruminants.

In Afar, birth rate for cattle, sheep, goats and camels were 7.8%, 16.8%, 12.6% and 10.8%, respectively (Belete, 1979). The peak birth periods are December and January for cattle, sheep and goats. For camels, most birth tended to occur in March. .In survey conducted by ILCA (1985) in Borena in normal years, calving rates of 70 to 75% were reported. Climatic variability affects calving rateand it may vary from 20 to 90% depending on season. In normal years 60% of all calves were born in the April/May rains. Ayele (1990) estimated birth rate of 60 % for all pastoral during normal period.

Purchase rates

Cattle purchase rate was calculated as the percentage of a household's cattle purchased during a given time. The cattle purchase rate in east African pastorals were too small with the highest record to be 3.9 %. The most mean purchase was recorded in the pre-drought period and post-drought phases, which was about 1.2 %. The least purchases were recorded during the drought period with an average of 0.5%. The purchase trends of small ruminants and camels were similar to that of cattle (Ndikumana et al, 2000).

Sales rates

Livestock sales rate was calculated as the percentage of a household's livestock sold during a given period. The small ruminants sales rate wee higher than purchase across all climatic phases. The highest rate of sales is during drought period, which is about 9.7%. As for cattle sales the highest sales rates were also during the drought period, which was 6.1% as compared to rain season of only 3.4% sales rate (Ndikumana et al, 2000) Belete (1979) estimated livestock sales in Afar region for cattle, sheep and goat were 2.7%, 3.5% and 3.1%, respectively. Camels sale were not reported during the survey period. In all livestock sold there were no female animals. In Borena Zone during normal period of take rates are high and the greatest off take of male is apparent (ILCA, 1985), and estimated to be 2-3%(Ayele, 1990)

Slaughter rates

Cattle slaughter rates were much lower than sales and purchase rate, which was less than 1 % for all pastoral areas of East Africa. The slaughter rates for small ruminants were much higher than cattle, indicating pastoralists prefer to slaughter small ruminants rather than cattle. A sheep or goat can be slaughtered for a feast or an honored or converted to a cash amount that can be retained within a family (ILCA, 1985) The small ruminant slaughter rates were higher during pre-drought and drought period, which is about 2.8 %, compared to post-slaughter phase which 1.1 to 1.5 %. Camel slaughter rates were higher than purchase rates but lower than sales rates. Pastoralists indicated that they preferred to sell, rather than slaughter, camels, as it was difficult to preserve the large carcasses of camels.

Mortality

Ndikumana et al (2000) have reported that the 1995-97 drought as well as the 1997-98 EL Nino rains had significant adverse effects on the livestock populations. During the drought, cattle mortality rates were highest in southern Ethiopia and northern Kenya where they increased to 49% and 35%, respectively. Small ruminant drought mortality rates were also highest in southern Ethiopia and northern Kenya, increasing to 52% and 43% respectively. The detrimental effects of floods included increased incidence of parasitic and epidemic disease among humans and livestock (particularly small ruminants) and the destruction of infrastructure. Cattle mortality during the floods was highest in southern Ethiopia (37%) while small ruminant morality was highest in northern Kenya (52%).

Mortality rate during normal period for Afar pastoral (Belete, 1974) for cattle, sheep, goats and camels were 3.5%, 23%, 15% and 1.1%, respectively. The high mortality rate in sheep as compared to goats is attributed for high internal parasite cases in sheep than goats. The major killer disease for goats was CCPP (Contagious Caprine Pluro-Pnuemonia). ILCA (1985) Reported overall herd mortality of 11-EP13% for Boran pastoralists during normal period. Calf death account for much of this, and once an animal passes weaning age its chance of its survival are quite good.

However, Kahsaye (2002) found that the mortality pattern for the small ruminants was similar to that of cattle- mortality increased during the drought period across all the zones of Eritrea. In parts of the north west lowlands of Eritrea, higher death levels were observed for goats and sheep than for cattle and camels due to the greater susceptibility of these animals to diseases such as CCPP (Contagious Cprine Pleuro-Pneumonia) During the drought period, sheep experienced higher disease-induced mortality rates than other species. The differences in mortality rates between the species were largely the reflection of management techniques used by the herders and the capacity of each species to resist stress conditions.

Species Composition

Species and species mix also plays a dominant role in determining pastoral resilience. Pastoral production seldom relies on just one species; more often there are four to five species, all with different functions. An appropriate species mix, of course, protects against climatic events as different species have different requirements, and resistance against climate induced diseases, but also helps to mitigate macro-economic shocks. For example, the diversification of the nomads in Northern Kenya in small ruminants besides camels greatly helped them to cope with the collapse of the camel market, following the civil war in Somalia ((Cees de Haan, and Gauthier. 2002).

The salient point of species mixing is the manipulation of their different food and water requirements and reproductive cycle to damp out fluctuation in the food supply under wide range of expectable rangelands of east Africa (Dyson-Hudson, 1980). Small ruminants hold a key position in any pastoral production system. The need for species diversity, cattle, camels, sheep and goats is for a complementary purpose for the following reasons (Ayele, 1990) a) small stock are more vulnerable to disease than large stock b) they cash buffers c) they have a high reproduction d) they lactate during dry periods, unlike cattle e) goats and camels survive a drought better than cattle and sheep f) small stock allow more rapid growth.

Herd diversification is one of the coping mechanisms pastoralist's uses. The Simpson index (SI) was used to calculate diversity of the herds. Accordingly, N.Kenya and S.Ethiopia had the most diverse herds with post-stress values of 0.56 and 0.68, respectively, while the pastorals of Uganda and Tanzania had the least diverse herds, with pre-stress SI values of 0.99. In Eritrea (Kahsaye, 2002) statistical assessments of herd diversification during both normal and stress periods using SI showed that for the herders in the pure-pastoral the herd structure was highly diversified, while for the agro-pastoral it tended to be dominated by a single species. Hence, herd diversity appears to be a strategy that is a particularly useful in arid areas, where advantage can be taken of the various adaptations of different livestock species (Belete, 1979)

Field survey conducted in 1981 in Borena showed that there were 120,000 sheep and goats representing 37 % cattle numbers. The small ruminant population is unevenly distributed with 77% of the sheep and 39% of the goat population. However, goats are more widely distributed than sheep and area kept in considerable number in areas where bush encroachment is dense (ILCA, 1985). Belete (1979) described that the estimated livestock population in Afar region is 196,000 cattle, 272,000 sheep, 284,000 goats and 63,ooo camels. Small ruminants out number other livestock.

Moreover, different livestock species are valued for different reasons. Fore example, equines were highly valued as a form of transport where small ruminants were highly valued as convenient sources of income and food (milk and meat). Coppock (1994) noted that large species differences in the maintenance of population density on the plateau during drought of 1983-85.He suggested that that cattle density declined by 54% from March 1983 to the end of the drought in March 1985 and subsequently recovered to 88% by June 1985. In contrast, the small ruminant population appeared less affected in a negative fashion. It was noted that the flocks might have migrated to the plateau during drought. Another comparison on livestock population (Coppock, 1994) between 1982 and after one year of post-drought recovery in 1986 showed that net change in population due to drought was on the order of minus 24 % (cattle), plus7%(small ruminants), minus 38% (camels) and minus 60%(equines).

Kahsaye (2002) explained the shift in the species composition of Eritrea Pastoral herd as a phenomenon mainly for adjustment strategy at a time of crisis. The shift is mainly due to the decline in the ability of the Sahelian pastures to support growth in cattle population compared to small ruminants, resulting in a general shift in species composition towards small stock. Herd diversification in Eritrea (Kahsaye, 2002) is maintained as a mechanism designed to meet the specific objectives of the household. The Somali pastoralists reduce their risk by combining the animal species in their herds and flocks; female stock make up the larger half of the herd in order to enhance production and reproduction options. Choosing which animals to herd depends mainly on ecological factors, combined with social values and market factors. In Somalia, herd and flocks composition can be a combination of camels, cattle, goats and sheep.

According to Focus (2001) report in Somalia that recently in response to market incentives and in order to maximize productive potential, there has been a gradual shift in herd composition towards less drought resilient species in specific areas. This is the case along border areas where cattle have increased for sheepherders of the Haded (Gedo Region) and is also the case for sheepherders of the Haded group in Sanaag, and for coastal herders in Central Provinces (Mudug and Galgadud), the number of sheep is reported to have greatly declined (Hawd areas). These shift have resulted in increased vulnerability to drought. Recent massive livestock losses in some areas (Awdal and Gedo areas) have mainly affected cattle and sheep, which are less able to cope with harsh climate extremes.

Mobility

Mobility, whether nomadic or transhumant, and whether over short or long distances, will to a large extent determine the capacity of pastoral populations to cope with drought. Mobility is clearly a matter of life and death for pastoral populations in the arid environment, but can be also beneficial in higher potential areas. Little empirical data is available comparing actual losses in different production systems. Anecdotal experience, for example from a World Bank-funded livestock project in Chad, shows that the mid-eighty drought caused higher losses and greater social deprivation under the sedentary higher potential farmers (Cees de Haan, and Gauthier. 2002)

Mobility is an example of pastoralists in case of drought. In an arid, highly variable and unpredictable environment, a large number of animals cannot be sustained on a permanent basis. In case of drought, livestock can be moved out of the drought prone area either through mobility (people move with herd) or through destocking (sales of stock); or livestock can be maintained in the area by fodder. Accordingly the best responses are mobility. This has been the response of pastoralists. They attributed a "primitive ecological wisdom", because they behave in a way that is ecologically rational according to the contemporary understanding of dry land functioning. However, this behavior may not be the preference of all pstoralists. With increased crop farming, human over population, commercialization, conflict mobility could considered a burden-at least among some pastorals (Adriansen, 2003)

Herds and flock are often separated in to distinct herding units in order to exploit feed and water resources better and adjust mobility. The manner in which they are split varies with herd/flock size season, production function, community preference and geographic isolation. Herd splitting is common in pastoral communities (Solomon Bekure et al, 1982), but less so in mixed systems, largely because of competition for cropping. On the other hand mobility has a negative impact such as (Nigatu and Getachew, 2002) on breeds genetic identity, disease transmission, education, human health, resource census survey, tax payment (other government obligations), infrastructure development.

According to Belete (1979) the mobility of Afar pastorals depends on the amount and frequency of rainfall and the availability of animal feed. Since the northern part of Afar region is wetter in most parts of the year, mobility generally takes place in the northern direction of the region. When there is a critical shortage of feeds, particularly in a hot dry season a westerly migration to the highlands are common. During mobility sheep, goats and few milking cows are left behind with the elderly people, while the rest of livestock move to other areas where feed and water is available. The migrants turn back to home after 2-3 weeks following the commencement of the big rain season usually from September to the end of November. During dry season the encampment is 5-15 km from water points, which reduces to 3-5 km at the time of wet season.

ILCA(1985) and Coppock(1994) summarized the mobility of Boran pastorals as follows. The division of cattle herd into encampment based milk herd(Warra), and free-ranging dry herds(Forra) allows a reduction in the number of non-lactating animals based on the encampment , so reducing grazing pressure on adjacent pasture and allowing a greater degree of encampment permenanence.This has an important effect both on livestock distribution patterns and the ecology of the area. Milk supply is maintained at the encampment , while dry animals , whose water needs and reaction to stress are less than those of milking cows, can exploit distant pastures. Forra herds may not come into contact with their home encampment for months a time, although interchange of herd animals and herdsmen will occur. Such herds generally return to the home grazing area (Meda) associated with the location of the major clan well, and the home encampment in the wet seasons when grazing and water are readily available. In dry season when the need for divided herds peak, Warra herds comprises 71% of all cattle and the rest are Forra. A larger proportion of cows and young calves are located in the Warra herds, while most castrates and immature are located In the Forra herds. A few bulls and a few castrates are kept with the Warra herd, and on occasions, particularly when there are family labor shortages, the division of the family herd into Forra and Warra groups will be difficult and more animals than the necessary may be kept in the Warra herd.

Kahsaye (2002) identified two distinct types of mobility in Eritrea. He mentioned that for transhumance pastoralists, movements are up ward and downward on a seasonal basis. Given the altitude/rainfall correlation, the agro-pastoralists have key annual movements to the lowest part of the range in rainy season and to higher elevations at the end of dry season. While for the nomadic population, movement is horizontal and with the extension of a dry period, the pure pastoralists and their livestock trek long distance frequently involving trans-borer migration. Cattle and sheep are the first to move, followed by camels and goats. The latter species show delayed migration because of their capacity to feed from scrub on rugged terrain (the case of goats) and from leaves of tall trees (the case of camels). Most movements are of relatively short span, following customary routes and territorial alliances with the neighboring groups, while long-distance migrations, including this trans-border, are less frequent and are usually performed by highly mobile Tigre group. In Tigre ethnic group large stock are like cattle are kept for their milk, while sheep and goats are highly regarded as potential sources of cash income and food because of their high reproductive rate.

Focus (2001) classified the pastoral groups of Somali in to three based upon to the degree of mobility. These are nomadic (opportunistic and variable migration patterns), transhumant (set migratory route on seasonal basis); agro-pastorals (almost sedentarised and also attached to crop production). Most Somali pastoralists tend to be transhumant through traditionally established indicative routes and can be found close to their origin areas during the GU season. Migration decision-making is normally based on an integrated multiple-choice system; where major determinants are rainfall, range resources access, animal disease, marketing options and political insecurity

Mobile pastoralists are not hostile to modern services. But the form and content of service provision is often such that nomads are unable or unwilling to use them.(UNDP,1996)

Conclusion

In the past, the single, most important traditional coping strategy was mobility, with pastoral populations moving from areas of mean resources to areas with improved resource conditions. Indeed, mobility also allows pastoralists to continue their livelihoods with minimum livestock losses, and is facilitated by faster pasture regeneration and faster livestock recovery. The better condition of the physical environment in the past (less environmental stress) and lower population also contributed as favorable conditions for mobility.

Today, as drought becomes more frequent in different regions (droughts were registered in 1991-92, 1994 and 1999-2001, and the El Niño floods in 1997, causing huge livestock destitution), populations and the number of permanent settlements and watering points are on the increase, thanks to development processes. Greater human and livestock populations translate into limited resource availability, and the decline in the constitution of livestock among pastoral communities. Therefore, to preserve the life of pastoralism and traditional early warning systems, development strategies, e.g. the promotion of agriculture in and around new administrative centers within the East African pastoral communities, need to be pursued with greater attention

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Market Information to Select Early Warning Indicators in Borena Pastoral Production System

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Abstract

Often pastoralists are unable to fulfill their food and non-food requirement from own crop agricultural output alone. Early warning analysts are concerned with all aspects of food security, including food availability and food access. Prices serve as a signal for both. The key commodities that provide reliable information about changing food security conditions (either food availability or food access conditions) should be intensively monitored. Using descriptive statistics and principal component analysis data from DPPC/EWS database and early warning reports from 1998-2003 were used for the analysis.

The monthly price of cereals shows that price often escalates starting from January to September. The price of donkey correlates negatively with the price of maize (-0.7) and other cereals highly as compared to other livestock price (Annex 1). Pastoralists do not appreciate the number of donkeys they have. The donkey is disregarded because of its non-food value by pastoralists. They are the first victims at the time of even a slight shock or when returning from dry season grazing area. Therefore, taking the price of donkey as a drought indicator would lead to a better conclusion in pastoral area of Borena. A commodity that creates variability in the market is usually subjected to shocks. Before the shock becomes severe and start to deplete assets, pastoralists take animals of less important for food to the market. Monthly prices comparison of common commodities in Borena pastoral market shows donkey as an actor of variability for the market.

Introduction

Drought is a slow onset disaster and is usually the most common form of disaster affecting livestock dependent regions. The impact of drought depends upon the underlining vulnerability to drought including the size of livestock herds and access to dry season grazing areas and water resources. If the pastoral economy is not already weakened, it can usually withstand at least one below average rainy season. Often pastoralists are unable to fulfill their food and non-food requirement from own crop agricultural output alone. In such type of economy, other sources of income such as wage labor, rent, gift etc play a significant roll in the household food availability (EWWG/DPPC, 2003).

Pastoralism is the dominant production system in the dry lowlands of Ethiopia. Pastoralists use dry land natural resources without considering their sustainability where other land-use systems cannot thrive. Key elements of this production system are opportunistic management of the rangelands and mobility of the herds. This enables pastoralists to make use of natural resources, water and fodder, the availability of which varies very widely in time and space. A central strategy of pastoralists is herd maximization. It is their best mechanism to deal with the unreliable, varying availability of natural resources (Ndikumana, 2000).

Pastoralists are highly dependent on the market condition of the surrounding area (ESAP 2003). Except with some opportunistic pastoralists they do not produce crops, which they often eat as a staple food. They rather procure from the proximal market following their movement area in the exchange of livestock. Any change on the price of either crop or livestock will directly affect them

(Wilson, 1988). Early warning analysts are concerned with all aspects of food security, including food availability and food access. Prices serve as a signal for both.

Due to the above facts, analysis of price is therefore, an essential element for assessment of vulnerability to food. Price data together with other information can be used as an important tool to identify the degree of vulnerability of a given area. The higher the price of food commodities, the lower the capacity of households to purchase food from the market and the higher their vulnerability to food insecurity and the vise–versa.

Food is more than a commodity that is sold and bought, it is the very means of life, the overriding human need; it is the social good. Lack of food kills, and causes most of the world's killer diseases. At the end of the second millennium, many millions of people lack enough nutritious food to live healthy lives. At the World Food Summit in 1996, governments made a commitment to halving the number of hungry people in the world by 2015, as a first step to the goal of food for all. "Trade is a key element on achieving food security", said the summit declaration, and agreed to pursue food trade and overall trade policies that will encourage producers and consumers to utilize available resources in an economically sound and sustainable manner (CTA, 1998).

The development of early warning systems began at the time of the 1974 World Food Summit, during which widespread drought and famine were affecting parts of the Sahel. The resultant systems to monitor food security were indicator based and the approach to assessing food needs based on a national level food balance sheet calculation (EWS, 1998). The Ethiopian Early warning system used to focus on monitoring production prospects. Recently price and market monitoring have become important monitoring areas. Since price and market conditions affect both food demand and rural incomes, monitoring them is fundamental to the success of any early warning operation. Price and market condition are among the 'early indicators' used by the Ethiopian Early Warning System. Early indicators by definition provide the longest possible lead-time between prognosis and the actual occurrence of disaster. Monitoring price and market is therefore crucial information to predict an impending disaster. The key commodities that provide reliable information about changing food security conditions (either food availability or food access conditions) should be intensively monitored (EWS, 1998).

Different production systems have got different interest of commodities to deal in the market. The Ethiopian Early Warning System should therefore identify items to monitor in different production systems of the country. This study was therefore designed to identify the type of commodities to be looked into as an early indicator of drought through market price in Borena pastoral areas.

Materials and Methods

Study area

According to the Oromiya National Regional State Disaster Prevention and Preparedness Commission October 2003 monthly report Dire, Arrero, Moyale, Liben, Teltelie and Yabelo Woredas of Borena area obtain more than 65% of their annual income from livestock. Therefore the after mentioned Borena and Gujji zones of pastoral area were selected for the study.

Data Source

Federal Disaster Prevention and Preparedness Commission (DPPC) in collaborations with Regional DPPC collects monthly price of commodities like price of cereal and livestock from all over the country for early warning purpose. Those row data are collected by each Woreda Early Warning Committee and sent to Federal DPPC to be stored and for further analysis. This data is used as a raw data. FDPPC monthly, annual, seasonal report and personal observation were also employed to collect information and analyze data.

Method of study

- Identification of the study periods and characterize them based on the drought situation
- Identification of staple foods
- Manipulating Price data
- Clearing raw data
    - Using visual inspection of data in tabulate and graphical formats
    - Identification and verification of outliers using range checkers
    - Triangulate with other data and information types (agricultural production, field reports)
- Dealing with inflation (if the price increase is observed check whether it is because of inflation or it is another factor)
- Replacing missing value

Analyses the price data

Statistical method: descriptive statistics and principal component analysis were used.

Results

Drought period

According to DPPC, 2000 report Borena pastoralists faced a critical food shortage and a huge number of livestock deaths were recorded for the reported year. Those destitute and displaced people were getting food aid from government and other humanitarian agencies to combat the threat of drought. The year 1997-1998 was identified as the El nino period where very high torrential rain was recorded (ILRI, 1999). During this year the availability of pasture and water was enough for pastoralists to pass the major dearth period. In 1998 there were no relief beneficiaries among Borena area pastoralists, Table 1. Following this the situation starts to deteriorate after 1998. In 1998 Hageya rain (mid Sept-late Nov 1998) failed and followed by the failure of Borena area main rainy season Gena (Early Mar-Mid Jun 1999) that resulted in 43% of the population become relief beneficiaries. Following the Gena rain, the Hageya rain of 1999 failed, and 100% of pastoralists around Borena became totally dependent on food aid in the year 2000.

Table 1. Pastoral and agro pastoral peoples who were affected by drought from 1998-2003

	Pastoral Beneficiary		Agro pastoral Beneficiary		Remark
	Number of Beneficiary	% From Total Pop	Number of Beneficiary	% From Total Pop	
1998	0	0	0	0	A total of 1,324,867 people, which is almost 15% of the Borena area, were getting food aid for five years.
1999	153,100	43	115,600	11	
2000	366,032	100	217,697	20	
2001	214,500	58	120,800	11	
2002	104,800	28	8,900	1	
2003	0	0	23,400	2	
Total	838,432	38	486,397	7	

Summarized from DPPC annual reports, 1998-2003

Principal component analysis

Principal component analysis (PCA) is a multivariate technique for analyzing relationships among several quantitative variables measured on a number of objects. It provides information about the relative importance of each variable in characterizing the market. Price variability was observed in Borena area markets because of the influence of some very susceptible commodities for shocks. Eighty six percent of the variability was contained in this analysis by taking the first four principal components (PC). With in this range donkey, barley and maize affected PC 1. The rest PC 2, PC 3 and PC 4 were influenced mainly by cow, ox and camel, respectively.

Table 2. Eigenvalues, proportion of variability and the cumulative variability explained by the first four largest principal components

	PC1	PC2	PC3	PC4
Eigenvalue	4.1054	2.0840	1.5992	0.8589
Proportion	0.411	0.208	0.160	0.086
Cumulative	0.411	0.619	0.779	0.865

Crop market

Often Pastoralists do not produce their own food crop for their annual home consumption. They rather sell livestock and procure crop or other commodities. According to the result obtained in this study and other early warning reports maize and barley were the most common food commodities consumed by pastoralists. Teff-mixed and sorghum were also common especially in normal seasons. The price of maize was high in 1998, although there was no food aid for Borena area in this year. Almost the same price maintains up to the year 2000 (Table 3). The year 2001 was considered as the best year for crop producing areas of Ethiopia, and there was excess production. This excess production in the nearby highlands promoted the introduction of cereals to the pastoral area and the price of cereals fell. In the mean time the rainfall condition in pastoral areas had shown some improvement and encouraged pastoralists to withhold their livestock from the market. This low price of cereal was maintained for a year, and started to soar up to the study year, 2003, following the drought situation of the near by crop producing areas. Nevertheless, there was no beneficiary in Borena area when 15 million people of the country were getting food aid in 2003. Before pastoralists cope with the previous embarrassing year the problem started to affect them and they started to take their only asset, livestock, to the market with throwaway prices.

According to the monthly data analysis and seasonal early warning report of Ethiopia maximum supply of cereal and lower price starts after the crop-seed setting stage and harvesting season, October-January (Table 4). The monthly price of cereals also shows that price often escalates starting from January to September.

Table 3. Annual Price of crops birr/quintal and livestock/head in different Market areas of Borena area.

	Years					
Commodities	1998	1999	2000	2001	2002	2003
Barley	160	193	187	80	95	142
Maize	137	148	146	77	78	138
Sorghum	116	171	153	86	53	87
Teff mixed	335	281	255	161	166	220
Ox	433	598	593	676	813	865
Sheep	87	74	84	87	92	97
Camel	0	725	775	860	933	998

Cow	407	470	389	481	555	627
Donkey	0	315	355	366	384	417
Goat	95	81	86	93	98	100

Livestock market

Pastoralists often sell animals to meet their immediate requirements such as purchasing food crop or health service etc. It could be either a normal or drought year, whatever the type of season it is they take animals to sell to the neighboring markets. In the Borena area, the prominent market place is called “Dubluk”. Although this market place is prominent, each Woreda has got its own market where pastoralists sell their supply and procure their demand. The physical condition of animals is very important to attract good market prices. In Borena market supply of shoat outnumbers followed by cattle and donkey, respectively. Recently, as the demand of camel increases the supply also starts to rise.

The annual price of livestock shows an increasing trend through the selected study periods. Although minimum price drops were observed in 1999-2000 for shoat and cow, price rise was observed both in drought and normal years. Obviously comparison of last year to this year for the price of livestock would be concluded with an increase for this year. This increased was at almost a constant rate.

The price of donkey correlates negatively with the price of maize (-0.7) and other cereals highly as compared to other livestock price (Annex 1). Pastoralists didn’t appreciate the number of donkeys they have. The donkey is disregarded because of its non-food value by pastoralists and considered as a poor mans property. Therefore they are the first victims at the time of even a slight shock of disaster. When the supply of cereal in the market starts to decrease, the price of livestock starts to lower and the price of cereal starts to rise. At this time, the first animal taken by pastoralists and observed in the market is donkey. The price of donkey starts to lower from March to July, when the crop supply reduces and goes up when the crop availability in the market improves, because of the influence of nearby markets.

Most of the time, pastoralists sell cattle and buy cereals on the local market. When the price of cereals rises, the price of livestock is reduced. This could not be justified as price inflation. Because if there is general price inflation, their income has also risen as a result of a corresponding increase in cattle prices.

The monthly price of livestock shows different figures. Throughout the whole year, the price of cow was almost similar. But, variation was observed in others, like donkey where the maximum variability among months was registered. The monthly price of those less regarded animals, especially donkey, was also observed related with increased price of cereals in April- July. The main supplier of donkeys to the pastoralists’ market is the pastoralist themselves. They keep donkeys mainly for loading water from the near by watering points and for packing at the time of dry season grazing movement. April to July is the rainy season (Gena) where pastoralists in Borena return from dry grazing area to their family and expect good production from their animals.

The price of camels is also different. Since the introduction and intensification of camels in Borena is recent history, it shows different picture. Its price increment and demand is also getting higher. The monthly price rise is also observed at the time of pastoralists’ movement to the dry grazing area. Therefore, it is also difficult to relate its price with early warning.

Table 4. Five year monthly price of commodities in different market of Borena area

Commodities	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Barely	124	141	134	138	154	167	169	150	142	141	137	119
Maize	103	109	117	133	148	149	146	144	127	121	112	110
Sorghum	100	110	103	115	147	149	135	148	168	148	112	118
Teff mixed	213	206	205	216	238	240	228	217	224	232	237	214
Ox	711	681	642	674	690	697	706	713	689	688	709	665
Sheep	82	89	84	92	89	92	89	91	79	77	81	84
Camel	868	885	893	1192	1246	1106	874	845	677	652	905	908
Cow	485	465	478	506	507	488	486	543	447	481	517	488
Donkey	392	405	407	386	341	350	349	394	363	364	390	381
Goat	91	89	87	94	86	88	92	93	90	88	95	95

Discussion

In pastoralists' area and even in all crop dependant areas of the country, the failure of rain would dictate an immediate drought that may lead to famine. This could be attributed to the recurrent drought experienced by the area. Livestock is the main income-generating activity for pastoral community and subordinate for crop producers. It is to be recalled that the year 2000 drought was not the failure of 2000 rain in pastoral areas of Borena area. The rain failure starts in 1998 and proceeded to 1999 Hageya rain (EWS, 2001). Pastoralists depleted most of their asset and copping mechanism before the year 2000. Then they were directly identified as beneficiary.

Early warning system of Ethiopia is interested usually to compare the price of a commodity for the same month in different years. According to this study, this wouldn't be a good method of indicator for current or upcoming acute disasters, because of the constant increase of the price of livestock. Comparison of livestock price of this year with that of last year of the same month gives the price of this month higher than the price of last year of the same month due to the ever increasing livestock prices from year to year. Although it is true and important to use annual price increase as an indicator it is wise to develop an appropriate increment range per year.

The trend of livestock supply to the market was also considered as an early indicator in pastoral areas. For example, except those who cease reproducing or who are sterile, supply of female shoat or cow is considered as an indicator of shock. Nevertheless, the supply and price of cow was found uniform throughout the whole year of a month (Table 4). This is true because of the significance of cow to pastoralists. Pastoralists are not interested to sell their replacement stock unless they are highly in need of money for very important matters. Even if they expect the upcoming month is much worse than the recent month they still wanted to keep their animals, especially cow for their optimistic expectation of the coming good months. They often sell first animals that are not of much interest like donkeys. As the number of donkeys increases in the market and when their price reduces that could be a first signal of drought in pastoralists' area. Therefore, taking the price of cow as a drought indicator would lead to a false conclusion in pastoral area of Borena.

A commodity that creates variability in the market is usually subjected to shocks. Before the shock becomes severe and start to deplete assets, pastoralists take animals of less important for food to the market. In a comparison of monthly prices of common commodities in Borena pastoral market the donkey was found as an indicator of variability for the market. Lower prices of other animals couldn't be considered as an early indicator. They would rather have to be considered as late indicators as they are observed late in shocks. Early warning should therefore select appropriate commodities for a particular area.

For Borena pastoral area, due to the proximity of the country's maize and barley producer belt, these two cereals become prominent in the market. The shortfall of these commodities in the crop producing area affects pastoralists directly. By the year 2003 they were not affected by drought and they had the potential to sell livestock and procure cereal. This clearly shows us that pastoralists are highly dependent upon the performance of the near by crop producers for their cereal demand. When the problems of drought were localized around Borena pastoralists, the near by crop producing areas were benefiting from the low price and huge supply of livestock by the pastoralists. That means the drought in Borena didn't have much influence on the crop producers. But, the problem surrounding Borena has a great influence on pastoralists' food security situation.

Domestic animals are usually introduced in an area according to the interest of human beings. Once they are introduced for their genetic merit, they start to play their role. There is also another genetic factor that they will be responsible for: they will add to the area more genetic variability. The introduction of camels to Borena has a very recent history. Although its price and importance have increased through time, (Table 2), its contribution to food security didn't exceed that of cattle. Nevertheless, it is accepted as an important animal for Borena pastoralists. Bush encroachment helps the demand of camel in Borena area to make use of the available resource. The recurrent droughts expose cattle for death and increase the fear of pastoralists to hold cattle and increase the number of camel as a risk minimization. This encourages the replacement of cattle with camel. If the problem persists for long, the tag of Borena pastoralists, huge number of cattle per person will diminish. In the mean time, the genetic variability of cattle will be reduced from further crossing. Moreover, before the absolute genetic make up of Borena cattle is known they have started to disappear.

Conclusion

- Instead of giving much emphasis for the very important animal type as an early indicator it is wise to see the market performance of less regarded animals for pastoral early warning methodology.
- The performance of cereals in the near by crop producer area will directly affect pastoralists as the vice-versa effect is mild to crop producers.
- Comparison of same month for different years on livestock price will be high. Therefore another methodology should be developed to regress those different years.
- Commodity specific analysis should be conducted to an area.
- Early warning should see breed introduction and depletion in pastoralists' area.

Acknowledgement

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Annexes

Covariance analysis of commodities

	Barley	camel	cow	donkey	goat	maize	ox	sheep	sorghum	teff
Barley	1.00									
Camel	0.03	1.00								
Cow	0.12	0.36	1.00							
Donkey	-0.64	-0.01	0.08	1.00						
Goat	-0.33	-0.12	0.39	0.30	1.00					
Maize	0.86	0.20	0.34	-0.68	-0.23	1.00				
Ox	0.39	-0.20	0.38	-0.30	0.24	0.26	1.00			
Sheep	0.51	0.53	0.42	-0.08	0.02	0.61	0.05	1.00		
Sorghum	0.57	-0.17	-0.05	-0.71	-0.27	0.67	0.30	-0.01	1.00	
Teff	0.57	0.11	0.21	-0.79	-0.13	0.54	0.50	-0.03	0.58	1.00

Principal component analysis of commodities

Variable	PC1	PC2	PC3	PC4
Barley	-0.439	-0.008	-0.087	-0.373
Camel	-0.059	-0.454	-0.369	0.584
Cow	-0.124	-0.535	0.303	0.149
Donkey	0.417	-0.221	0.035	-0.225
Goat	0.138	-0.281	0.559	-0.082
Maize	-0.451	-0.146	-0.133	-0.204
Ox	-0.239	-0.047	0.572	-0.051
Sheep	-0.197	-0.520	-0.261	-0.373
Sorghum	-0.378	0.274	0.037	-0.041
Teff	-0.392	0.106	0.192	0.507

Concepts of Participatory Research with Resource Poor farmers: *Review of Literature*

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Abstract

Recent evidence of non-adoption of technologies by resource-poor farmers is disturbing and calls for a shift from the conventional linear 'researcher-extension-farmer' approach towards resource-poor farmer participatory research approaches. To this extent, many agricultural researchers and development agents now seem to be generally agreed that resource-poor farmer participation leads to; improved efficiency of the public sector research system by addressing farmers 'felt needs; the development of site specific technologies; legitimization of farmers own indigenous research; and the empowerment of farmers for self-help development. This paper re-states the importance of effective resource- poor farmer participatory research, how it can be achieved and then looks at modes and typology of farmers' participatory research. Resource-poor farmer participatory research cannot be achieved overnight and it is easier said than done. There has, therefore been, a general limitation of successful practical examples to back the theoretical models that have been developed. The paper argues that this is one reason why commitment to participatory approaches has remained low with some research programs using the 'farmer participatory label' on non- participatory approaches just to attract support (financial or otherwise) as the concept seems fashionable nowadays. Finally the paper suggests that approaching resource poor farmers through Farmers Researcher Groups (FRG) can be a good mechanism to ensure their participation.

Keywords: Resource poor farmers, participation, farmers' participatory research

What is 'participatory research'?

The concise Oxford Dictionary defines 'participation' as 'having share in something with another person' whilst the Collins Dictionary also defines it as 'taking part in', and to become involved in '. It would appear that these definitions suggest a state of mutual respect between partners in whatever they are 'sharing' or 'taking part in 'in order to achieve a common goal. The term 'farmer participatory research' is here used to describe the practical process of bringing together, through dialogue, the knowledge and research capacities of the local farming communities with that of the scientific institutions in an interactive way. It involves activities where resource-poor farmers work together ('share', 'take part') with scientists in the identification, generation, testing and application of new technologies and practices. More than just sharing, it is an approach where formal research puts farmers' agendas first, learns from their innovations and supports their full participation in the research process. This approach contrasts with conventional research models in that resource-poor farmers are not treated as passive subjects, but rather, as active partners who serve as consultants, design projects, gather data, interpret meanings, evaluate findings, recommend actions and disseminate results. (Roling 1990).

The idea of farmer participation in research is not new. For example, in Zimbabwe (Mutimba, 1995), the large-scale commercial farmers have a along history of participation in research. They provide research grants annually to the formal research system; they are represented in the Agricultural Research Council; they have the power to influence the direction and output of research; they run their own research and advisory services for the major crops; they maintain close contacts with research scientists; and they host trials on their farms. Socially, they share class and professional attitudes and values with agricultural scientists, with whom they quite readily interact. However, the peasant farmers, who constitute a large majority, are largely outside the formal technology development system and they have little power to bring pressure to hear on the public-sector research system. Consequently, the public research system has not benefited from farmers indigenous knowledge system either. As Chambers and Jiggins (1987a) point out, the challenge now for agricultural research is not how to increase production overall but how to enable resource- poor farmers to produce more.

This paper, therefore, focuses on resource-poor farmers who, as Chambers and Jiggins (1987a) point out, are characterized by poor physical conditions they are in (undulating and sloping topography; shallow infertile soils; scattered, small and irregular plots; proneness to droughts and other hazards), and also by their poor social and economic conditions (unreliable access to inputs, credit, extension and labor; high priority for food production; complex farming systems).

Why resource-poor farmer participatory research?

Recent evidence of non-adoption by resource-poor farmers of technologies from the public research systems is disturbing. In a study of 53 ‘farming systems adaptive research’ initiatives from Swaziland, Zambia and Zimbabwe, only 15 initiatives were found to have led to any adoption by farmers, of which just three technologies, all involving new varieties, were widely adopted (Waddington, 1993). The cost of developing the technologies involved in these initiatives, the bulk of which nobody wanted, must have been enormous. This calls for a serious re-look at the approaches used in developing agricultural technologies. If this were happening in the private sector, developers of such technologies would have ‘cases to answer’. The reasons for the low levels of adoption can be traced back to the lack of farmer involvement in the technology development process as, had farmers been involved; researchers would have focused on their felt needs. If we are to see an improvement on this, resource-poor farmers’ knowledge of their problems, circumstances and research has to be given due regard in planning agricultural interventions. There is therefore need for deliberately targeting research efforts toward these resource-poor producers, with an emphasis on low-cost, scale-neutral technologies. The need for more careful targeting implies a greater flow of information between farmers and the public sector research system, and more emphasis on mechanisms for enhancing user control in the research process. When farmers are involved in the formal research process, it is possible for the public research system to focus more sharply on farmers’ priority problems and opportunities thereby increasing chances of adoption and improving the efficiency of research resource use (Mutimba, 1997).

Farmers are researchers and experimenters (Rhodes and Booth 1982, Chambers and Jiggins 1987b, Richards 1991). For centuries, they have experimented and selected crop varieties, materials and farming methods suited to their circumstances. In a study in Zimbabwe, Mutimba (1995) observed that peasant farmers were, on average, handling 21 different types of crops and livestock each at any one time. If one considers the different varieties and breeds the farmers deal with and the different management practices they apply to them, one can easily see that the technologies that the farmers process at any one time, run into hundreds considerably more than research scientists are trained to handle. Farmer experimentation, therefore, represents an untapped resource. There is an argument that participation involves more than respect for indigenous knowledge but a sharing of ways of knowing. It is based on the concept of the farmer as one constantly involved in a learning process about his environment and his relation to it (Arokoyo, 1998). He continues on saying, inquiring is the essence of being human and man is a scientist by definition constantly seeking to make sense out of his environment and testing the resulting constraints in practice. In this view the researcher is a colleague helping to improve the farmers learning system by sharing ways of researching.

Peasant farming environments are so heterogeneous that adaptation of new technologies to each site would make impossible demands on formal research resources. The demands can be reduced if the farmers are enabled to select and adapt technologies to suit their particular environments and if farmers' indigenous technical knowledge can be fed into technology development. They have research experience that could complement formal research. In participatory research, as research agenda addresses farmers' problems, results should feed back directly in to farmers learning processes as knowledge or technical options. This feed back loop ensures that research is relevant and contributes to farmers problem solving. For researchers this process offers the benefit of linking their works efficiently with farmers, with out having to initiate separate community development process (Hagmann *et al*, 1999)

Effective farmer participation leads to: improved efficiency of the public sector research system by addressing farmers' felt needs; the development of site specific technologies; legitimization of farmers' own indigenous research; and empowerment of farmers for self-help development (Ashby, 1990). Participation therefore has to do with contribution, involvement, organization and empowerment. Empowerment implies access to and control over technology, information, material resources and decision-making. Although empowerment is often not considered an output in itself, it may be a key process in participatory research.

In spite of its advantages there has been some challenges regarding the practical ways of reaching resource-poor farmers and the conditions necessary for their participation (Mutimba, 1997).

a) Experience with extension shows that those farmers who readily make themselves available to outside intervention tend to be those with high access to resources

b) Most models (PRA, RRA, and RAAKS) reflect a strong tendency to use farmers as sources of information to enable researchers to make their own decisions.

c) Young scientists with neither experience nor interacting skills are 'thrown into the deep end' as they come out of colleges. Can they be expected to have meaningful dialogue with farmers? Can farmers be expected to take these young 'scientists' seriously? As the scientists mature and gain mastery of their job, as their ability to dialogue with farmers begins to improve, as they begin to be appreciated by the farmers, they are promoted to senior positions, removed from farmers and replaced by other college leavers.

d) Low commitment to participatory approaches from research management

Actors in a participatory research process

In a classical sense, there are three main actors in a participatory research process. These are farmers; public sector researchers; and public sector extensionists. In an effective participatory research process, the three subsystems are closely linked and highly complementary. They understand their common purpose and they each have relative advantage that is useful in mutually articulating their research agenda.

The farmer: can identify own priority problems: can suggest some of the causes to the problems; has knowledge of the local environment; has knowledge of own possibilities; can assist in monitoring trials; can offer land, draft power and labor; has practical experience in trying out new technologies and fitting them in his whole farming system.

The researcher: may be able to identify constraints unknown to farmers or external to the farming environment; may identify regional and national obstacles; may be a source of experience and ideas from other places; carries out research; has knowledge of fundamental biological and economic constraints; has statistical analyzing skills.

The extensionist: can assist in the management of trials and in collecting technical data thereby helping in achieving the desirable agro-ecological coverage without overstretching the resources of the research services; knows the farmers and the area. Hence can assist in interpreting certain phenomena: can provide information on the most urgent and relevant constraints to productivity; can assist the researcher in gaining 'entry' to the farming community; has skills to interact with both farmers and researchers (Mutimba, 1997).

The Participatory Technology Development (PTD) Process

Jiggins and de Zeeuw (1992) have elaborated a step-wise methodology, which provides a useful guide on how to get started (in farmer participatory research), identifying researchable problems, designing experiments, experimentation, sharing results and keeping up the process.

Veldhuizen *et al* (1997) prepared a comprehensive guide for trainer in PTD and the framework is summarized as follows:

Understanding Problems and Opportunities

Farmers' Views on the problems they face must be sought with their ideas on solutions. Insights into how the local population sees its own situation trends in the farming system, cause and effect relationships, the wider political and socioeconomic context, and any resource that can be better used. Information should also be sought on the experiments that local farmers have already carried out, and on their own continuing efforts at local development.

This will lead to a clear definition of problems and opportunities that is shared by all participants, including the outsiders.

Looking for things to try

In this phase we will start with more detailed analysis of problems and opportunities identified in the previous phase. Making inventory of existing technologies and indigenous knowledge is very crucial at this stage. Indigenous knowledge is the basis for indigenous decision-making and will influence the indigenous organizational structure. These factors are conditions for indigenous innovations. Farmers' experiments within the village, as well as sources of knowledge from outside are consulted. The options will be critically viewed (assessing the advantages and disadvantages for the different groups) and the criteria for setting priorities, as well as those available from formal research and extension will be considered.

Besides a jointly agreed agenda for experimentation, an additional outcome of this phase is improved skills on the part of farmers in diagnosing problems and identifying solutions. There should also be an improved organizational basis for conducting research at village level more systematically.

Organizing and Conducting Experiments

Based on the research agenda, the farmers and the facilitators jointly design experiments that can be managed and evaluated by the farmers. This will accommodate farmers' own experimental practices and their criteria for assessing results.

This phase should lead to the development of locally applicable short cut technological innovations. It will also yield insights into any likely adoption problems. In addition, greater understanding of the PTD process and improved farmers skills in experimentation will result.

Sharing Results

Farmers learn from each other through out the PTD process, but it is especially important that they should do so once a successful innovation has been developed. Activities to encourage the sharing of results build on networks developed during earlier phases. An inventory of existing patterns and channels of farmer-to-farmer communication may serve as the basis for planning activities, which may include organizing exchange visits, developing manual or slide shows, and training farmer promoters. At this stage the program makes preparations for scaling up the PTD process by starting to work with larger groups and seeking to increase the number of villages covered. An inter-village PTD network may develop. A broader range of institutional contacts may also be sought.

Sustaining and scaling up

The final objective is to leave the villages with a permanent capacity for implementing an effective PTD process. Training and institutionalization are therefore major concern through out the project, but particularly during this phase. The emphasis will be on consolidating community networks and organization, fostering a supportive external institutional environment and documenting the PTD approach. The outcome of this phase is that the village has a more productive and sustainable farming system and is more self-sufficient in research. We gradually withdraw from the village and are free to launch the PTD process elsewhere.

Farmers Researcher Groups (FRG)

In spite of certain difficulties in achieving perfect participation some authors suggest Farmers Researcher Groups/Extension Groups as mechanism to ensure resource poor farmers participation. Chambers and Ghildyal (1985) recommend using farmer groups, focus groups and innovator workshops in spite of the risk of bias in favor of the resource-rich. Norman et al. (1988), quoted by Hal Mettrick (1993), described farmers experimenter group as a group of farmers that meet on a regular basis to discuss farming problems, implementation procedures for on-farm trials, and alternatives for farming systems improvement. Group members also play an important role in informing other farmers about their results and the experimental methods used. Outsiders may be invited to participate in some of the group activities, but the group is self-governed.

In recommending a farmer research group approach, a recent workshop in Zambia agreed that "the aim of a research group is to generate a group of farmers with experience in experimenting and conducting research and who are able to collaborate with the Adaptive Research Planning Teams in developing an on-going research agenda" (Drink water 1994).

PTD focuses on transformation of local experimentation from being relatively ad hoc, unorganized and individual to being more focused, systematic and organized into a community process of technology development. Thus, PTD is a process not only of producing appropriate technologies but also of building self-help institutions for agricultural development. Although such institutions can take different forms, farmer- experimenter groups very often form an important part of them.

In the PTD process, the experimenter groups also contribute to:

- Deepening the situation analysis and problem identification through the confrontation of opinions;
- Developing a joint understanding of main constraints and opportunities;
- Enhancing farmers own experimental work through exchange of results, replications across farms, and increasing the range of technologies that can be tested;
- Linking with support institutions (governmental and non-governmental) to obtain their services; and
- Ultimately, influencing government policies (Veldhuizen et al, 1997)

Farmers groups can be successful in carrying out Farmers Participatory Research and an assessment of the most appropriate mode of operation, and of the best entry point for researchers and extensionists, is necessary within the context of each targeted community. In terms of spreading ideas and changing behavior, small groups have been proved very effective (Mason et al, 1999).

Modes of Farmer Participation

From the approaches outlined above and a synthesis of experiences from nine countries, Biggs (1989) identifies four modes of farmer participation, each characterized by the intensity of farmer involvement (Table 1). These are ‘contract’, ‘consultative’, ‘collaborative’, and ‘collegial’. The contract mode could correspond to the on-farm trial approaches whilst the consultative mode corresponds to the FSR and on-farm client oriented research approaches. The collegial mode advocates a strongly farmer-centric approach.

The collaborative mode represents the ideal in that it involves continuous interaction between researchers and farmers who are seen as equal partners in the research process. The mode allows for flexibility and does not follow strict stage of research. The emphasis of an on-farm program at any given time depends on the specific nature of the problems being faced by resource-poor farmers and the capability of the program. Each year, a range of participatory diagnosis, trials, and management methods is used. Priorities in the use of scientists’ time and other resources are on holding meetings for different purposes, involving different groups on farmers and other people at the village level.

Table1: Participation of farmers in research: distinguishing features of four modes

	Contract	Consultative	Collaborative	Collegial
Type of relationship	Farmer’s land and services are hired or borrowed, e.g. the researcher contracts with farmers to provide specific type of land	There is a doctor-patient relationship. Researchers consult farmers, diagnose their problems, and try to find solutions.	Researchers and farmers are partners in the research process and continuously collaborate in activities.	Researchers actively encourage the informal R&D system in rural areas.
Research emphasis	Testing and verification of technology	Surveying and diagnosis, testing and adaptive research.	Learning from farmers to guide applied and adaptive research.	Understanding and strengthening informal R&D.
Interaction over time	Variable	Determined by stages of activities,. i.e. diagnosis, design, development, verification, diffusion, monitoring	Continuous specific emphasis of activities each year, depending on joint researcher/farmer diagnosis of local circumstances.	Variable

	Contract	Consultative	Collaborative	Collegial
Types of farmers involved	Those who can guarantee the conditions of the contract	Representatives of the client group (which is defined by scientists).	Representatives of client groups (which are jointly defined by scientists and farmers) and change over time. Research farmers	Research farmers from the informal R&D system
Who speaks for resource poor farmers in the research process	Views and opinions of farmers are not emphasized	Field-level staff, Social scientists and Local representative.	Themselves, Research farmers, Local representatives, Junior and senior scientists	Themselves
Emphasis on extension/development	Variable	Research aimed at extension target areas or recommendation domains.	Variable	Strengthening the integration of informal research and extension capabilities
Priorities in on-farm research	Trials and written reports	Informal and formal surveys and trials. Reports of researcher analysis Field days for extension purpose.	Village research legitimacy meetings Meetings for diagnosis, panning, and interpretation trials Formal surveys	Supporting research farmers and research-minded local representatives and politicians Information networks for resource-poor farmers

Source: Biggs (1989)

Pretty *et al* (1995) observe that whilst the term 'participation' has become part of the normal language of many development agencies, it is not clear what exactly they mean as, within the same project or program, the term is often interpreted in ways that appear contradictory. It has been used to justify the extension of control of the state and to promote local capacity strengthening and self-reliance; it has been used to rationalize the primacy of external decisions and to devolve power and decision-making away from external agencies; it has been used to describe both data extraction and interactive analysis. From their observations Pretty *et al* (1995) has identified seven levels of participation (Table 2). These are passive participation; participation in information giving, participation by consultation participation for material incentives, functional participation, interactive participation; and self-mobilization. These observations seem consistent with those by Biggs (1989). The problem with the first four levels of participation (Table 2) is that the superficial and fragmented achievements have no lasting impact on people's lives. If the objective of external intervention and support is to achieve sustainable development, then nothing less than functional participation will suffice.

Table2: A typology of participation

Typology	Components of each type
1. Passive participation	People participate by being told what is going to happen or has happened. The information being shared belongs only to external professionals.
2. Participation in information giving	People participate by answering questions posed by extractive researchers and they do not have the opportunity to influence the proceedings, as the findings of the research are neither shared nor checked for accuracy.
3. Participation by Consultation	People participate by being consulted, and external agents listen to views. The external agents define both the problems and solutions, and may modify these in the light of people's responses.
4. Participation for material benefits	People participate by providing resources (e.g. land, labor) in return for material incentives. Much on-farm research falls under this category.
5. Functional participation	People participate by forming groups to meet Predetermined objectives of externally initiated projects. Such involvement tends to be after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
6. Interactive participation	People participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
7. Self-mobilization	People participate by taking initiatives, independent of external institutions, to change systems. Such self-initiated mobilization and collective action may or may not challenge existing inequitable distributions of wealth and power.

Source: Pretty, Thompson and Kiara (1995)

Conclusions

Farmer participatory research refers to the active participation of farmers in planning (problem diagnoses, identification of potential solutions and making decisions on what needs to be done) the research agenda, conducting research, evaluating potential technologies and applying the new technologies and practices. It is the practical process of bringing together, through dialogue, the knowledge and research capacities of the local farming communities and of the scientific institutions in an interactive way. Pretty, Thompson and Kiara (1995) call it 'interactive participation' whilst Biggs (1989) calls it 'collaborative mode of participation'.

This approach contrasts with conventional research models in that resource-poor farmers are not treated as passive subjects, but rather, as active partners who serve as consultants, design projects, gather data, interpret meanings, evaluate findings, recommend actions and disseminate results. Farmers' indigenous knowledge forms the base of the research agenda.

The importance of resource-poor farmer participation in research is now unquestionable but, attempts to adopt the approach are still poorly conceived and poorly supported in terms of resources and training of scientists. Because there has not been much evidence that the approach necessarily leads to the development of more appropriate technologies and higher adoption levels, commitment to the approach is still low. What is happening now is more like putting a 'resource-poor farmer participatory research label' (because it appears fashionable) on a system, which still regards farmers only as a junior partners waiting to receive and implement plans. Their participation in the research process is still confined to the provision of local resources (land, labor, and draft power and farm equipments) to enable successful implementation of the researcher's programs. This is simply a kind of participation for material benefit and doesn't enable us to exploit the whole merits of farmers' participation. For better improvement of the relevancy and overall efficiency of research we need to ensure collaborative/ interactive type of participation.

Of course, the practical implementation of participatory approaches may require necessary skills, resources and above all our own commitment. However for its many advantages in making our research more demand driven and hence client oriented and efficient, we need to further internalize participation in a real sense and make it a key element of our research system. One of the mechanisms to realize resource poor farmers could approaching them in self-reliant and self governed groups; Farmers Researcher Groups/Extension Groups.

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ANIMAL PRPDUCTION

Growth performance of Horro steers fed on different levels of molasses and maize grain at Bako

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Abstract

A total of twenty five growing Horro steers with average initial body weight of 206 kg were randomly assigned to the following five treatments: 1.7kg maize grain (Treatment 1), 1.3kg maize grain + 0.6kg molasses (Treatment 2), 0.8kg maize grain + 1.2kg molasses (Treatment 3), 0.4kg maize grain + 1.8kg molasses (Treatment 4) and 2.4kg molasses (Treatment 5). In addition to the treatment diets, all groups were supplemented with equal amount of noug cake (1.3 kg/h/d) to provide the protein requirements of the steers and a measured amount of teff straw as a basal diet.

Treatment had no significant (p>0.05) effect on final body weight, total body weight gain and average daily weight gain of Horro steers. Steers on diet 2, showed higher average daily weight gain (642 gm/d/h) followed by those on diet 1, 4, 3 and 5 (589, 587, 545 and 513gm/d/h) respectively.

Result of economic analysis indicated that substituting 0.4kg of maize grain by 0.6kg molasses, 0.9 kg maize grain by 1.2 kg molasses and 1.3kg of maize grain by 1.8kg molasses gave high net benefit of Birr 255.98, 229.76 and 243.26, respectively. The increment from feeding 0.4 kg maize + 1.8 kg molasses per head per day to 1.3 kg maize + 0.6 kg molasses per head per day (treatment 4 to treatment 2) was found to be economical and increased a net return by 38.26 % and either of the three treatments can be recommended interchangeably.

The result revealed that recommended levels of molasses from treatment 2 to 4 can substitute maize grain to support better growth performance of animals, since there was no significant (p>0.05) differences observed in weight gain of Horro steers. Thus, recommended levels of molasses can replace maize grain and one can use molasses as energy sources in a concentrate supplements for fattening Horro cattle.

Keywords: Growth performance, Horro steers, Molasses, Ground maize grain, Bako

Introduction

Natural pasture and crop residues are the major sources of livestock feed in western Oromia. Because of the steady conversion of grazing land into cropping fields, crop residues are gaining importance as animal feed. The shortcomings of these feeds, however, are their low protein and fermentable carbohydrate levels. Thus, they can supply only sub-maintenance requirement of animals when they are fed alone (Alemu *et. al*., 1991; Nuwanyakap *et. al*., 1987 and Seyum *et. al*., 1998). Different authors (Alemu *et. al*., 1991; Nuwanyakap *et. al*., 1987 and Seyum *et. al*., 1998; Lemma *et. al*., 1996; Alemu, 1976) recommended supplementation of crop residues by feeds of high protein and energy sources, for efficient utilization of the former. Among the high nutrient density diets suggested for supplementation noug cake and molasses are available in the western Oromia.

Molasses is an agro-industrial by product used as energy supplement for livestock in different parts of the world where sugar cane processing factories are available. Studies in Ethiopia (Amsalu et. al., 1995; Nuwanyakap et. al., 1987; Alemu, 1976) and elsewhere (Sibanda et. al.,

1987) showed a promising result from finishing studies where molasses was used as one of the major constituent of the ration.

So far, the conventional energy concentrate for fattening livestock are mainly grain feeds and flour mill by products. Research recommendations have been developed for sheep and cattle using maize grain as an energy source in a concentrate supplement for finishing sheep (Solomon *et al*., 1993) and cattle (Mulugeta *et. al*., 1995). However, due to the high cost of grains it is wise to look for alternative cheap sources of energy in a finishing diet.

Molasses, as an important energy source, appeared with the start of Fincha sugar factory in western Ethiopia. Replacing maize wholly or partly with molasses in the recommended concentrate supplement in finishing Horro cattle will not only cut feed expenses down, but also serve as a sound and diversified use of the sugar factory by products. Thus, the objective of this research was to compare the finishing performance of Horro steers fed molasses based concentrate supplement and identify the level of substitution of maize grain by molasses for finishing Horro steers.

Material and Methods

Description of the study area

Bako Agricultural Research Center is located 250 kms west of Addis Ababa at an altitude of 1650 masl. The center received mean annual rainfall of 1200 mm in a bimodal distribution, 80% of which falls from May to September. The area had a mean relative humidity of 59% and mean minimum and maximum temperatures of 13.5 and 27 ^{o}C, respectively.

Animal feeding and management

A total of 25 growing Horro steers with similar age and average initial body weight of 206 kg were used. These animals were randomly assigned to five treatments. The treatments were based on previously recommended 3kg Concentrate (49% maize and 49% noug cake, 1% salt) for finishing Horro oxen (Mulugeta *et al*., 1995).

Treatment1= 1.7 kg maize grain
Treatment 2= 1.3kg maize grain + 0.6kg molasses
Treatment 3= 0.8kg maize grain + 1.2kg molasses
Treatment 4= 0.4kg maize grain + 1.8kg molasses
Treatment 5= 2.4kg molasses.

In addition to the treatment diets, all animals were supplemented with equal amount of noug cake (1.3 kg/h/d) to provide the protein requirements of the steers and a measured amount of teff straw as a basal diet.

Molasses from Fincha sugar factory; noug cake and maize grain from local markets and teff straw from surrounding areas were bought and brought to the center. All steers were kept in individual pens and fed the treatment diet for 56 days after 15 days adaptation period.

Statistical Analysis

Data on daily feed intake and fortnightly body weight of the steers were recorded during the experimental period. The data was analyzed using the General linear model of Statistical Analysis System (SAS, 1996). During analysis treatment was considered as independent variables where as final body weight, total weight gain, daily weight gain and feed intake considered as dependent variables.

Economic analysis

For market value assessment, three local live animal dealers made price estimation and an average price was used for economic analysis. The economic analysis of feeding Horro steers with different levels of molasses and maize grain were made using partial budget, dominance and marginal rate of return analysis. In this analysis, the cost of noug cake and teff straw were not included but the changes in average prices of young steers, maize and molasses were considered. Maize price was taken as an average of five years and this average market price was converted to field price by reducing the costs of the farmers may incur beyond the farm (harvesting, shelling and transportation costs). Besides, the stability of this recommendation was supplemented by sensitivity analysis by varying the prices of inputs.

Result and Discussion

Growth performance of Horro steers

Initial body weight, final weight, total weight gain, average daily body weight gain and intake are indicated in Table 1.Treatment had no significant ($p>0.05$) effect on final body weight gain and average daily weight gain of Horro steers. This indicates that final weight gain and average daily weight gain were almost similar for all treatments. In agreement to this result Amsalu and Tesfaye (1999) reported that there was no significant differences between two successive molasses urea block supplemented groups in their growth rate. Steers on diet 2, showed higher daily weight gain (642 g/d/h) followed by those on diet 1, 4, 3 and 5 (589, 587, 545 and 513g/d/h), respectively. This is almost similar to the report of IAR (1976), the supplementation of teff straw basal diet was noted to support 629g/d for cattle. Since, there was no significant ($p>0.05$) difference observed between maize grain and molasses as supplement with noug cake in body weight gain of Horro steers the recommended level of molasses can substitute maize grain to support better growth performance of animals.

Feed intake of Horro steers

All supplements that offered to each steers were completely consumed regardless of molasses level. This is probably due to the DM intake, which was not materially affected by energy level, but it was rather significantly influenced by protein level.

An improvement in weight gain was observed as the level of molasses substitution increased from 0.6 to 1.8kg of supplementation. Similarly, Pickstock (1985) has reported that in time of drought when energy and protein reserves fall to dangerously low levels molasses urea mixtures can be feed in amount of up to 2kg a day there by helping to satisfy both energy and protein needs for maintenance. The total feed intake increased from 896 to 1034kg as maize was substituted with more molasses eventhough total intake per kg weight gain was higher ($p>0.05$) as level of molasses substitution increased from 18.8 to 51% of the ration.

A similar report indicated that optimum levels of fermentable carbohydrate could be included up to 50% of the ration (IAR, 1976). In agreement to this Jepsin and Creek (1976) have observed that under Ethiopian condition, inclusion of 40% of molasses in fattening diet was noted to support maximum live weight gain of local animals even though in Zimbabwe it was demonstrated the optimum level of molasses in fattening diet is 30%.

The higher gain was observed from treatment 2 to 4 with 0.6kg, 0.9kg and 1.8kg of molasses substitution; the weight gain per kg of supplement intake was also higher from diet 2 to 4. It implies substitution of maize grain by molasses for finisher diet had no effect on feed intake, digestibility, weight gain and feed to gain ratio.

Economic analysis

The economic analysis of feeding Horro steers with different levels of molasses and maize grain were made using partial budget, dominance and marginal rate of return analysis. In this analysis, the cost of noug cake and teff straw were not included but the changes in average prices of young steers, maize and molasses were considered.

The result indicated that substituting 0.4 kg of ground maize grain by 0.6 kg molasses, 0.9 kg maize grain by 1.2 kg molasses and 1.3 kg of ground maize grain by 1.8 kg molasses gave high net benefit of Birr 255.98, 229.76 and 243.26, respectively. The increment from feeding 0.4 kg maize + 1.8 kg molasses per head per day to 1.3 kg maize + 0.6 kg molasses per head per day (treatment 4 to treatment 2) was found to be economical and increased a net return by 38.26 %. Since the treatments were not compared against farmers' practices, MRR as low as 1% is also accepted and gave the highest net benefit. Dereje and Abdissa (2001) indicated that the price of maize at Bako drops during January and February and reach the peak in June and July. Asfaw *et al. (*1997) identified that in east wellega zone of Oromia region, feed shortage is serious between February and May.

Based on the findings of this study, it will therefore be advisable and economical to plan the start of fattening program immediately after maize harvest. The recommended rate of feeding is economically feasible if each of the prices of maize and molasses per kilogram is not exceeding Birr 0.98 and 0.07, respectively. Besides, detailed knowledge of livestock marketing trend in the area is also needed to decide when to start the fattening activities.

Conculusion and recommendation

The study revealed that recommended levels of molasses from treatment 2 to 4 can substitute maize grain to support better growth performance of animals, since there was no significant ($p>0.05$) differences observed in final body weight, total body weight gain and average daily weight gain of Horro steers.

It can be marked that fattening of Horro steers by feeding 1.3 kg maize grain + 1.3 kg noug cake + 3 kg teff straw + 0.6 kg molasses per head per day or substituting 0.9 kg and 1.3 kg of the earlier recommendation of 49.5% maize grain of the 3 kg concentrate per head per day by Tesfaye et al. (2000) with 1.2 kg and 1.8kg molasses per head per day is economical and either of the three treatments can be recommended interchangeably. The stability of this recommendation was supplemented by sensitivity analysis by varying the prices of inputs. The recommendation was found to be very sensitive to the changes in the prices of maize and molasses. It will therefore be advisable and economical to conduct the fattening program immediately after harvest or else whenever the price of molasses is less than the maximum as indicated in sensitivity analysis.

Thus, recommended levels of molasses can replace maize grain and one can use molasses as energy sources in a concentrate supplements for finishing Horro cattle.

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Table 1. Least square means of initial body weight, final body weight, average daily gain and intake of Horro steers fed different levels of molasses as a substitute to maize

Trait (kg)	TRT EFF	Treatments				
		1	2	3	4	5
Initial weight		209.4 ± 8.57	206.8± 8.57	204.8 ± 8.57	205.4 ± 8.57	207.5 ± 8.57
Final weight	Ns	242.4 ± 9.87	242.7 ± 9.87	235.3±9.87	238.2 ± 9.87	236.2 ± 9.87
ADG (gm)	Ns	589.3 ± 54.5	641.9 ± 54.5	544.6 ± 54.5	586.6 ± 54.5	513.4 ± 54.5
Total intake		839.2	896.0	924.0	978.8	1034.1
Maize Intake (%)		56	40.6	24.2	11.4	0
Molasses intake (%)		0	18.8	36.4	51.4	64.9

Ns=non significant

Table 2: Analysis of variance of body weight and daily weight gain of Horro steers fed different levels of molasses in a concentrate ration

Source of variation	Final body weight	Average daily gain (g/d)
Treatment	58.8	11924.8
Error mean square	486.9	14821.8
Error DF	20.0	20.0
R-square (%)	2.3	13.9
CV (%)	9.2	21.2

Table 3: Partial budget, dominance and marginal analysis on the fattening of Horro steers with different levels of maize grains and molasses.

Item	Treatments				
	1	2	3	4	5
Average wt.	242.35	242.7	235.2	238.2	236.2
Adjusted wt.	239.93	240.28	232.95	235.82	233.84
Gross benefit	768.76	800	756.67	754	743.33
Costs that vary					
Maize	67.59	51.69	31.81	15.9	0
Molasses	0	1.68	3.36	5.04	6.72
Transportation of molasses	0	7.39	14.78	22.18	29.57
Initial price	496.80	460.30	454	444.67	466.67
TCV	564.39	521.06	503.95	487.79	502.96
Net benefit	181.41	255.98	229.76	243.25	217.41
Dominance analysis using tabular method (NB are arranged in descending order)					
NB in descending order	255.98 (2)	243.25(4)	229.76(3)	217.41(5)	181.41(1)
TCV for each treatment	521.06	487.79	503.95	502.96	564.39
Dominance analysis	ND			D	D
MRR (%)	38.26%				

D: Dominated; ND: Non dominated; MRR: - 1%

Table 4: Sensitivity analysis for changing prices of maize and molasses in fattening Horro steers.

Item	Treatments				
	1	2	3	4	5
Average initial price of young steers Birr/kg)[2]	2.37	2.23	2.22	2.17	2.25
Average final price of young steers (Bir/kg)[1]	3.20	3.33	3.25	3.20	3.18
Average price of maize (Bir/kg)[2]		0.98			
Average price of molasses (Bir/kg)[2]		0.07			

1 Changes greater than the indicated figure are acceptable

2 Changes less than the indicated figure are acceptable

Data

Maize field price = 0.71 Birr/kg
Noug cake price = 0.20 Birr/kg
Teff straw price = 0.05 Birr/kg
Molasses price = 0.05 Birr/kg

Transportation cost of molasses = 0.22 Birr/kg
Weight down adjusted to: 1%

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Growth performance of crossbred calves reared on skim milk as partial milk replacer

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Abstract

Calf rearing costs are high due to feeding high amount of whole milk during early life. The effect of partial replacement of whole milk with skim milk on growth performance of 48 crossbred calves was studied. Calves were allocated into four treatments that employed whole milk to skim milk ratio of 3:1, 2:1, 1:1 and 1:0 based on breed and sex. Calves were reared on colostrum for the first four days of life and whole milk up to 20 days of age. Calves were then introduced into the experimental liquid diet-feeding program. All calves were weaned off liquid diet at the age of 70 days. Body weight attained at 10 and 24 weeks of age were not affected by skim milk feeding. Friesian cross Boran calves had markedly higher growth rate than Jersey crosses (P<0.05). Calf breed significantly (P<0.05) affected dry matter intake. Replacement of whole milk with skim milk at the ratio of 1:1 could be used for rearing calves without a check in growth rate.

Keywords: Calves, whole milk, skim milk, growth, feed intake, Friesian, Jersey, Boran, Crossbreed

Introduction

Calf rearing is one of the most important husbandry practices, which sustain dairy herd through supplying replacement stock. However, rearing costs are high. Although calves are reared on colostrum and whole milk during early life, rearing them exclusively on undefated whole milk raises production cost. This is particularly important because under Ethiopian context milk fat has high economic value when separated from milk and sold as butter (Zelalem and Ledin, 2000). Part of the whole milk, which is used for rearing, can be saved for sale or home consumption if replaced by more cheaper milk replacer diet.

A high quality milk replacer should contain 20-24%CP, preferably from milk byproducts (NRC, 1989). The young calf has little ability to utilize none milk source of carbohydrates, such as sucrose or starch, so the major carbohydrate must be lactose from milk products (Acker and Cunningham, 1998) as the calf is naturally well endowed with lactase (lactose digesting enzyme). Conventional milk replacers are made by adding animal fats to skim milk (Roy, 1980).

Dairy byproducts are the major source of carbohydrates (lactose) and proteins used in high quality milk replacers that have excellent nutritional value (Davies and Drackly, 1998). Vegetable proteins have failed to serve this purpose due to their low digestibility and their antigenic properties when fed to young calves (Killshaw and Sossons, 1979). A number of other protein sources have been tested in milk replacers for young calves. These include pea protein (Lalles, 1993), potato protein (Kolar and Wagnar, 1991; Branco-Pardal et al, 1995), fish protein (Huber, 1975; Diaz-Castaneda and Brisson, 1987), whole blood protein (Raven, 1972), red blood cell proteins (Sedgman et al, 1985). In addition to milk replacer, milk or colostrum, calves should be fed a high quality dry starter diet and hay from seven days of age. High quality starter and hay will encourage early rumen development.

In Ethiopia, under smallholder or commercial dairy farms milk replacers are not popular and are not used. There are no commercial milk replacer formulas on markets. Farm produced milk byproducts such as buttermilk are not used for calf rearing. Instead they are used for making cottage cheese. Whey, a chief protein source, produced as cottage cheese byproduct is seldom used as cattle feed. On the other hand, a worldwide industry has developed to produce and market milk replacers for calves and other young animals (Crane, 1991). However, information is limited on using skim milk as milk replacer for rearing calves and method of feeding as well.

The objective of this study was to evaluate the growth performance of crossbred calves reared on skim milk and develop an economical and suitable skim milk feeding strategy for rearing calves.

Materials and methods

Calves: Forty-eight Friesian cross Boran and Jersey cross Boran calves of 56-62% exotic blood inheritance were stratified by breed and sex and grouped into 4 treatments.

Treatments: Amount of whole milk and skim milk used as treatments was at the ratio of 3:1, 2:1, 1:1 and 1:0 whole milk to skim milk for treatments 1,2,3, and 4 respectively (Table 1).

Table 1. Amount of whole milk and skim milk consumed by each calf in each treatment

Treatments	Whole milk : skim milk ratio	Liquid diet consumed up to weaning, kg		
		Whole milk	Skim milk	Total
1	3:1	176.8	41.2	218.0
2	2:1	161.4	56.6	218.0
3	1:1	135.5	82.5	218.0
4	1: 0	218.0	0. 0	218.0

Liquid diet feeding: All calves were reared under artificial rearing method. Calves were fed colostrum in buckets from birth up to four days of age, and whole milk up to 21st days of age when replacement of whole milk with skim milk was commenced. All calves were weaned off from liquid diets at the age of 70 days (Table 2). Data collection on body weight and dry feed intake continued up to the age of 180 days.

Dry feeds: In order to complement Crude Protein (CP) and Metabolizable Energy (ME) value differences due to skim milk feeding in each treatment, four different calf starter diets were formulated to make each treatment iso-caloric and iso-nitrogenous (Table 3).

Table 2. Daily colostrum, whole milk and skim milk allowances for calves in the experiment

Calf age (days)	Type of liquid diet	Liquid diet (litres/day)
1-4	Colostrum	3
5-15	Whole milk	3
16-20	Whole milk	4
21-42	Skim milk and whole milk	4
43-63	Skim milk and whole milk	3
64-70	Skim milk and whole milk	2

Table 3. Calf starter formula used in the experiment.

Type of feed ingredients	Treatments (Whole milk: Skim milk)			
	1 (Diet 1)	2 (Diet 2)	3 (Diet 3)	4 (Diet 4)
Wheat bran (%)	29.6	30.1	20.2	20.0
Wheat midlings (%)	39.2	28.1	40.0	40.0
Noug cake (%)	21.6	32.4	25.4	25.0
Meat meal (%)	7.4	6.0	9.4	10.0
Bone meal (%)	1.2	1.5	4.0	4.0
Salt (%)	1.0	1.0	1.0	1.0
CP(g)	7100	7145.8	7303	6976. 0
ME(MJ)	503.7	485.2	419.7	555.9

Data collection and Laboratory analysis: Data were collected on body weight, and daily liquid and dry feed intakes.

Whole milk and Skim milk samples were collected weekly for chemical analysis. Milk fat was analyzed using Gerber method (BSI, 1989). CP was determined using formaldehyde titration method according to the technique described by Pyne (1932). Total Solids was determined by oven drying method (Marth, 1978).

Feed samples on offer were collected daily and bulked for weekly sampling. Samples were analyzed for Dry Matter (DM), Ash, and CP using standard procedures (AOAC, 1980). Neutral Detergent Fiber (NDF) was determined according to the procedure described by Goering and Van Soest, (1970). Two-stage technique of Tilley and Terry (Van Soest, 1967) was used to determine In-vitro Dry Matter Digestibility (IVDMD).

Statistical analysis: Data were analyzed as Split Plot Design (Nested) using ANOVA procedure of SAS (SAS, 1988). Test was used to compare different response variables between whole milk and skim milk, and between male and female calves.

Results

Total solids and protein composition of whole milk and skim milk used in this study were similar (P>0.05). However, whole milk used had 4.18% more fat per cent than skim milk (P<0.05) (Table 4).

Table 4. Chemical composition of liquid diets

Liquid diet	Number of samples	Total Solids (%)	Fat (%)	Protein (%)
Milk	20	13.2±0.3	4.8±0.1^{a}	4.3±0.04
Skim milk	20	9.0±0.9	0.17±0.0^{b}	3.2±0.03

Means with different superscripts within columns are different (P<0.05)

Chemical composition and IVDMD values of starter diet and hay used in the experiment are presented in Table 5. CP values in each starter diet were sufficient to support growing calves. IVDMD value was higher by 3.6% for calves in Treatment 1 than for calves in Treatment 3.

Table 5. Chemical composition and IVDMD of starter diet and hay used in the experiment

Feed Item	DM%	Ash%	CP%	NDF%	IVDMD%
Diet 1	89.6	7.1	21.0	36.8	82.6
Diet 2	90. 0	7.4	24.6	37.1	79.4
Diet 3	89.2	12.3	25.1	43.0	79.0
Diet 4	89.4	15.4	24.0	38.0	79.9
Hay	89.7	8.3	5. 0	73.3	53.9

Mean weaning and six-month weights were not affected by skim milk level. However, Friesian x Boran calves were heavier than Jersey x Boran calves by more than 14 Kg (P<0. 05) at 6 months (Table 6). Calf sex didn't affect body weight (P>0.05) (Table 7). Mean body weight gains during pre- and post- weaning periods were not affected by calf sex (P>0.05). However, body weight gains of calves during pre-weaning and post-weaning were 40-50 grams higher for Friesian crosses than Jersey crosses (Table 8). Overall body weight gains of calves was numerically higher for calves reared on whole milk than calves on partial skim milk. However, this difference was not marked (P>0.05).

Calf growth rates were similar (P>0.05) between males and females (Table 9).

Table 6. Mean body weights attained at different ages

Variables	Number of Obs.	Body weight, kg		
		Birth	Week 10	Week 24
Overall mean	48	25.7	47.3	70.9
Treatments		NS	NS	NS
1	12	25.6	47.2	71.1
2	12	25.1	46.3	67.2
3	12	25.4	47.8	71.4
4	12	26.1	47.8	73.8
Breeds		*	*	*
Jersey crosses	24	23.1	43.0	64.0
Friesian crosses	24	28.0	51.5	77.8
R2		0.3	0.5	0.5
C.V.%		19.2	11.0	12.4

* =P<0.05, NS=Not Significant.

Table 7 Mean body weights of calves by sex grouping

Calf Sex	Number	Birth weight (kg)	Week10 weight (kg)	Week24 weight (kg)
Males	24	26.4±1.0	47.5±1.5	72.2±2.6
Females	24	24.5±1.1	47.0±1.2	69.6±1.9

Table 8. Mean daily body weight gains of calves in the experiment

Variables			Daily weight gain, g	
	Number	pre-weaning[1]	post-weaning[2]	Overall[3]
Overall mean	48	311.6	214.6	252.3
Treatments		NS	NS	NS
1	12	309.6	217.6	253.3
2	12	303.6	189.5	233.9
3	12	322.6	215.1	257.0
4	12	310.7	236.3	265.2
Breeds		*	*	*
Jersey crosses	24	286.3	190.6	227.8
Friesian crosses	24	336.9	238.6	276.8
R2		0.2	0.3	0.4
C.V.%		22.8	27.8	15.8

* P<0.05, NS- Not Significant, 1= Birth to 70 days, 2 = 71 to 180 days, 3 = birth to 180 days

Table 9 mean daily body weight gain of calves by sex grouping

Calf sex	Number	Preweaning (g)	Post weaning (g)	Overall gain (g)
Males	24	321.4±13.0	223.5±141	153.9±10.9
Females	24	301.8±15.4	205.7±11.9	250.7±8.0

Total calf starter and hay intake (as fed) from two weeks to six months of age was not affected by skim milk feeding level and calf breed (Table 8). However Friesian cross Boran calves had markedly (P<0.05) higher starter intake as compared to Jersey cross calves.

Table 10. Mean starter and hay intake from two weeks to six months of age

Variables	Number of obs.	Diet intake, kg	
		Starter	Hay
Overall mean	48	105.9	128.4
Treatments		NS	NS
1	12	104.9	129.7
2	12	99.8	122.9
3	12	113.0	127.5
4	12	104.4	130.5
Breeds		*	*
Jersey crosses	24	93.5	114.8
Friesian crosses	24	117.5	140.5
Calf sex		NS	NS
Females	24	105.1	130.3

Males	24	105.9	126.4
R2		0.6	0.6
C.V.%		12.7	11.2

* $P<0.05$ NS- Not Significant.

Table 11 Mean daily feed intake of calves by sex grouping.

Calf sex	Number	Calf starter (g)	Hay (g)
Males	24	107.0±4.6	130.3±4.2
Females	24	105.08±3.8	126.4±3.6

Discussion

Skim milk used as partial milk replacer was very low in fat indicating availability of too low energy from skim milk alone. However, its CP content was not apparently (p>0.05) different from that of whole milk.

Crude Protein composition of starter diet used in treatment 3 was not expected to be higher than that of Treatment 1. Since calves in Treatment 4 were to be reared on whole milk, diet formulation was based on assumption that calves in this group will get more CP from Whole milk as compared to calves in the other Treatments. All starter diets had higher NDF values, which are above acceptable level of 15-25% (Schingoethe, 1998). At higher proportion of NDF energy intake will likely be limited by gut fill, while at lower proportion chemostatic factors may limit intake and insufficient fiber may be available for normal rumen function as suggested earlier (Schingoethe, 1998).

Body weight attained at six months of age were not affected by level of skim milk as compared to the control group (Treatment 4), indicating that whole milk can be partially replaced by fresh skim milk. However, calf breed affected body weight attained at 10 and 24 weeks of age. Failure of body weight to be affected by calf sex in this study is in agreement with earlier reports (Marshall and Smith, 1971). This might be due to low androgen level in male calves at early age to accelerate growth as reported earlier (Acker and cunningham, 1998).

Body weight gains during pre-weaning, post-weaning and overall periods failed to be affected by skim milk feeding. However, numerical values indicated better growth rate for calves on whole milk. In earlier report, it has been indicated that calves on whole milk gained more weight than that fed on non-fat milk. However, efficiency of energy utilization as Kilo Calorie of Metabolizable Energy intake above resting metabolism requirement per gram of gain was reported to be highest for calves on none fat milk (Marshall and Smith, 1971). In this study, Friesian cross calves gained more than Jersey crosses during pre-weaning, post-weaning and during the whole feeding periods, indicating the superiority of Friesian crosses over Jersey cross calves. This agrees with Acker and Cunningham (1998), who indicated weight gain to be dependent on genetic potential.

Skim milk feeding level didn't markedly affect starter feed and hay intake. However, calves fed two part whole milk and one part skim milk had numerically lower starter intake, while calves fed one part whole milk and one part skim milk had numerically higher starter intake. Breed affected starter diet and hay intake most probably due to marked difference in calf size. Calf size has been reported affecting feed intake (Acker and cunningham, 1998).

Conclusion

Replacement of whole milk with skim milk in rearing calves at the ratio of 1:1 starting at the age of 21 days can be used without check in calf growth rate as compared to calves reared on whole milk alone.

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Traditional feeding management, drought and migration of the camel herds of Afder Zone, Somali Regional State, Ethiopia

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Abstract

This study was initiated with the objectives of generating base line data in the area of traditional feeding management, drought and migration of the camel herds. The study was undertaken in the five purposely selected Woredas of Afder zone. Sampling methods used was stratified random sampling technique where each Woreda were classified into small (10 – 20 camels), medium (21-50 camels) and large (>50 camels) herders were considered. The study revealed that the traditional feeding management practices by camel owners. During grazing, particularly during the dry season, camels were found to cover large area (8, 10, 9 Km for small, medium and large herds respectively). The El-kari herds covered the least distance compared to other Woredas ($P \leq 0.05$). During the drought, they crossed national and international boundaries. All the camels irrespective of herd size and Woreda ($P \leq 0.05$) grazed for 5.3 to 5.7 hours before noon. The mean intervals between grazing were two hours. Salt sources of the study area were salt water, salty plants and salt itself. Salt feeding is commonly practiced during early dry season or late wet season. The mean water intake of adult camel was found to be 126-140 liters at first pause and 49-55 liters at the second pause. The mean watering intervals were 6.7-7.2 days during the dry season and watering interval of the wet season varied from one to two months. El-kari herd owners offered water at longer interval ($P \leq 0.05$) than the rest and these camels took more water during second pause ($P \leq 0.05$). It was noticed that the longer the watering interval the greater was the water intake in first pause ($P \leq 0.05$). It was observed that adult camels could survive without water 44.6 days. The mean feed deprivation tolerance were 31-39 days. During drought camels were the last species to be taken to market.

Keywords: herd management; feed deprivation tolerance; water deprivation tolerance; feeding management; salt feeding; watering; drought and migration; watering interval.

Introduction

Inadequate feeding is one of the serious problems in arid animal production systems. Like some other livestock species, camels have developed specific feeding behavior. In each season, they select the most palatable plants available (Dessalegne, 1985; Tekel, 1989).

In Afder zone, camel feed shortage is widely reported. However, few or no studies have been attempted. There is a lack of information on the plants and their current trends. Therefore, there is an urgent need to study camel feed management and their migration during different season through appropriate research on herd management, distance coverage during grazing, Feed deprivation tolerance, Water deprivation tolerance, Feeding management (Foraging), salt feeding, watering, drought and migration of the herds so that appropriate and timely interventions can be employed in feeding management during different season. Therefore, the present study was initiated with the objectives in generating base line information on traditional feeding management, drought and migration and also investigating the constraints of traditional camel husbandry in Afder zone of Somali Regional State.

Material and methods

The study was undertaken in Afder Zone, which is located in south east of Ethiopia and borders the Republic of Somalia. The zone covers the south-western corner of Somali Regional State (SRS) with an altitude varying from 250m to 600m. The zone has eight district/Woredas (West-Imey, El-kari, Gorobagagsa,Gouradamole, Hargelle, Jarati, Barey, Dollo-bay) and is inhabited by Somali pastoralists. Agro-pastoralism is practiced along the edges of three rivers namely Ganale, Web and Shabele. Crop production by agro-pastoralists mainly depends on rainfall that is erratic and hence livestock products particularly milk provides most of the daily food requirement of the pastoralists. In agro-pastoralism, small scale farming of sorghum and maize along the Ganale and Web rivers and petty trading generate additional income for the households. Accurate figures on livestock populations are not available because the area was largely inaccessible for the census survey made in 1994. The camel population figure estimated by the Southeast Rangelands Project (SERP) in 1998 showed that there were 260,000 heads of camel.

Sampling Procedure

The sampling method used was systematically stratified random sampling technique for the selection of the herd size whereas Woreda selection was based on accessibility, security situation and population. Accordingly five Woreda (Dollo-Bay, Jarati, Hargelle, Barey and El-kari) out of eight Woredas of Afder zone were selected.

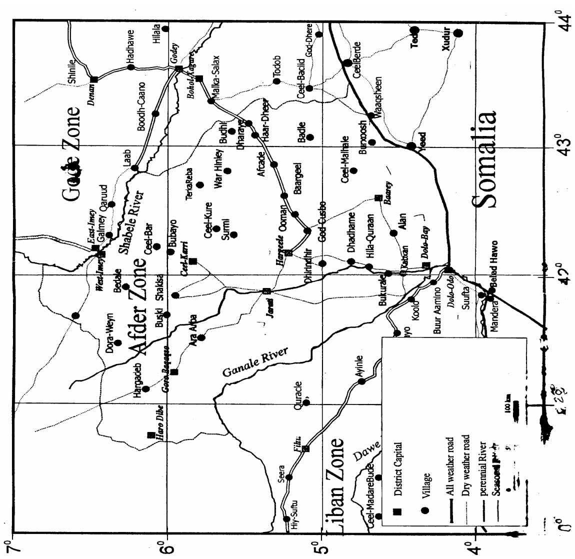

Figure 1. Location of the study area

In this study camel herd size was stratified as large herd (> 50 heads of camel), medium herd size (21-50 heads of camel), and small herd size consists of households that own 10 –20 heads of camel regardless of other livestock they have.

The study therefore excluded households, which owns less then 10 camels. This is due to the fact that these households were considered poor camel owners, in the area as they cannot herd separately and independently, and not able to provide information about their herds. The household was used as the unit of investigation; and the camel herd was used to stratify the household into three wealth classes. From each of selected Woreda five households for each of three-wealth class were randomly selected totalling 15 households for a Woreda and 75 households for the five Woreda.

Data collection

A single visit formal survey method (ILCA, 1992) was employed to collect information on traditional feeding management practices, drought and migration, herd management, distance coverage during grazing, feed deprivation tolerance, water deprivation tolerance and salt feeding management.

Statistical analysis

The statistical analysis of the primary data collected was made using the statistical package for Social Science (SPSS) version 10.

Results and discussion

Distance covered during grazing

It is known that camels are mobile in nature and can cover over a great area for foraging than any other domestic animals, which becomes very difficult for herders who had to roam with camels throughout. Although the area coverage during pasturing depends on the season, availability of feed, adaptability and the knowledge of the area, a distance of 8 to 10 km per day (Table 1) some times they cover 20 km per day has to be covered during dry season. According to the information obtained from camel owners, the mean area coverage throughout the year had been approximately 8, 10, and 9 km in small, medium, and large herd size, respectively. The long distances were recorded in Dollo-Bay (Figure, 2) with mean of 15, 10.5, and 9.6 km for small, medium and large herd sizes respectively; while the least area coverage observed at El-kari with mean area coverage of 1.8, 3.8, and 2.3 km for small, medium and large herd size, respectively. The area coverage distances within the various Woredas are significantly different and the mean differences are also significant when El-kari is compared with other Woredas. The later has difficult accessibility due to the different valleys made by flood. The wider coverage found in the present study is within the range of camel foraging coverage reported by different authors (Knoess, 1984; Bekele and Getu, 1998).

Table 1. Camel foraging characteristics

Herd size	Parameters	N	Mean	S.D
Small	Coverage during grazing (Km).	21	7.8	4.50
	Continuous grazing before noon (hour)	24	5.7	1.10
	Interval between grazing (hour)	24	1.8	62.00
	Feed deprivation tolerance (day)	23	39.0	23.00
Medium	Coverage during grazing (Km)	26	9.9	4.90
	Continuous grazing before noon (Hour)	25	5.8	1.20
	Interval between grazing (hour)	26	1.7	0.55
	Feed deprivation tolerance (day)	26	30.8	19.00.
Large	Coverage during grazing (Km)	24	9.4	4.90
	Continuous grazing before noon (hour)	25	5.3	1.20
	Interval between grazing (hour)	25	1.8	0.72
	Feed deprivation Tolerance (day)	25	35.0	22.00

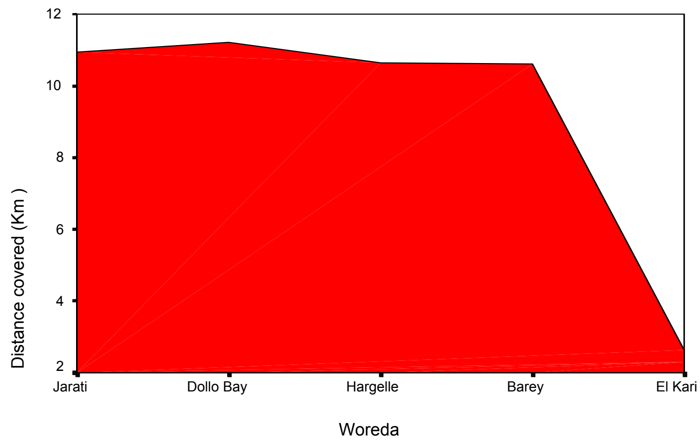

Figure 2. Woreda wise opinion of respondents on distance covered during foraging.

Time spent and interval of grazing

The minimum and maximum time spent on foraging during day time depends on range condition. Whenever the range condition was good, the minimum time spent for foraging during the day time was within the range of three to eight hours. In the present study, average hours of day time foraging was found to be 5.6 before noon and there was no significant differences ($P \leq 0.05$) among the studied herd size or among the Woredas. Then after about some time (two hours) around 2-3 p.m., camels again started browsing/grazing and continue until 2.a.m. Tazera (1998) also reported a similar practice in Southern Ethiopia. After continuous morning grazing the camels rest under the shades of trees and it is locally called as Harsi. The mean resting time between grazing were 1.8, 1.7, and 1.8 hours for small, medium and large herd size, with maximum of three hours (Table 1). The length of the resting time depends on the satisfaction of the animal (feed) on the first place before hot time of the day (noon), when camels are in need of rest. Other factors that determine the length of resting period are the environmental temperature. Long resting period was observed during months of February and March due to hot weather through out the day time.

Feed deprivation tolerance

As reported by respondents, camels can survive without feed for certain days when unexpected situation arises. The mean period that camels can live without feed varies with herd size 39, 31, 35 days for small, medium, and large herd sizes with high standard deviations, respectively (Table 1). It looks that there is slight difference for feed deprivation tolerance among the studied herd size. The response from camel owners at Jarati Woreda indicates that the overall mean tolerance days are about 42 days while at Hargelle Woreda it is about 21 days. The variation among the herd sizes and Woredas could be the owner's perception, or the difference of seasons, places/area, animal conditions and camel subtypes.

Management strategy and constraints

Camel management becomes difficult whenever there is a chronic feed shortage, grazing areas infested with biting flies and, when some plant start germinating or give new shoots but not enough to graze or browse at beginning of the rainy season. In these situations camels change their behaviour of normal foraging system because they feel stress and scattered in the field consequently camel herders face difficulty in managing their herds. The herders worked very hard to prevent camel from predators by frequent counting their herds while they are foraging. Therefore, additional labor was necessary to look after camels. During the dry season, a camel herd is divided into two sub-units: Irman and Horweyn. The former consists of milking camels and the later consists of rest of the herd (main herd). This finding is in agreement with the report of Hashi (1987). The principle of sub-dividing the herd and the family members to look after them is part of camel management strategy to overcome the problems of dry season feed scarcity. According to the traditional camel management system, each herd must have chairperson, who is responsible for most of the management decision.

Feed supplementation

Herders supplement good milker and pregnant camels by cutting palatable leaves and use hand feeding. Wilson (1998) suggested that if animals are expected to produce extra work or large quantity of milk supplementary feeding may be required. The current finding is contradictory to previous reports by Abebe, (1991) in Ogaden which could be due to the difference in camel husbandry practices and locations. Salt licks and good forage are the most important inputs to camel husbandry in the arid environment. Most respondent agreed that salt is needed for well being of their camel. It was noticed that when camel browsed salt rich plants, their condition improved and lactating camel produce more milk. On the other hand, when camel suffered from salt shortage, camel owners recognize such clinical features, which is unusual sign of ill health of animal (Jeel). Previous studies also reported the same (Abebe, 1991; Tezera, 1998). This study was revealed that 95.8, 100, and 76.0 % of small, medium and large herd owners, respectively feed salt to their camel during wet season. The availability of different variety vegetation during wet season will increase salt requirement of the camel. Some respondent suggested that salt water is more important during dry season. About 45.8, 84.6, and 80 for small, medium and large herd size reported that they gave salt water for their herds during dry season (Table 2). The camel owners reported that camel prefers salt supplementation during wet season and provision of salt water during dry season

Table 2. Frequency of salt water offers by herd size group and season

Herd size	Season	Frequency	Percent
Small	Wet	1	4.2
	Dry	11	45.8
	All	4	16.7
	No response	8	33.3
	Total	24	100
Medium	Wet	2	4.2
	Dry	22	84.6
	All	1	3.8
	No response	1	3.8
	Total	26	100
Large	Wet	1	4.0
	Dry	20	80.0
	All	2	8.0
	No response	2	8.0
	Total	25	100.0

Depending on salt availability and the season, camel owners use different types of salt sources; saline wells (salt rich wells found in the study area), salt plants and salt earth. The best-known potential area for such salt in the study area is Godusbo, which is located in northeast of Hargelle.

Table 3. Frequency of foraging of salt rich plants by herd size group and season

Herd size	Season	Frequency	Percent
Small	Dry	6	25.0
	All	4	16.7
	Late wet	11	45.8
	No response	3	12.5
	Total	24	100.0
Medium	Dry	5	19.2
	All	8	30.8
	Late wet	6	23.1
	No response	7	26.9
	Total	26	100.0
Large	All	2	8.0
	Late wet	19	76.0
	No response	4	16.0
	Total	25	100.0

Watering

It is well known that camels can survive for a long time without drinking water, which makes them different from other domestic livestock. This was confirmed during last drought season (1999-2000), which coincided with the current study period.

Distance to watering sites and watering interval

During the dry season, the mean distance to watering sites from their dwelling area were 21.2, 19.8 and 25.1 km for small, medium, and large herd sizes, respectively. However, during the wet season, these were 8, 7, 10.7 km for small, medium, and large herd sizes, respectively (Table 4).

Table 4. Camel watering and watering interval for different herd sizes

Herd size	Parameter	N	Mean	S.D
Small	Distance to watering point during the dry (Km)	23	21.2	9.7
	Distance to watering point during wet (Km)	11	8.0	6.0
	Watering interval during the dry season (day)	23	6.7	2.3
	Watering interval during the wet season (day)	23	34.0	20.9
	Water intake at first pause (liter)	21	126.0	43.6
	Water intake at second pause (liter)	21	55.0	19.6
Medium	Distance to watering point during dry (Km)	26	19.8	8.0
	Distance to watering point during wet (Km)	13	7.0	6.0
	Watering interval during dry (day)	26	6.8	7.0
	Watering interval during the wet season (day)	26	28.1	21.0
	Water intake at first pause (liter)	26	130.0	13.9
	Water intake at second pause (liter)	23	49.0	40.2
Large	Distance to watering point during dry (Km)	25	25.0	11.9
	Distance to watering point during wet (Km)	6	10.7	5.9
	Watering interval during dry (day)	25	7.2	2.4
	Watering interval during the wet season (day)	23	35.0	18.8
	Water intake at first pause (liter)	25	140.0	50.9
	Water intake at second pause (liter)	19	53.0	19.5

During the dry season, the distance from dwelling to water point was significantly ($P \leq 0.05$) greater at Dollo-Bay Woreda compared to Jarati and Hargelle Woredas. During the wet season, neither the woreda nor the herd sizes contribute to the difference in distance to water point. During the dry season camel travelled long distance to reach watering sites and sometimes herders spend one or two nights between watering sites and their dwelling sites. These observations more or less agree with the earlier reports (Krokfor, 1993; Bekele and Getu, 1998; Tezera, 1998). Long hours of walking between watering points and grazing area have been reported by Wilson (1998). The watering interval depends on factors such as vegetation types, physiological status of the animals (lactating or non lactating), and the season. The mean watering interval during the dry season was 6.7, 6.8, 7.2 days for small, medium, and large herd sizes, respectively, while the mean watering interval during wet season was about 34, 28, and 35 days for small, medium, and large herd, respectively (Table 4). During the dry season, El-kari herd owners offered water at longer interval ($P \leq 0.05$) compared to other Woredas and there was no difference among the herd size. However, during the wet season watering intervals were statistically similar for all Woredas and different herd size. The result obtained in the present study demonstrates the differences between watering interval of dry and wet seasons and varied from place to place and with in the range of figures reported in the literature (Wilson, 1984a; Herren, 1990; Abebe, 1991; Elmi, 1991; Dioli et al, 1992; Hussein, 1993).

Water intake

Moreover, the water intake of the camel is determined by watering interval and the quality of water. Camels prefer to have access to water throughout the day or night was called *Ceel-joog* (watering day). The major water intake will take place during the first session and they take rest for about 1-3 hours and herders were found to push them to drink more water again. According to the views of the respondents, the aim of second session is for reserve (Durduur). This means camels have to spend six hours in the day time or 12 hours in the night around watering points. The mean water intake for first pause was 126, 130, and 140 liters for small, medium, and large herd size, respectively. The mean water intake for next pause of the same day was found to be 55, 49.5, and 53 liters for small, medium, and large herds, respectively (Table 4). Comparing water intake based on herd size, revealed that the longer the watering interval of large herd size, the larger water intake for the first pause. Those herds of El-kari and Hargelle, which had longer intervals between watering, took significantly ($P \leq 0.05$) more water during the first pause of water intake. The Dollo- Bay and Barey herds were not different in water intake during first pause and they had short watering interval. Water intake of first pause was independent of herd size . During second pause also the El-kari, irrespective of the herd size consumed more water ($P \leq 0.05$) as reserve compared to rest of Woredas except Jarati. The total water intake observed in the present finding is in agreement with earlier finding of Abebe (1991) and Hashi (1987). But it is comparatively higher than the report of Dioli et al (1992).

Water deprivation tolerance and watering during dry season

Camel has long time for water deprivation tolerance but any interval over seven days during dry season is considered as stress condition. Consequently it reduces the appetite and milk yield. Respondents replied that the overall mean number of days that camels can survive without taking water was 44.6 days).

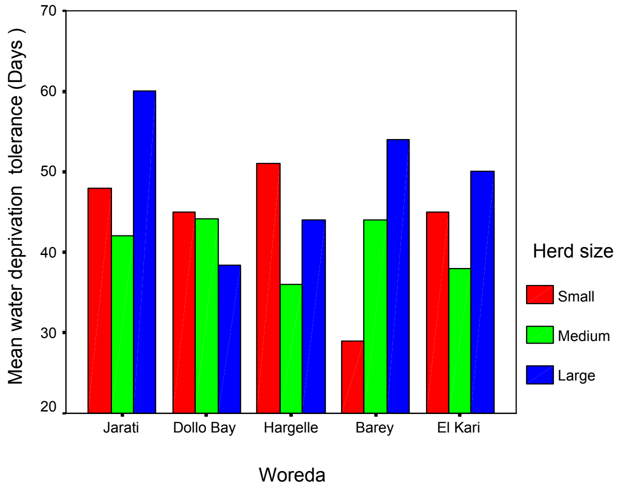

Figure 3. Opinion of respondent on water deprivation tolerance of camels by herd size and Woreda.

According to Hassan, (1971), camel can survive without water for 54 days. This figure is higher compare to report of Schwartz, (1992), which was 15 –20 days and Abebe (1991), which was 30 days. The adaptation and the economic water use by camel in almost all its metabolic functions were described by Schwartz (1992.). The result obtained in the present study revealed the extreme water deprivation of camels. According to the Schwartz (1992), the most significant aspect of this adaptation is the economic use of water in almost all metabolic functions. Numerous factors contribute to the superior water economy of the camel. According Wilson (1998) a major physiological adaptation of the camel is its ability to allow body temperature to fluctuate. In camels, about 95 percent of the evaporative heat losses are achieved by sweating. Camels can tolerate fluctuations of the deep body temperature from 34 to 42 ^{o}C. They can store considerable amount of heat during the day and can dissipate this by non-evaporative mechanism, radiation, conduction and convection, during the cool hours of the night ((Schwartz, 1992; Wilson, 1998). During wet season when vegetation is green and succulent it is not uncommon to see that camels go without water for 1-2 months. When dry season is approaching camel owners were found preparing themselves for hard work in order to provide water for their animals and they prepare necessary equipment for watering their camels. These include containers known as wadaan made by skin of goats or sheep used to fetch water from bottom of wells (5-10 m depth) and the qabaal (bucket), which is an open wooden container used to pour the water lifted by wadaan. These good buckets have the capacity to hold water for four to five camels at a time. The camel owners are in fatigue throughout the dry season, since they are engaged in bringing water to their camels from mid-night to morning (Abokor, 1986). Therefore, watering camels is the most laborious task that exhausts camel herders of all activities.

Drought and migration of the herds

Unfortunately, the study area was the most drought-affected area in Somali Region during the drought of 1999-2000. When there was drought across the study area, camel pastoralist preferred different strategies in order to save their family and animal from impact of the drought. Among the livestock species most affected groups were cattle, small ruminant, camel calves and old camels. The previous work of Stiles, (1993), Coppock, (1994), and Asefa (2000), in Ethiopia also indicated that cattle and small ruminants were more prone to disaster than camel. However, the sample size of this data is limited, because during data collection, herds were migrating. Nevertheless, the information provided suggests the primary estimation of drought susceptibility of different species. There has been long distance migration through out the study area. Many herders crossed the Kenya and Somalia side. During the peak period of drought almost all camel owners were frustrated and they considered this drought as disaster. They have been communicating with others every day to work out means by which they can save their animals. They used to discuss the dilemmas that faced them including where to go to save their assets and how they can face next season with minimum after effect. During drought season almost all cultural and religious practices and occasions will be postponed and people will focus only to save their herds from the impact of the drought. Such cultural and religious disturbances caused by drought are hardly discussed in the available literature, but they are the real challenge faced by camel pastoralists during every drought time

Table 5. Number of livestock lost (%) during of 1999- 2000 drought by herd size

Species	Herd size		
	Small	Medium	Large
Camel	11	12	16
Cattle	61	60	55
Sheep/goat	28	28	29

Observation of the researchers revealed that during early rainy season when depressions were filled with water, camel pastoralist migrated and settled on the upper land in order to avoid mosquito and biting flies, which are abundant in the low-lying areas (Bay). On the other hand, during late wet season, pastoralist preferred to come down to the low lying areas, because during this time flooded water will dry up, and the mosquito effect became minimum. At the same time, seasonal biting flies will emerge on the upper land (Dhuug). During season of ample availability of both feed and water, pastoralist liked to settle at vicinity of the urban areas in order to get access to market for the sale of milk and live animal and to get exchange goods without taking of long journey. During this period, it was noticed that migration was minimum and cultural practices including marriage and religious learning activities increased as large number of people were together in a place.

Conclusion and recommendation

Camels are mobile in nature and cover over a great area for foraging than any other domestic animals. The wider coverage observed was caused due to the feed shortage in the study area. Feed shortage is one of the serious problems in Afder zone of SRS. In this zone most forage plants are becoming limited, because of the rangeland degradation and overgrazing resulting in a shortage of plants. The problem of traditionally managed camel was further exacerbated by the frequent drought. Therefore, there is an urgent need to rehabilitate and restore the degraded rangeland through appropriate study on rangeland condition followed by development intervention.

It was noticed that camels can survive for a long time without drinking water, which makes different from other domestic livestock. However, the ability of the camel to survive long time , without drinking water should not obscure the fact that, in common with other livestock, it does need to drink. It was observed that during prolonged dry season, camel owners face problems of water crises and there was long hours of walking between watering points and grazing areas and some times herders spend one or two night between watering sites and their dwelling sites. Therefore, there is need to study availability of water resources and the distribution of water points. Nevertheless thought adaptation of camels for long period water and feed deprivation tolerance in well known from previous reports and confirmed by present work, effect of such dehydration and feed deprivation on milk production and reproduction is essential to understand in detail. This is another relevant area for immediate research focus.

Salt supplement, especially salt earth, salt water and plant rich plant salts is indispensable for camels, therefore chemical composition, contribution to the camel health and economic feasibility in utilizing these salt sources should be studied.

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Rural Smallholders Milk and Dairy Products Production, Utilization and Marketing Systems in East Shoa Zone of Oromia

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Abstract

A survey was conducted (July - December, 2002) in three districts of East Shoa Zone of Oromia (Arsi Negelle, Adami Tulu and Lume) to assess the present milk and dairy products production, utilization patterns and marketing system in the area. The average numbers of cattle per household were 17.3, 16.8 and 12.1 for Adami Tulu, Arsi Negelle and Lume districts, respectively. The average milk off-take of local Arsi cows was about 1.0 liter/head/day. On average about 3.0 liters of milk was produced/household/day out of which about 2.5 liters (83.3%) was accumulated for further processing and the remaining 16.7% consumed on daily basis. On average about 1.4 kg of butter was produced per household per week in all the three districts. Out of this total production about 1.2 kg per week (85.7%) was marketed and the remaining for home consumption. Thirty percent of women interviewed in Adami Tulu and Arsi Negelle did not make cottage cheese. Most of the respondents who produce "Ayib" use both for home consumption and sale. About 96.7% of the respondents in Adami Tulu and Arsi Negelle and about 93.3% in Lume districts did not sell fresh milk due to insufficient production and cultural taboo. There is a need to strengthen extension activities to increase milk production in the area and to change the attitude of farmers toward fresh milk sale. The establishment of organized milk collection and marketing infrastructures would encourage them to change these trends.

Key words: Milk, Milk products, Production, Consumption, Utilization, Marketing.

Introduction

The overall goal of meeting food self-sufficiency in the country includes plans for increased milk production, which should base on an increase in smallholder milk production. Increased production of milk is dependent on improved production facilities and marketing. So far, efforts have been made to increase the milk production by crossbreeding local zebu with exotic high yielder. However, to achieve sustainable smallholder dairy development, it is imperative that efforts to increase milk production be accompanied by developments in market infrastructure to facilitate marketing of increased milk production.

In most parts of the country, farmers practice the informal marketing system where the smallholder sells his surplus supplies to neighbors or in the local market, either as liquid milk or in the form of butter or a cottage type of cheese called "*ayib*" although some farmers restrain from selling of fluid milk because of cultural reasons. Few African smallholder milk producers have access to formal milk marketing systems (Debrah and Berhanu, 1991). Unless milk and milk products find a market outlet, they are retained for household consumption and the level of production is kept low (Fekadu, 1994). This low level production together with the general decline in the local production over the years as a result of the fast growing population, have lead to an increase in import dependence in dairy products. According to Wondosen (1998), the average per capita consumption of milk is 16 liters in Ethiopia compared to 27 liters in most African countries and 200 liters for developed countries.

Lack of regulations concerning the production and marketing of standardized dairy products in the region seems among the deterrent for dairy development. Therefore, describing the present milk production, utilization and marketing system could lead towards the dairy development in the country. Milk consumption varies considerably between, and within, countries. While wealthy consumers in poor countries regard milk as a basic food product, poor people in poor countries regard milk as a supplement to the traditional diet (Falvey and Chantalkhana, 1999). Within countries, consumption varies widely between and within social groups. Therefore, the objectives of this study are assessment of the present milk and dairy products production and utilization patterns in the area, and describing the current milk and dairy products marketing system in the areas.

Materials and methods

Description of the study area

The study was conducted in three districts of the East Shoa zone of Oromia (Arsi Negelle, Adami Tulu-Jido Kombolcha and Lume). These three districts are purposively selected based on the survey result of ATRC (1997) that, they are potential areas for milk and milk products production. The districts are found in the Mid-Rift Valley of Ethiopia. The altitudes of these areas range from 1500 to 2300 m. above sea level and have a semi-arid type of climate. The Mid-Rift Valley has an erratic, unreliable and low rainfall averaging between 500 and 900 mm annually. The rainfall is bimodal with the short rains from February to May and long rains from June to September. The predominant production system in these areas is mixed crop-livestock farming. Cattle are the most important livestock species in the areas.

Adami Tulu-Jido Kombolcha

The area is located some 167 km from Addis Ababa. It has area coverage of 140,325 ha at an altitude of 1650 m asl receiving an average annual rainfall of 771 mm, and minimum and maximum temperatures of 12.8 and 27.3ºC, respectively. The predominant crops of the area are haricot bean, teff and wheat with maize being the most important both in terms of the proportion of farmers growing it and the area coverage (ATRC, 1998, unpublished).

Arsi Negelle district

It is located about 231 km south of Addis Ababa and area coverage of 189,587 ha situated at an altitude ranging from 1500 to 2300 m asl receiving an average annual rainfall of 800 mm (500-1000 mm). The minimum and maximum temperatures of the area are 10 and 23ºC, respectively. The major crops grown in the area are wheat, maize, haricot bean and teff.

Lume district

It is located about 75 km south east of Addis Ababa at an altitude ranging from 1500-2250 m asl receiving an average annual rainfall of 900 mm (457-1400 mm). It has a total area coverage of 78,003 ha and the minimum and maximum temperatures of 18 and 25ºC respectively. The predominant crops grown in the area are teff, wheat, maize and barley.

Sampling procedures:

Six peasant associations (PA) from each district were randomly selected. From each PA, five women who owned milking cows and process milk were purposively selected and interviewed.

Accordingly, 30 women from each district, and a total of 90 women from the three districts were individually interviewed using a semi-structured questionnaire. The survey mainly focused on the production of milk and dairy products, utilization and marketing of dairy products. The reported milk and dairy products produced, utilized and marketed in the area were based on the farmers' response. The data collected through survey were analyzed using the descriptive statistics procedure of the Statistical Package for Social Science (SPSS, 2000).

Results and discussion

Cattle holding and milk production

The average numbers of cattle per household were 17.3, 16.8 and 12.1 for Adami Tulu, Arsi Negelle and Lume, respectively, with the high proportion being milking and dry cows indicating that milk is the primary function of animals in these three districts (Table 1). The majority of the cattle in the area are indigenous Arsi zebu. The number of crossbred cows was insignificant. The majority of the farmers prefers local cows claiming that crossbred animals are susceptible to feed shortage, diseases and even did not know how to manage them. Some farmers prefer exotic animals for their higher milk production and traction. The average milk off-take of local Arsi cows was about 1.0 liter/head/day (Table 1). The reported average daily milk off-take of local and crossbred cows in the current study was lower than the means reported in literature. This lower average daily milk off-take per cow per day in the current study could be attributed to the critical feed shortage due to drought in the country in general and in the study areas in particular. Acacia pod is the only feed resource given as a supplement to lactating cows before milking especially in the Adami Tulu and Arsi Negelle areas.

Table 1. Average household cattle herd size, composition, milk yield and lactation length of cows in the three districts of East Shoa zone of Oromia as reported by respondents.

	Districts			
Animals	Adami Tulu N = 30	Arsi Negelle N = 30	Lume N = 30	Mean N = 90
Milking cows/HH	3.2	3.1	2.2	2.8
Dry cows/HH	3.3	2.8	2.1	2.7
Oxen/HH	2.8	3.2	3.5	3.2
Heifers/HH	2.7	2.3	1.0	2.0
Calves/HH	3.2	3.1	2.2	2.8
Young bulls/HH	1.3	1.9	0.8	1.3
Bulls/HH	0.7	0.3	0.2	0.4
Crossbred cows/HH	0.1	0.1	0.1	0.1
Average herd size/HH	17.3	16.8	12.1	15.3
Average daily milk yield (liters)				
Local	0.9(28)	1.0(28)	1.0(27)	1.0(83)
Crossbred	8.0(2)	3.3(2)	6.0(3)	5.8(7)
Lactation length (months)				
Local	10.5(28)	9.9(28)	8.0(27)	9.5(83)
Crossbred	8.5(2)	11.5(2)	9.7(3)	9.9(7)

Numbers in parenthesis indicate the number of observations in each district ; HH = Household

Mukasa Mugerwa *et al* (1983) also reported that local cows around Debre Zeit produced 524 liters of milk in a 239 days lactation period, which is about 2.2 liters/day. Similar study conducted by Brokken and Senait (1992) also revealed that the average daily yield of local cows was about 2 liters compared with about 6 liters for crossbred cows. According to CSA (1996), an average lactation length of cows in private holdings ranged from 5 to 7 months, with average daily milk yield of 1.3 liters. The value obtained in the current study is comparable with the value reported by Fekadu (1994) in southern parts of Ethiopia, a mean lactation length and daily milk yield of 11 months and 1.0 liter respectively.

On average, each household owned about 2.8 milking and 2.7 dry cows making the average total cows per household about 5.5 (Table 1). The lactation length of local cows varied from 5 to 12 months with an average of 9.5 months while the calving interval varied from 1 to 2 years.

Milk consumption and utilization patterns

Fresh milk, fermented milk, buttermilk, whey, butter and cottage cheese were among the common dairy products produced and consumed in the area with varying degree. In most cases fresh milk and fermented milk were not consumed on the daily basis, as they were reserved for further processing. The milk consumption system of the area was characterized by considerable product diversity. At the household level the consumption pattern is defined as the combination of the types, quantities and frequencies of dairy product consumption (Mullins *et al*., 1994). These parameters are closely linked to household location and income classes. Earlier reports indicate that in most parts of Ethiopia the milk produced on farms are used for calves, consumed by the family members and sold to local markets (O'Mahony and Ephraim, 1985; Zelalem, 1999). But selling of milk was not common in the study areas. Reasons for not selling fresh whole milk are indicated in Table 2. Among the many reasons reported by farmers, insufficient amount of milk production and cultural restriction were the most common hindering factors. These problems were also reported by Alganesh (2002) in Eastern Wollega. According to this author, about 21.3% and 19% of the women in Eastern Wollega did not sell fresh milk due to scarcity and cultural restriction respectively. Because of low milk production in the traditional sector, little or no milk is usually available for sale. Besides, difficulty is often experienced in finding a market (Van den Berg, 1988). In some households, only the husband has the privilege to drink milk though it depends on the number of milking cows they have. Usually it is the husband and rarely babies of less than one year age that have access to fresh milk. The percentage of households regularly consuming buttermilk was relatively high in the area.

Table 2. Reasons of respondents for not selling fresh whole milk in three districts of East Shoa zone of Oromia.

Reasons	Percent respondent in each districts			
	Adami Tulu	Arsi Negelle	Lume	Mean
Lack of demand	3.3	10.0	6.6	6.7
Low price	0.0	0.0	0.0	0.0
Lack of market/ collecting centers	3.3	13.3	16.7	11.1
Cultural restriction	46.8	33.3	30.0	36.7
Scarcity of milk	43.3	40.0	46.8	43.3
Preference to processed product	3.3	3.3	0.0	2.2

Consumption of processed dairy products was observed even less frequently among the rural low income households, indicating that the majority of the population do not consume processed product (butter) to any substantial degree. The limited consumption of butter may be due to the higher price associated with it and the need for cash income to buy some necessities. Butter can fetch them a good price compared to other milk products. Butter was consumed only during holidays and special occasions in rural low-income households because it fetches routine cash income.

Out of the thirty women interviewed in Adami Tulu and Arsi Negelle, nine women (30%) did not make "shalalaa"-(Ayib) (Table 3). Most of the respondents (90.5%) who produce cottage cheese in Adami Tulu use cottage cheese both for home consumption and sale while the rest use cottage cheese only for home consumption. Among the respondents who produce "shalalaa" in Arsi Negelle, about 62% used both for home consumption and sale while 28.5% used only for home consumption and about 9.5% produce it only for sale (Table 3). In Lume district 50% of the respondents made cottage cheese both for home consumption and sale. About 46.7% produced it only for home consumption and only about 3.3% of them produced solely for sale (Table 3). The processing of buttermilk into cottage type cheese depends on the amount of milk they have and the need for money to buy other necessities. At farm level whey is fed to calves or consumed by humans to break thirsty since water is a critical problem in the area.

Table 3. Dairy products utilization patterns in three districts of East Shoa zone of Oromia as reported by respondents.

Percent respondent in each districts			
Parameters	Adami Tulu	Arsi Negelle	Lume
Do you make butter?			
Yes	100(30)	96.7(29)	100(30)
No	0.0(0)	3.3(1)	0.0(0)
Do you sell butter?			
Yes	96.7(29)	89.7(26)	83.3(25)
No	3.3(1)	10.3(3)	16.7(5)
Do you make cottage cheese?			
Yes	70.0(21)	70.0(21)	100(30)
No	30.0(9)	30.0(9)	0.0(0)
For what purpose do you use cheese?			
Home consumption	9.5(2)	28.5(6)	46.7(14)
Sell	0.0(0)	9.5(2)	3.3(1)
Both	90.5(19)	62.0(13)	50.0(15)

Numbers in parenthesis indicate the number of observations in each district

The average milk and milk product production, consumption and marketing per household are indicated in Table 4. The average milk production in Adami Tulu district was higher than Arsi Negelle and Lume by 18.9% and 24.6%, respectively. This higher average milk off-take per household in Adami Tulu could be related to the number of milking cows per household (3.20) compared to Arsi Negelle (3.10) and Lume (2.20) (Table 1), available feeds in the area and parity of the cows from which milk was collected. The number of milking cows per household in the current study is even higher than the total cows per household reported by Zelalem (1999) in the central highlands of Ethiopia (2.7, 2.7 and 1.7 for Holetta, Selale and Debre Zeit, respectively). The average fresh milk consumption per day (0.5 liters) reported in this study (Table 4) is in agreement with the value reported by Alganesh (2002) in Eastern Wollega (0.55 liters).

Table 4. Production, consumption and marketing of milk and milk products per household in three district of East Shoa zone of Oromia as reported by respondents.

Districts				
Parameters	Adami Tulu N = 30	Arsi Negelle N = 30	Lume N = 30	Mean N = 90
Average milk produced/day (liters)	3.5	2.8	2.6	3.0
Average milk consumed/day (liters)	0.5	0.3	0.6	0.5
Average milk marketed/day (liters)	0.0	0.0	0.0	0.0
Average milk accumulated/day (liters)	3.0	2.5	2.0	2.5
Average butter produced/week (kilogram)	1.5	1.4	1.4	1.4
Average butter consumed/week (kilogram)	0.4	0.1	0.1	0.2
Average butter marketed/week (kilogram)	1.1	1.2	1.3	1.2
Average butter price/kilogram (ETB)	21.4	24.7	23.7	23.3
Average cottage cheese price/kilogram (ETB)	2.8	3.1	3.3	3.0

ETB = Ethiopian Birr, N = Number of households

In the majority of the households, milk was not consumed fresh on a daily basis as it is accumulated to ferment naturally as the first step in processing. Out of the total milk produced per household per day, about 83.3% was accumulated for further processing, and the remaining

16.7% was consumed on a daily basis (Table 4). Contrary to this, in a study conducted among pastoralists on the Borana plateau, 69% of the milk produced was used as fresh milk and the remainder was soured for direct consumption or butter processing (Coppock *et al.*, 1992). The amount of fresh milk consumption depends on the living standard of the family and availability of food crops in the year. If there is a failure in food crop production and scarcity of food supply, the major portion or almost all the fresh milk produced per day is accumulated and stored to make butter to sell and buy cereals. Coppock *et al (*1992) reported that in the long rains, use of milk was dominated by consumption (46%), followed by storage to make butter (29%) while in the dry season the proportion consumed was similar (43%), but more (50%) was allocated to butter making. In the area studied, the processing and marketing of dairy products is under the control of women. This has been commonly reported elsewhere in African pastoral and agro-pastoral systems (Kerven, 1987a,b). A study conducted on the dairy marketing in Kenya also indicated that nearly 60% of milk produced in Kenyan smallholders is consumed within the producing households (Stephen and Joash, 1990). On average about 1.4 kg of butter was produced per household per week in all the three districts. Out of this total production about 1.2 kg per week (85.7%) was marketed (Table 4). Only about 0.2 kg (14.3%) of the total butter produced was consumed. On average about 174 g of butter was sold per household per day in these areas. This value is higher than the value reported by Debrah and Berhanu (1991) that rural dairy-producing households sold on average 127 g of cooking butter per household per day.

Marketing of milk and dairy products

In all the three districts, farmers practice the informal marketing system where they sell their products to neighbors or in the local markets. About 96.7%of the respondents in Adami Tulu and Arsi Negelle and about 93.3% in Lume district did not sell fresh milk (Table 5). These values are much higher than the value reported in the central highlands of Ethiopia. According to the report by Zelalem (1999), about 57% and 40% of farmers in Holetta and Selale, respectively, did not sell fresh milk while around Debre Zeit fresh whole milk was seldom sold. The same author also reported that, around Holetta about 83% of the farmers sold butter at varying frequencies while around Debre Zeit only one farmer sold butter once in a week. In most cases butter was not consumed in poor farm family but rather it is sold to buy other commodities including cooking oils, as the latter are cheaper than butter. In deed about 3.3%, 10.3% and 16.7% of the respondents in Adami Tulu, Arsi Negelle and Lume, respectively, stated that they never sold butter (Table 5).

The majority of the women in the study districts sold their dairy products (butter and cheese) once a week (Table 5). The vast majority of the farmers are living at about two hours walking distance from the market place and there is no formal dairy marketing system in place. The small quantity of butter produced per day may not be accumulated to the desired volume to be marketed. On average they travel about 7.3 km (ranging from 1 to 30 km) to market places. About 50% of the respondents travel more than 10 km in a single trip on foot to take their products to market. Milk products were marketed on the basis of volume rather than weight. Butter was commonly measured in cups, which have different sizes (small, medium and large). Two medium cups were equivalent to one kg of butter and sold at the rate of 23.3 Birr/kg of butter. Butter was also sold in coffee cups of different sizes. On the average six medium coffee cups were equivalent to one kg of butter. These estimations were based on experience and mostly decided by butter traders. The middlemen reap most of the benefits by buying from the rural producers on the basis of rough estimates of volume and selling on the basis of weight to consumers in urban areas. In all the study areas, there was no report of marketing sour milk, buttermilk and whey. About 34.5%, 23.1% and 58.3% of the respondents in Adami Tulu, Arsi Negelle and in Lume districts, respectively, sold their products directly at market. Only 8.4% of the respondents in Lume sold the butter solely to their neighbors while the rest sold their products both at the market and to their neighbors. Almost all of the consumers or traders consider the color, flavor, texture and cleanness of the products during transaction. According to the respondents, butter with an even and yellowish color, clean flavor and close texture is considered as quality butter. Butter that fails to fulfill these requirements does not fetch them a good price. Therefore producing good quality butter is very important to earn better income and could help to promote the living standard of the rural producers. There was a fluctuation of both butter and cottage cheese price depending on seasons, holidays and wedding.

Table 5. Frequency of selling of milk and dairy products in three districts of East Shoa zone.

Selling frequency	Fresh whole milk (%)	Butter (%)	Cottage cheese (%)
Adami Tulu			
Do not sell	96.7(29)	3.3(1)	9.5(2)
Every day	-	10.0(3)	-
Every other day	3.3(1)	10.0(3)	9.5(2)
Once per week	-	66.7(20)	76.2(16)
Twice per week	-	-	4.8(1)
Fortnightly	-	10.0(3)	-
Arsi Negelle			
Do not sell	96.7(29)	10.3(3)	28.5(6)
Every day	-	-	-
Every other day	3.3(1)	10.3(3)	4.8(1)
Once per week	-	69.1(20)	66.7(14)
Twice per week	-	-	-
Fortnightly	-	10.3(3)	-
Lume			
Do not sell	93.3(28)	16.7(5)	40.0(12)
Every day	6.7(2)	-	-
Every other day	-	13.3(4)	3.3(1)
Once per week	-	50.0(15)	56.7(17)
Twice per week	-	10.0(3)	-
Fortnightly	-	10.0(3)	-

Number in parenthesis indicate the number of observations

Butter packaging materials

Various plant leaves including “Baala bakkanniisaa” (*Croton macrostachyus*), “Baala warqee” (*Ensete ventricosum*), “Baala qobboo” (*Commicucarpus africanus*), “Baala hiddii” (*Solanum spp*) and “Baala dabaaqulaa” (*Cucurbita pepo*) are used as the most common butter packaging materials in most parts of the study areas. According to some respondents these leaves may reduce the volume of the butter because butter remains on leaves when the leaves are removed. As a result they use cleaned muslin cloth instead of leaves believing that butter does not stick to this cloth. Some respondents also reported the use of plastic bags as a butter packaging material. The effect of these packaging leaves on the quality and characteristics of butter deserves further investigation.

Summary and Conclusion

Fresh milk, fermented milk, buttermilk, whey, butter and cottage cheese are among the common dairy products produced and consumed in the area with varying degree of consumption. In most cases, fresh milk and fermented milk are not consumed on the daily basis because they are reserved for further processing. Out of the total milk produced per household per day (3.0 liters), about (2.5 liters) was accumulated per day for further processing while only about (0.5 liters) of the total production was consumed on a daily basis. According to some respondents, butter was consumed only during holidays and special occasions in rural low-income households as it fetches income for the family. On average about 1.4 kg of butter was produced per household per week in all the three districts. Out of this total production about 1.2 kg per week (85.7%) was marketed per household per week. Only about 0.2 kg (14.3%) of the total butter produced was consumed per household per week.

About 36.7% of the women interviewed did not sell milk due to cultural restriction. There is a need to strengthen extension activities to increase milk production in the area and to change the attitude of farmers toward fresh milk sale and establishment of organized milk collection and marketing infrastructures could encourage them to change this trend. There is also a need to stimulate the consumption of dairy products in the area as low demand for dairy products can potentially discourage production in the long run.

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Lessons from On-farm Performance Evaluation of Simmental x Borana Crossbred Cows at Adami Tullu and Arsi Negelle Districts, Mid Rift Valley

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Abstract

Twelve Simmental x Borana crossbred in-calf heifers/primiparous cows in their last trimester were distributed to selected farmers in Adami Tullu and Arsi Negelle districts in July 1997 to evaluate their performance under farmers management condition. Data were collected for five years (August 1997 to July 2002). Cows kept by farmers around Adami Tullu showed better performance for all traits considered in this study as compared to those at Arsi Negelle. They had higher mean DMY (5.49 ± 2.34kg Vs 3.58 ± 1.74kg), mean LMY (1479.44 ± 689.63kg Vs 971.25 ± 484.12kg), mean LL (269.67 ± 106.93 days Vs 249.90 ± 96.27 days) and shorter mean CI (497.55 ± 98.43 Vs 599.00 ± 162.05). A highly significant effect of year on milk yield was observed ($P< 0.001$). A relatively better performance was observed in the first year following their dispatch. Cows gradually seemed to adapt to the on-farm conditions and showed steady increase in milk yield across the year. Both calving season and season of milking had a highly significant effect on daily milk yield ($P < 0.001$). Generally cows that calved during the short rains (March – May) and main rains (June – August) tended to perform less. Parity had a highly significant ($P < 0.001$) effect on daily milk yield. There was a gradually increasing trend in daily milk yield from first to fourth parity. It has been concluded that keeping crossbred cows is profitable but the need to improve milk marketing, supply of industrial by products, veterinary and AI services and the importance of close and regular monitoring has been indicated.

Introduction

In Ethiopia especially in semiarid areas where livestock provides a livelihood for the majority of the population, indigenous livestock breeds form the backbone of the livestock production because of their ability to survive and reproduce under stressful tropical conditions. Although the country is reputed for its wealth of livestock population, productivity per head of indigenous breeds is low and progress in livestock production has remained stagnant (Gizaw, 1987) primarily hampered by genetic component, shortage of feed, disease and management factors apart from technical, policy and institutional problems (Azage *et al.,* 1995). Crossbreeding indigenous animals with temperate breeds has been used in the past and certainly continues to be used in the future in order to meet the ever-increasing demands because of the rapidly increasing population. However, the crossbreeding and/or replacement strategies used were indiscriminate due to the fact that there is no proper policy and breed utilization strategy in place. The extension service and farmers training program is also poor in this regard.

Results of crossbreeding study at Adami Tullu using Simmental, Holstein Friesian and Jersey breeds as sire and Borana and Barka as dam breeds indicated that F_1 crosses on the average produced four to five times the milk that could be obtained from pure indigenous breeds kept on-station (ATRC, 1994). It was also revealed that Simmental x Borana crossbred cows supported a

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favorable level of growth rate of their calves and produced enough amount of milk in a cow-calf program. Hence, Simmental crosses were selected and recommended as the best dual-purpose breed in fulfilling the requirements of smallholder farmers in the area (ATRC, 1994). The present study was intended to evaluate the performance of Simmental x Borana F_1 crossbred animals under smallholder farmers' management conditions and demonstrate them in Adami Tullu and Arsi Negelle areas.

Materials and Methods

Study Area

Two areas, Adami Tullu and Arsi Negelle districts located within the radius of 80 km from Adami Tullu Research Center, were selected for the execution of the project. Adami Tullu district is characterized by semi-arid climate with a bimodal rainfall pattern that is unevenly distributed with values ranging from 500 – 700 mm per annum. The mean minimum and maximum temperature is 12.6 and 29.6^{0}C, respectively. Arsi-Negelle district is located in Eastern Shoa Zone of Oromia region at about 240 km from Addis Ababa. It has an altitude ranging from 1700 to 2000 m.a.s.l. The topography of the area is gently sloping or flat. The soils of the area are lightweight, friable loam or clay loam. The rainfall of the area is bimodal, with the short rain occurring from February to April and the main rain from June to October. The temperature of the area ranges from 18^{0}C to 25^{0}C.

Selection of Participant Farmers

A total of eleven farmers (6 from Adami Tullu and 5 from Arsi Negelle districts) were purposively selected for the study using service cooperatives as a sampling structure. Two farmers per service cooperative were selected. Criteria used included willingness of the farmer to participate in the project, allocate 0.5ha of land for improved forage production and construct simple shelter for the crossbred animal, accessibility, presence of literate person in the family who can keep records and ability to afford for the subsidized price of the crossbred animal. The following agreement was signed between the Center and participating farmers.

That the Center provides:

- In-calf crossbred heifer/cow at a subsidized price
- Forage seeds (*Lablab purpureus* and Rhodes grass) free of charge each year until the project phases out
- Technical counseling and support on improved dairy management and forage production
- AI, vaccination and treatment services free of charge

That the farmers:

- Allocate at least 0.5 ha of land and cultivate forage crops or pasture
- Provide labor required on-farm
- Handle project animals based on recommendations given and refrain from either selling or using the animals for different purposes that may affect the project
- Construct shelter for the crossbred animals

Experimental Animals and their Management

Twelve in-calf heifers/primiparous cows in their last trimester were distributed to the selected farmers in the month of July 1997. The farmers were provided with seeds of *Lablab purpureus* and Rhodes grass to be planted on 0.5ha of land each year throughout the project period. All the participant farmers kept the crossbred animals separate from other stock both while grazing and housing. At both sites crop residues formed the bulk of basal diet in addition to pasture grazing for about 6 hours a day. Industrial by-products such as noug seed cake, wheat bran/middling and linseed cake were offered as supplemental diets at varying levels at each household. Regular biannual vaccination against major livestock diseases, treatment and artificial insemination services were provided free of charge by the center.

Data Collection and Analytical Methods

Trained enumerators were used to record milk yield and feed intake parameters on weekly basis using standard formats and a spring balance throughout the experimental period that took place from August 1997 to June 2002. Farmers were also trained on basic modern animal husbandry practices and record keeping. Descriptive statistical method was used to analyze the data for simple comparisons using the MINITAB statistical software package. Effects of calving season, year, season of milking and parity on milk yield were analyzed using the GLM of SAS statistical software (SAS 1999). The model used was: $Y_{ijkl} = \mu + C_i + Y_j + S_k + P_l + e_{ijkl}$, where Y_{ijkl} is the dependent variable; μ is the overall mean; C_i is the effect of i^{th} calving season (n = 4); Y_j is the effect of j^{th} year (n = 5); S_k is the effect of k^{th} season (n = 4); P_l is the effect of l^{th} parity (n = 4) and e_{ijkl} is the residual error term.

Results and Discussion

Milk Yield Performance, Lactation Length and Calving Interval

Mean ± SD values for daily milk yield (DMY), lactation milk yield (LMY), lactation length (LL), and calving interval (CI) are presented in Table 1. Statistical comparison between the two sites has not been done due to small sample size. However, cows kept by farmers around Adami Tullu showed better performance for all traits considered in this study as compared to those at Arsi Negelle. They had higher mean DMY (5.49 ± 2.34kg Vs 3.58 ± 1.74kg) and mean LMY (1479.44 ± 689.63kg Vs 971.25 ± 484.12kg). They also had high mean LL (269.67 ± 106.93 days Vs 249.90 ± 96.27 days) and shorter mean CI (497.55 ± 98.43 Vs 599.00 ± 162.05). This is in contrary to the fact that Arsi Negelle has conducive environment for dairying. Three reasons presumably contribute to this variation. First, farmers and cows in Arsi Negelle were not closely monitored during the study period as compared to those in Adami Tullu area due to logistic problem. Case reports from the latter were immediately attended in addition to the regular monthly monitoring. Second, farmers in Arsi Negelle area might be occupied by other farm activities and hence gave less attention to the crossbred animals. Third, milk marketing is more difficult in the former area and this may force them to reduce the level of management given to the animals. Milk marketing problem has never been reported in Adami Tullu area.

Results of the present study are lower than the on-station findings but fairly superior to the performance of indigenous breeds both under improved management (509 kg/lactation as reported by Sendros and Tesfaye (1998)) and farmers' management condition (292 kg/lactation (Gryseels et al., 1989)). It was also lower than the on-farm milk yield performance of Friesian x Borana crossbred cows in Debre Berhan (1906.5 kg/lactation – mean of first and second lactation) and Selale (1650 kg/lactation) areas (Gryseels et al., 1989; Ababu et al., 2003). However, it was comparable and in some cases superior to the on-farm dairy performance of F1 crossbred cows comprising different crosses (Friesian x Barka and Jersey x Barka) distributed to Holeta and Bako areas (Tesfaye 1995).

Effects of Year, Season and Parity

A highly significant effect of year on milk yield was observed (P< 0.001). A relatively better performance was observed in the first year following their dispatch presumably due to the residual effect of the better management the cows received on-station until the last trimester and the longer lactation length recorded during the first lactation. Cows gradually seemed to adapt to the on-farm conditions and showed steady increase in milk yield across the year (Table 2).

Both calving season and season of milking had a highly significant effect on daily milk yield (P < 0.001). Generally cows that calved during the short rains (March – May) and main rains (June – August) tended to perform less. This is, of course, in accordance to the general expectation because the cows have to pass in the long dry season during most of both the gestation and lactation period. This warrants for the need to synchronize the breeding and calving seasons with seasons of feed availability and the need to supplement animals during critical stages of production; i.e., during pregnancy and lactation especially during periods of feed shortage.

Parity had a highly significant (P < 0.001) effect on daily milk yield. There was a gradually increasing trend in daily milk yield from first to fourth parity (Table 2). This is in accordance with the biological and physiological phenomena that as cows attain mature physical state they also tend to gradually increase their daily and lactation milk yield until they are 6 to 8 years of age (Warwick and Legates, 1979).

Economic feasibility study of keeping crossbred dairy cows under smallholder farmers' circumstances (Temesgen and Tadele, 1998) verified its profitability as was indicated by a gross margin of ETB 441.00 – 2107.00 per cow per year and a total gross margin of ETB 1519.00 per cow for the whole project animals considered as a unit. The internal rate of return for the whole project year was calculated to be about 228%.

Problems Encountered

- *Violation of agreement by farmers:* Two of the participating farmers sold out the cows after their second lactation on-farm resulting in incomplete recording of the consecutive lactation performances
- *Poor veterinary and AI service delivery systems:* Participating farmers from Arsi Negelle used to report breeding and health cases to the district veterinary clinic. However, service rendered was unsatisfactory
- *Logistics:* The Center had three vehicles at the time of planning and commencement of the project. In the course of time two vehicles were damaged and there was only a single car available for all activities of the center. This greatly hampered regular monitoring according to plan
- *Shortage of feed supply:* High price and shortage of supply of concentrate feeds were frequently reported by participating farmers and the Center had to assist them in purchasing the feeds from major urban areas
- *Milk marketing:* Milk marketing was found to be a limiting factor at Arsi Negelle. Milk was relatively cheap and even at lower price demand was low.

Conclusion and Recommendation

The importance of close and regular monitoring/supervision while conducting an on-farm research has been clearly revealed as evidenced by the inferior productive and reproductive performance of cows at Arsi Negelle no matter what the area is more conducive for dairying. There is a need to improve milk marketing via establishment of dairy cooperatives, small-scale milk collection, processing and marketing units and through creation of awareness regarding the benefit of milk as a diet to encourage more consumption. There is a need of sufficient and regular concentrate/industrial by-products supply especially to the peri-urban areas and promotion of improved forage varieties to improve the feed availability. Finally, a systematic crossbreeding program has to be followed in order to avoid the fear of genetic dilution as the result of male calves born from such and other crossbreeding activities at the community level. It is imperative, therefore, that appropriate policy has to be designed and implemented. Dairy can be a profitable and attractive venture to the smallholder farmers provided that supply of improved genotypes, market, veterinary and artificial insemination services are improved.

Table 1. Mean ± SD values for DMY, LMY, LL and CI of Simmental x Borana crossbred cows at Adami Tullu and Arsi Negelle areas

Location	N	DMY (kg)	LMY (kg)	LL (kg)	CI (days)
Total	12	4.61 ± 2.34	1326.98 ± 669.89	263.29 ± 102.43	531.36 ± 123.26
Adami Tullu	6	5.49. ± 2.34	1497.44 ± 689.63	269.67 ± 106.93	497.55 ± 98.43
Arsi Negelle	6	3.58 ± 1.73	971.25 ± 484.12	249.90 ± 96.27	599.00 ± 162.05

Table 2. Least squares means for daily milk yield (kg) as affected by parity, calving season, year and season of milking

Parity			Calving Season			Year		Season of Milking	
Parity	N	Mean ± SE	Season	N	Mean ± SE	Year	Mean ± SE	Season	Mean ± SE
Significance		***			***		***		***
1	12	4.74 ± 1.97^{c}	Sept. – Nov.	15	5.18 ± 1.41^{a}	1997	6.21 ± 1.46^{a}	Sept. – Nov.	4.75 ± 1.14^{bc}
2	10	4.37 ± 1.85^{d}	Dec. – Feb.	4	5.17 ± 0.88^{a}	1998	4.35 ± 2.19^{c}	Dec. – Feb.	5.16 ± 1.00^{a}
3	6	5.58 ± 1.73^{b}	Mar. – May	18	4.34 ± 0.63^{b}	1999	4.56 ± 2.08^{c}	Mar. – May	5.00 ± 1.02^{ab}
4	3	6.52 ± 1.85^{a}	June – Aug.	8	4.31 ± 0.97^{b}	2000	4.98 ± 1.88^{b}	June – Aug.	4.61 ± 1.05^{c}
-	-	-	-		-	2001	5.91 ± 1.45^{a}	-	-

R2 = 46.56; CV = 35.79

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Effect of Substituting Concentrate Diet by Lablab Hay (*L. purpureus*) on Postpartum Productive Performance of Lactating Borana Cows.

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Abstract

Thirty-two primiparous lactating Borana cows in their early lactation were randomly assigned to four treatment groups: basal diet (teff straw) + 3 kg concentrate head^{-1} day^{-1} (A); basal diet + 0.9 kg concentrate + 2.6 kg lablab hay head^{-1} day^{-1} (B); basal diet + 2.1 kg concentrate + 1.13 kg lablab hay head^{-1} day^{-1} (C); and basal diet + 3.75 kg lablab hay head^{-1} day^{-1} (D). There was significant difference ($P<0.05$) in total dry matter intake (TDMI), metabolizable energy intake (MEI) and average daily gain (ADG). Animals in treatment D had the lowest TDMI and MEI whereas animals in treatment B had the lowest ADG. There was no significant difference ($P>0.05$) in weight change between cows in all the treatment groups, whereas the mean change in body condition score of cows was significantly different ($P<0.05$) among the treatment means. There was no significant difference ($P>0.05$) between the treatment groups for all the yield parameters considered in the present study. However, cows in treatment C and D gave the highest and lowest yield, respectively. It has been concluded that lablab hay can potentially replace concentrate diets with out adversely affecting lactation yield performance and condition of Borana cows.

Introduction

Cattle in the tropics are usually dependent on natural pastures and crop residues, with crude protein content often below 7.5%, which reduces rumen efficiency and true digestibility of the feed. As a result lactating cows are unable to meet their nutritional requirement and lose weight and condition during lactation (Mukasa-Mugerwa, 1989).

During the dry season when feed shortage persists for more than six months cows generally lose 50 – 80 kg of body weight and exhibit drop in fertility and milk production. This situation prolongs lactation anoestrous period and cows tend to calve in alternative years (Ward, 1968; cited by Mukasa-Mugerwa, 1989). Supplementing poor quality basal feeds with either quality diet or forage legumes can improve the digestive and metabolic condition of ruminants. However, under smallholder farmers' condition supplementing poor quality livestock feeds with grain concentrate is unaffordable and expensive. One way of improving the utilization of available crop residues is by proper supplementation with leguminous forages (Lagasse *et al.,* 1990; Abubeker *et al.,* 1995; Popi and McLennan, 1995).

Lablab purpureus combines a great number of qualities that can be used successfully under various conditions. Its advantage is adaptability- it is drought resistant and is able to grow in a diverse range of environmental conditions world wide with potential dry matter yield of 8 – 11.5 tones per hectare (IAR, 1986; Murphy and Colucci, 1999). The wild forms of lablab are believed to have originated in India (Deka and Sarkar, 1990) and were introduced in to Africa from Southeast Asia during the eighth century (Kay, 1979). Presently, lablab is common in Africa, extending from Cameroon to Swaziland and Zimbabwe, through Sudan, Ethiopia, Uganda, Kenya and Tanzania (Skerman *et al.,* 1991).

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The dry season feeding strategy using high protein farmers-grown lablab hay in association with crop by-products and residues has been a significant intervention in small-scale dairy farm in Botswana (Kiflewahid *et al*., 1989). This experiment was intended to evaluate the effect of substituting costly concentrate diet by lablab hay on body weight change and milk yield of lactating Borana cows fed on a basal diet of teff straw.

Materials and Methods

Study Area

The study was conducted at Adami Tullu Research Center located in the middle of the great rift valley of Ethiopia, 165 km south of Addis Ababa on the high way to Awasa. It is situated at an altitude of 1650 masl, $7^{0}9'$N latitude and $38^{0}7'$E longitude. The area receives a bimodal type of rainfall averaging 760 mm per annum. The maximum and minimum temperature is 27^{0}C and 12.7^{0}C, respectively and the soil type is fine sandy loam with sandy, silt and clay in the proportion of 34:48:18, respectively.

Experimental Animals and their Management

Thirty-two primiparous lactating Borana cows in their early lactation were used in this study. The animals were randomly assigned to either of the following treatment groups: basal diet (teff straw) + 3 kg concentrate head^{-1} day^{-1} (A); basal diet + 0.9 kg concentrate + 2.6 kg lablab hay head^{-1} day^{-1} (B); basal diet + 2.1 kg concentrate + 1.13 kg lablab hay head^{-1} day^{-1} (C); and basal diet + 3.75 kg lablab hay head^{-1} day^{-1} (D). The concentrate mixture constituted wheat middling (80%), noug seed cake (19%) and salt (1%) with estimated nutrient concentration of 20% CP and 11 MJ ME per kg DM. The supplemental feeds were designed to provide the same level of ME (30 MJ) and similar amount of CP of about 600 g head^{-1} day^{-1}.

The animals were confined in an individual feeding pen and were provided with the basal diet twice a day at about 8.00 and 17.00 hours; the supplemental diets were offered immediately after morning and evening milking. The offer and leftover were properly recorded. Cows were hand-milked twice a day. They were also weighed and condition scored fortnightly.

Table 1. Chemical composition of the experimental diets

Feed Type	DM	N	CP	NDF	ADF
Lablab hay	92.1	2.7	16.8	42	36
Noug seed cake	93.1	5.68	35.5	33.3	28.2
Wheat bran	95.2	2.7	17.01	52.17	17.25
Teff straw	94.2	0.52	5.9	78	42.7

Statistical Analysis

One-Way ANOVA of the MINITAB statistical software (Minitab, 1996) was used to test for significant difference between the treatment groups.

Results and Discussion

Dry Matter Intake, Body Weight Change and Body Condition Score

Chemical composition of the experimental diets is presented in Table 1. Means for total daily dry matter intake (TDMI), total metabolizable energy intake (TMEI), average daily gain (ADG) and feed conversion efficiency (FCE) are presented in Table 2. There was significant difference ($P<0.05$) for most of the variables measured among treatment groups. Animals in treatment D had the lowest TDMI and MEI whereas animals in treatment B had the lowest ADG. However, studies conducted elsewhere on voluntary intake of lablab by cattle indicated a satisfactory palatability especially at vegetative stage of growth (Jakhmola and Pathak, 1981). Wood (1983) found that after flowering, the leaf was the most valuable component of lablab crop as it not only has a much higher content of protein than the stem but also it is strongly preferred by cattle.

The overall average body weight change and body condition score change during the experimental period is presented in Table 3. There was no significant difference (P>0.05) in weight change between cows in all the treatment groups, whereas the mean change in body condition score of cows was significantly different (P<0.05) among the treatment means. An average weight gain of 350 g per head per day of zebu cattle yearlings grazing dry maize stalks, dry grasses and green lablab during July and September in Brazil (a dry season when cattle usually lose weight) was reported by Schaaffhausen (1963b). Hendrickson and Myles (1980) conducted several field and pen studies with steers using lablab hay as a supplement to reverse the autumn and winter weight loss by cattle grazing native pasture in Queens land. They found positive results with weight gains ranging from 93 to 1036 g head^{-1} day^{-1} depending up on the form in which lablab was offered.

In the present study animals supplemented with lablab hay alone had a modest level of ADG (406 g head^{-1} day^{-1}) in addition to supporting milk production requirement. This result should be considered against the fact that even non-lactating cows usually lose weight during the dry season in Adami Tullu area (Obradovic and Abraham 1975).

Yield Performance

The overall mean values of milk, fat, protein, lactose and total solids yield during the experimental period are presented in Table 4. There was no significant difference (P>0.05) between the treatment groups for all the yield parameters considered in the present study. However, cows in treatment C and D gave the highest and lowest yield, respectively.

In studies done by Hamilton *et al* (1970) in Australia, cattle consuming pure stands of lablab maintained a high level of milk production and a slower decline of yield with time. A Cuban system based on pasture plus forage rations produced from intercropping showed that animals on which included lablab had an increase of milk production of three liters per cow per day; the same response was achieved by using supplementation with soybeans. Besides improving production, the lablab system had the lowest cost per tone of DM (Cino *et al*., 1994). Similar results were obtained in Honduras (Sinclair, 1996) in a trial comparing two forage systems (maize stover Vs maize stover/lablab). The system including lablab produced more milk per animal and per hectare than the traditional one. In addition, the cows assigned to maize/lablab system gained more body weight than cows in the maize system (Sinclair, 1996).

The present study is in agreement with the above-cited works. Replacing the concentrate diet in a ration of lactating cows with lablab hay can support a modest level of both milk production and weight gain.

Conclusion

The result of the present study confirms the hypothesis that the dry season feeding strategy using high protein farmers-grown lablab hay in association with crop by-products and residues can be a significant intervention in a small-scale dairy farm. It has been concluded that lablab hay can potentially replace concentrate diets with out adversely affecting lactation yield performance and condition of Borana cows.

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Table 2.Estimated daily total dry matter intake (TDMI) total metabolizable energy intake (TMEI), average daily weight gain (ADG) and feed conversion efficiency (FCE) of lactating Borana cows in different treatment groups.

	Treatments				LS
	A	B	C	D	
N	8	8	8	8	
TDMI (kg/day)	8.18 ± 0.11	8.21 ± 0.18	8.31 ± 0.13	7.60 ± 0.27	**
TMEI (MJ/day)	67.64	63.74	67.14	57.08	
ADG (g)	630	340	530	410	
FCE (kg gain/kg DMI)	0.077	0.041	0.064	0.054	

Table 3. Mean ± SE weight gain and body condition score (BCS) change of lactating Borana cows fed on teff straw basal diet supplemented with either concentrate, lablab hay or concentrate diet replaced with different levels of Dolichos lablab hay

Parameters	Treatments				LS
	A	B	C	D	
N	8	8	8	8	
Weight gain, kg	37.75 ± 4.09	20.50 ± 4.86	31.69 ± 5.70	24.37 ± 3.46	-
Range	13.50 - 50.00	5.50 - 47.00	2.50 - 48.50	8.50 - 35.00	
BCS change	1.50± 0.32	0.25 ± 0.31	1.00 ± 0.26	0.37 ± 0.18	**
Range	0.00 - 3.00	-1.00 - 2.00	0.00 - 2.00	0.00 - 1.00	

Table 4. Mean ± SE (P≤ 0.05) yield performance of lactating Borana cows supplemented with either concentrate diet, Dolichos lablab or concentrate diet substituted with lablab hay at different levels.

		Milk Yield (Kg)		Fat Yield (Kg)		Protein Yield (Kg)		Lactose Yield (Kg)		Total Solids Yield (Kg)	
Treatment group	N	Mean ± SE	LS	Mean ± SE	LS	Mean ± SD	LS	Mean ± SE	LS	Mean ± SE	LS
A	8	250.53 ± 41.68	NS	12.15 ±2.75	NS	7.93 ± 1.49	NS	10.29 ± 2.14	NS	34.83 ± 6.99	NS
B	8	264.11 ± 26.11	NS	12.13 ± 2.08	NS	9.45 ± 1.23	NS	11.53 ± 1.25	NS	36.57 ± 4.13	NS
C	8	296.49 ± 29.90	NS	11.63 ± 1.04	NS	10.26 ± 1.12	NS	12.96 ± 1.49	NS	39.55 ± 4.15	NS
D	8	215.38 ± 17.40	NS	9.7 ± 0.55	NS	8.00 ± 0.64	NS	8.82 ± 0.73	NS	29.40 ± 2.01	NS

NS = Non significant

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Livestock rearing, rangeland management and change in the vegetation cover in Jijiga zone rangelands of Somali Regional State, Ethiopia.

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Abstract

The rangelands between Kebribeyah and Hartisheik refugee camps have been reported to have changed and reduced productivity, which in turn affected the livelihood of the indigenous pastoralists and agropastoralists in the area. In view of this, secondary data on livestock rearing, rangeland management, the change in the vegetation cover, wood resource, production and utilization status, current situation of water and rainfall availability, erosion, degradation and their measures were investigated. One time visit purposive survey was done using 30 pastoralist and 10 refugees for 14 degraded villages and one slightly degraded village. The study showed that both human and livestock population have increased in the area thus resulted resource over exploitation. The respondents have also agreed that they depend 70 % on free grazing, 22 % on cut and carry grass and 8 % on crop residue during the wet season whereas they depend 63 % on free grazing, 20 % on cut carry and 17 % on crop residue during the dry season. With regard to tree utilization the study revealed that 95 % of the respondents agree that the major source of fuel-wood is tree similarly they 100 % agreed that major source for construction wood is tree. The respondents had the same idea that they depend on ponds 60 %, on Birkas 30 %, on natural depressions 7.5% and on others 2.5%. However, water availability has declined. 68 % of the respondents have indicated that wind erosion is the major erosion whereas32 % stated water erosion to be the major erosion type. Finally, the respondents agree that tradition control efforts made are insignificant. Therefore, necessary interventions are recommended, besides the need for an overall improvement of the range condition and the animal production system in the sampled villages.

Keywords: Livestock rearing, rangeland management, vegetation change, land degradation, soil erosion and source of fuel and construction wood.

Introduction

In arid and semiarid lands of Ethiopia, the primary livelihood of the pastoralists is the management of livestock: cattle, goats, sheep and camels. Thus, livestock is critical to the wellbeing of lowland households in terms of income, savings, food security, employment, traction, fertilizer and fuel (Blench, 2001). Pastoralism is predominant in the arid and semi-arid areas including Shinile and the vast rangelands in the southern part of the Somali Region. A large part of the population has mixed herds consisting of camels, sheep, goats, cattle and/or donkeys; whereas agropastoralism is commonly practiced in the northern part of the region (Tesfaye and Hailu, 1997).

Despite the importance of pastoralism in the region as a living system, land degradation becomes one of the major threats to the increasing livestock as well as human population. Moreover, the diverse causes of land degradation in the region remained unchecked during the past two decades that land degradation has doubled due to unwise exploitation by man (Abdulkadir, 1999).

The rangelands between Kebribeyah and Hartisheik refugee camps have been reported to have changed and reduced productivity, which in turn affected the livelihood of the pastoralists and agropastoralists in the area. Therefore, with such problem in the Somali Region, and in particularly in these areas, has been initiated this research work to assess livestock rearing, rangeland management and change in the vegetation cover in 14 degraded villages and one slightly degraded in Jijiga zone rangelands of Somali Regional State, Ethiopia. With the following objectives: to investigate the animal production system and rangeland management and to assess the change in the vegetation cover .

Materials and methods

Description of the Study Area

The study was undertaken in the rangelands around Hartisheik and Kebribeyah refugee camps, located 750 km southeast of Addis Ababa, in Jijiga zone of the Somali Regional State (SRS). The Jijiga zone is situated in the north part of Somali Region and borders in the east with Republic of Somalia, in the west with Oromia region and Fik zone of SRS, and in the south with Degahbour zone (Fig.1).

The Jijiga zone is divided into six administrative districts: Jijiga, Kebribeyah, Harshin, Babile, Awbare and Gursum (In figure). In most of the western and northern districts of the zone, the livelihood of the population is mainly farming while the rest are either pastoralists or agropastoralists.

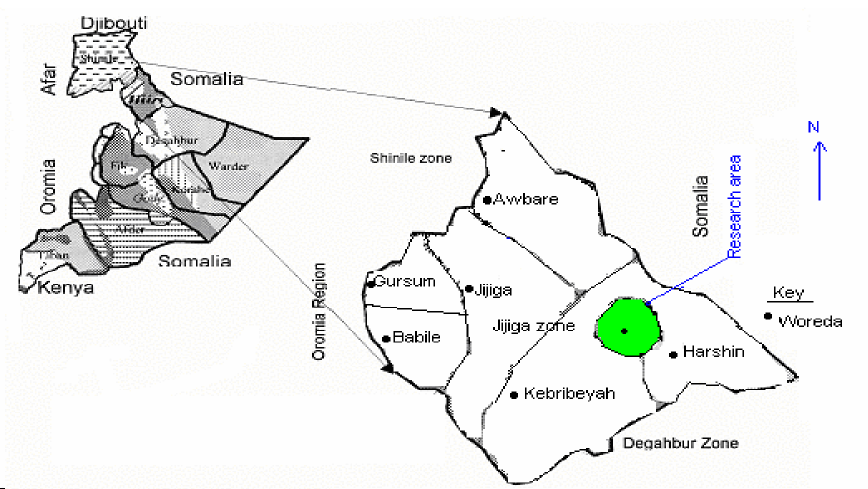

Figure 1. Jijiga Administrative Zone, Somali Region, Ethiopia

The Jijiga zone is classified as semi-arid mid highlands. The altitudinal range in the study area is between 600 and 2200 m. a. s. l. Temperatures in the cattle rearing areas in SRS are high all the year round where the mean minimum value is around 20 °C and the mean maximum around 35 °C. The mean annual rainfall is 550 mm. The rainfall is bimodal and there are four seasons: March to May, July to September, September to February and May to June. The former two are rainy seasons and the latter two are dry seasons (Tesfaye and Hailu, 1997).

Sampling procedure and data collection method

A single-visit formal survey method (ILCA, 1990) was followed to gather primary information on livestock rearing, rangeland management and the change in the vegetation cover. The same survey method was employed to collect information on wood resource and production and utilization status, current situation of water and rainfall availability, erosion, degradation and their measures.

Systematic (purposeful) sampling procedure was followed to select the pastoralists for the primary data collection. A total of 30 informant pastoralists, two elders from each sample site (village) were identified and selected based on the number of years that they have been in Hartisheik and Kebribeyah and a total of ten refugees from the two refugee camps to undertake collection of primary information. A well-structured questionnaire was adapted from previous reports (Baars and Said, 1999) and additional questions were added, to fulfill the objective of the study. Data were also collected at community level with the help of the elders and the survey was conducted before the GU (main rainy season, Mid March-Early June 2003).

Data analysis

The statistical analysis of the primary data collected was made using the statistical package for Social Science, (SPSS) version 10.

Result and discussion

Living System in the areas

Human, Livestock Population and the Rangeland

The finding of this study shows that the population of both livestock and human has increased in the study area, which resulted in increased demand for food, water and shelter. Earlier finding reported that increased population pressure also leads to greater water development and permanent human settlement in arid rangelands (IFAD, 1995). Although the direct effect of water points on land degradation is relatively limited, the development of water supplies for more intensive use can upset an entire eco-system by changing traditional dry season grazing areas into year around grazing (IFAD, 1995).

On the other hand, the study has revealed that population increase in the study area has affected the family livelihood where the milk could not cover the family. This is supported by the findings of study conducted in Borena (Coppock, 1996). Furthermore, the larger number of people in the region means that fuel-wood is being cut at an ever greater rate. The inevitable result of all these pressures is land degradation. It was reported earlier that in communal areas, the traditional collective internal discipline in the management of the resources disappeared and over-grazing and land degradation followed Jodha (1992).

The study have also indicated that little emphasis was given strengthening the traditional pastoral institution and resource management practices, which is against the priority areas for pastoralist development recommendations by IFAD (1995) and de Haan (1996). Both recommended that priority should be given in the strengthening of traditional pastoral institutions and resource management practices. It is therefore obvious that as both human and livestock populations in the study area have increased, there is need to improve the livestock management systems to protect the land from more aggravation and enhance livestock production as well.

Livestock Rearing in the Area

The mainstay of the pastoralists is livestock production. The finding of this study indicates that the major livestock reared in the area include cattle, goats, sheep and camel. The local people in the area depend on the milk and livestock sale; however there are occasions where the meat is also used. This agrees with the earlier finding reported by Jahnke (1982) that in pastoral systems, the product is milk, the main function of livestock is subsistence though social and cultural functions are important. Management is characterized by the adaptation of the feed requirements of the animals to the environment through migration. Land tenure is communal (Jahnke, 1982).

Moreover, the findings of the study showed that in general the livestock production in the area was not relatively good due to different reasons mainly climatic change as well as land productivity decline, livestock population increase. As there are critical challenges and the livestock production system is getting a hard time and can not cover the family need the pastoralists in the area have started small plots of farms. This will result the removal of the few forest stand remained in the area and aggravate the degradation of the area unless coupled with modern technology as the rainfall intensity as well as the duration is very limited. Hence the recently started farming activity needs more understanding and critical evaluation.

Rangeland Management Practices

Modern rangeland management practices are not utilized among the pastoralist of the region. Most of the respondents have agreed that the common grazing management practices in the area include free grazing, stall-feeding and combination of the two. They depend 70 % on free grazing, 22 % on cut and carry grass and 8 % on crop residue during wet season whereas they depend 63 % on free grazing, 20 cut and carry and 17 % on crop residue during the dry season (Table, 1). These grazing management systems have resulted pressure on the land, reduced production and overgrazing. Thus the reduction of rangeland production results imbalance of the livestock in the area and the available feed resource.

According to the perception of the pastoralists towards the management of the rangeland however, modern systems are not utilized but the idea of the traditional management is still there but not practiced. The pastoralists understand that the land is more populated than the past and can not support this number of livestock unless other systems are utilized. During the study it was noticed that the number of land enclosures for pasture, small plots of farming and water Birkas have increased thus movement of livestock have reduced and this resulted vegetation reduction around water points. Similarly earlier finding stated that wide range of removal levels may co-exist over short distance due to the location of water points and settlements. Thus, even at low livestock densities pockets of excessive grazing pressure can be found (Coppock, 1991)

Table 1. Source of feed for the livestock in the wet and dry season and their importance

Season	Source of feed	Frequency	Percentage
Dry season	Grass on grazing land	4	10
	Grass from cut and carry	8	20
	Hay	21	52.5
	Crop residues	7	17.5
	Total	40	100
Wet season	Grass on grazing land	27	67.5
	Grass from cut and carry	9	22.5
	Hay	1	2.5
	Crop residues	3	7.5
	Total	40	100

The implications of this grazing system, where the communal land for grazing is minimal besides, the livestock population increase has been found to have resulted overgrazing. Hence to minimize this there is a need for proper intervention as overgrazing may result many other problems. Other studies show similar findings. Overgrazing can cause soil compaction and erosion, and can decrease soil fertility, organic matter content, and water in filtration and storage(Oldeman et al, 1991).

Source of Fuel and Construction Wood and its Utilization

The pastoralists in the area have received less intervention in many aspects hence they live in more primitive and traditional way. The findings of the study have shown that energy for cooking in the area was mainly the tree and/ or shrubs. This is supported by earlier finding which, says that in rural Africa, 80-90% of the energy demand (mostly for food preparation) is derived from woody vegetation (Openshaw, 1984). On the other hand there is excess upheaval of trees for construction as tree wood constitutes major part of house construction materials, these two factors have resulted increased tree cutting.

The study showed that 95 percent of the respondents agree that the major source of fuel-wood was tree and shrubs (Table 2). Women are responsible collecting the fuel wood, however, this task of collecting is becoming time consuming as the available forest resource is getting limited and places firewood collection became far. It was reported that it takes on average 1-½ -2 hours in a distance of 6-8 km per day. This increases the burden on woman besides, the other work overload, which they got as their share in the family job division. This is confirmed by the finding of IOM (1996). Women are particularly affected in natural and human induced environmental degradations as they are the main providers of water, fuel, fodder and forest products (IOM, 1996).

The big business center near this area Hartisheik had great influence on the construction wood in the area. The residents in the area have indicted that as Hartisheik came into the seen 15 year back in the first refugee influx from Somalia. Hartisheik was established after the first refugees from northern Somalia were settled in. This has encouraged the supply of both construction and fuel wood from surrounding and even far people. This is supported by a case study conducted by WFP in 1996, which indicated that it coasted to the Kenyan government 10.5 million dollars to provide local water and fuel wood annually. This figure does not consider indirect environmental impact such as accelerated decrease in forest cover, degradation of rangelands from the refugees (Jacobsen, 1994).

Tree clearing for firewood and construction have significantly contributed to forest resource reduction in the area. Therefore, this needs control measures and if not acted on time will fan the flames of the current situation therefore, awareness raising and natural resource management trainings should be given to the community. Besides, control measures from the regional government. For further proper forest resource utilization there is a need for holistic approach diversifying the income of the rural people so that they will opt another job than this time consuming and laborious job

Table 2. Summary of source of energy and for cooking and construction wood in the study area

Wood types	Wood use	Detail of wood use	Frequency	Percentage
Fuel wood	Source of fuel wood	Trees/shrubs	38	95
		Others	2	5
		Total	40	100
	Who is responsible for fuel wood collection	Men	35	87.5

Wood types	Wood use	Detail of wood use	Frequency	Percentage
		Woman	2	5
		Children	3	7.5
		Total	40	100
	Is it time consuming	Yes	23	57.5
		No	17	42.5
		Total	40	100
	How long does it take	< 30 minutes	7	17.5
		30-1hour	10	25
		>1 hour	23	57.5
		Total	40	100
	Is there fuel wood shortage	Yes	25	62.5
		No	15	37.5
		Total	40	100
Construction wood	Source of construction wood	Trees/shrubs	40	100
		Others	0	0
		Total	40	100
	Who is responsible for construction wood collection	Men	40	100
		Woman	0	0
		Children	0	0
		Total	40	100
	Is it time consuming	Yes	38	95
		No	2	5
		Total	40	100
	How long does it take	< 6 hours	6	15
		6-12 hours	3	7.5
		>12 hours	31	77.5
		Total	40	100
	Is there construction wood shortage	Yes	36	90
		No	4	10
		Total	40	100

Fuel and Construction Wood Production Status

The pastoralists use traditional Somali hut, which are temporary and can be dismantled and transported to other areas when there is a need. It is also true in the pastoral system the land is communal and used together but not protected and treated together without external intervention. The study reveals that the fuel/construction wood production in the area is not promising, as rehabilitation efforts were not paid by government/non-government institutions and the community itself. There are no nurseries in the area except two nurseries due this to this fact there is shortage of seedlings is the area.

75% of the respondents have agreed that there are no nurseries in the area (Table, 3). No seedling supply in most of the sites and there is no private initiative even though the interest of the community to produce and plant is very high. So far no seedling is brought to most of the sites by the government and NGOs as well. The main problem regarding towards construction wood is most of construction tree species were cleared off almost nil due to increased human population. No measures were taken to reserve the exiting construction wood trees as well as replacing the cleared trees.

Table 3. Summary of construction wood production in the study area

Wood production	Detail of wood production	Frequency	Percentage

Are there source of seedling (Nursery)	Yes	10	25
	No	30	75
	Total	40	100
Type of nursery	Government	2	5
	NGO	10	25
	Other	28	70
	Total	40	100
Number of seedling produced and supplied to the community	<3000 seedling	12	30
	>30000 seedling	0	0
	Nil	28	70
	Total	40	10

Trees have an important role to play in natural as well as in agricultural ecosystems, including: shade and windbreaks, mobilization and cycling of nutrients, particularly from deep levels of soil, nitrogen fixation for tree legumes, source of fodder for livestock, carbon sequestration, habitat for many species of birds, insects, small mammals, epiphytic plants. Livestock raising can affect tree populations directly by causing damage on branches, trunk, sprouts, re-growing (Bellefontaine et al., 1997).

Therefore tree forest utilization control measures should be put in place besides, the replacing of the already cut and utilized trees. It is important to understand that to replace the trees cleared need a source for the seedling to be planted hence community nurseries are highly important to be established.

Current Situation

Rainfall Pattern and Water Availability

Rainfall plays an important role in livelihood of the pastoralist as the rangeland and the vegetation growth needs adequate moisture available in the soil. The rainfall pattern in the area is bimodal and the main rain starts in late March to May, which is called GU whereas the second rain starts in late June and stretches to September called Karen. The respondents had the same idea that they depend on ponds 60 %, on Birkas 30 % and on natural depressions 7.5 % and on others 2.5 % (Table, 4). Water in the area is not sufficient and there is always acute shortage in the dry season (Table 4). People travel long distance in search of water during the dry season. The Kebribeyah borehole and Hartisheik Hafir dams serve a lot and provide water the pastoralists in the area. Camel caravans collecting water from Hartisheik and Kebribeyah is know to this area and common during the dry spell.

Table 4. The rainfall intensity, duration and water availability

Rainfall and water source	Detail of rainfall and water	Frequency	Percentage
Source of water	Natural depression	3	7.5
	Ponds	24	60
	Birkas	12	30
	Others	1	2.5
	Total	40	100
Rainfall intensity and duration	Adequate	2	5
	Inadequate	38	95
	Surplus	0	0

	Total	40	100
Water availability in wet and dry seasons	Adequate	6	15
	Inadequate	34	85
	Surplus	0	0
	Total	40	100

Erosion, Land Degradation and their Traditional Control Measures

In appropriate and over utilization of natural resource have created different changes on the land and created suitable conditions for water and wind erosions. The findings of the study point out that there is soil erosion problem in the area in almost all types of the land-use including rangeland, grassland and woodland. It varied across the sites depending on resource utilization, population and soil type among the sampled villages. The local people described that grasslands are highly degraded and almost are not existent. Loss of grassland productivity due to overgrazing could be a clear indictor of the current grassland degradation.

The observation made during the study period revealed that soil crust formation is one of the indicators, besides the pedestals and small hills made by the wind erosion during the dry spell. Wind erosion is a big problem in the area and there is dust during the dry spell. This was true during the dry spell and the wind was taking away all the movable small soil particles and transports to far places in less vegetation and barren areas where it does not transport or transports insignificant in vegetation covered areas. According other studies made, each year 75 billion metric tons of soil are removed from the land by wind and water erosion globally' (Pimentel et al, 1995)

High runoff in the area was also observed which have induced rill erosion, which later on gets developed into gullies. Barren areas were common and herbaceous cover was very poor. Thus, soil erosion is widely perceived to be a major problem in the study area as the case in most sub-Saharan Africa. Most agency reports and government publications highlight the degradation of soils as a major development challenge, but soil and water conservation (SWC) efforts in Africa have had a chequered history. From the early colonial era to the present, attempts have been made to introduce SWC measures in a wide range of settings, yet many have failed. (Chris et al, 1996)

The few measures undertaken in exercising erosion control efforts are insufficient besides, the ineffectiveness. The most important forestry and soil and water conservation activities carried out in the past through non-government organization are bunds construction, traditional drainage ditches and seedling plantations, which is not sufficiently applied and considered, be less effective. The limitation of these measures was in the design and the lining out structures for betterment and effectiveness. Table 5 presents a summary of the status of soil erosion and control measures undertaken in the 15 villages investigated.

Table 5. Degradation/erosion status and the control measures

Degradation/erosion status	Detail of degradation/ erosion	Frequency	Percentage
Types of erosion	Wind	27	67.5
	Water	13	32.5
	Total	40	100
Indicators of erosion	Barren area	21	52.5

	Low productivity	11	27.5
	Rills and pedestals	4	10
	Gullies	3	7.5
	Total	40	100
Causes of degradation	Overgrazing	25	62.5
	Tree clearing	14	35
	Crop cultivation	1	2.5
	Total	40	100
Control measures undertaken	Soil bunds and ditches	1	2.5
	Seedling plantation	2	5
	Non	37	92.5
	Total	40	100

No management measures have been undertaken in the area to wards the different land use systems. It is therefore important to think ways to mange and save the available resource by utilizing effective modern control as well as management measures.

Comparison of the Past and Present Range Situation

Change in the Vegetation Cover and Floristic Composition

The natural vegetation of the area was very good and dense in both herbaceous and the tree/shrubs layers. According to the view of the pastoralist in the past the open land was very little except the settlements. The land was under full vegetation cover as the search of human and livestock for satisfying divergent needs was below the available resources resulted over exploitation. This supported by the earlier report of Demel and Yonas (2002) which indicated that Ethiopia is also one of the countries exposed to serious ecological imbalance. This has involved deforestation followed by a continuous cropping and overgrazing with little or no investment in the soil, whis has left few opportunities for the soil.

Besides the great influence made by the refugees the local people have also contributed due to the fact that they overlooked the need for tomorrow. Deforestation and land degradation are the two intertwined processes caused by various natural, human and livestock actions. The extent to which the destruction of forests is speeded up increases the rate of soil erosion and the resultant land degradation leading to the general destruction of the ecology and environment of a an area.

The respondents have all agreed that the land was under communal land management where less consideration was given to the land, which has resulted in the existing problems. Nomadic producers who move their stock in search of pasture according to season have traditionally used arid rangelands under a communal property regime. From the wet season grazing they will move their animals to higher-potential river valleys, cropland or mountain meadows for the dry season. With highly variable rainfall, pastoral economies are typically of the "bust and boom" type: a "boom" when rainfall is plentiful and herds and flocks grow, and a "bust" when drought (or late winter storms as in the case of Central Asia) occurs and animals die (Mearns, 1996). Thus, biotic factors such as rainfall, rather than livestock density, determine long term primary production and vegetation cover (Mearns, 1996).

As the people were selecting some of the species to satisfy their needs for construction and for cooking energy some of the species have disappeared. The majority of tree/shrub species in the area used to be different species of acacia but the composition has decreased and few less value species have dominated the area. The respondents mentioned that for marketing purpose people always look the quality and prefer better quality ones. For example the Galol Charcoal is expensive than Qudac (*Acacia tortolis*) charcoal.

Furthermore, the respondents have agreed that in the herbaceous layer the fast growing and regenerating species have disappeared and the perennials were replaced with annuals. In line with the findings of the study it was reported that pressure is characterized by an increasing density of non-native species and a corresponding decrease in the abundance of native plants in pastures and rangelands. The result is a decrease in the nutritional quality of rangelands and natural pastures. In order to combat this, livestock owners and rangeland managers may then be forced to spend considerable sums to first initiate and subsequently maintain control programmes as suggested by McNeely et al., (1995)

Conclusion

The study revealed that the current situation of the rangeland was shaped by the increased livestock and human population. Moreover, human tree utilization have also contributed to rangeland degradation in the area. Therefore, necessary interventions are recommended, besides the need for an overall improvement of the range condition and the animal production system in the sampled villages. Furthermore, although the information gathered in this study is valid and significantly contribute to an understanding of species composition of the native pasture, rangeland condition, rangeland management, human impact on the rangelands, more data is required to ensure that the conclusion reached at are certain and environmentally valid. Further studies that try to assess an understanding of how species composition is influenced by, and respond to, grazing management, human utilization and other environmental factors should be undertaken for some detailed knowledge of the dynamics of these factors.

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Reproduction, breeding and management of female and male camels in Afder Zone of Somali Regional State, Ethiopia

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Abstract

This study was initiated with the objectives of generating base line information in the area of traditional reproduction management, breeding females and bulls of the camel herds. The study was undertaken in the five purposely-selected Woredas of Afder zone. Stratified random sampling technique was used to classify camel herder's in each Woreda's according to camel number into small herd owner (10 – 20 camels), medium herd owner (21-50 camels) and large herd owner (>50 camels). The study revealed that in all age groups, number of female camels was higher than that of males indicating the importance milk production and reproduction in arid area. According to herd owners responses the first age of breeding was 3.9 to 4.5 years; estrus duration was 6.6 to 7.5 days; gestation length was 12.7 to 12.8 months; age of first calving was 5 to 5.4 years; post partum anoestrus period was 7 to 9 days; calving interval was 23 to 24 months regardless the herd size and Woreda. Traditionally managed bulls were reported to reach age at first service at 5.5 years; sexual maturity at 7 years of age; a capacity 10 services per day (including the night), and also successfully mate/serve 60 to 67 she-camels in a breeding season.

Key words: reproduction management; breeding female; breeding bulls, pregnancy and abortion; calf crop; selection; sexual maturity

Introduction

There is a very little information available on traditional reproductive system and problems of male camel (FOA, 1990). The same report indicated that a phimosis, paraphimosis, orchitis and testicular hypoplasia were the commonest clinically observed cases. However, reproductive problems that related camel reproduction were not investigated in detail when compared with the cattle (Muse and Merk, 1990).

Most research works done on camels in eastern part of Ethiopia are around Jijiga and Shinile Zones of Somali Regional State due to relatively good infrastructure and easy accessibility (Bekele, 1995; Tezera, 1998; Zeleke, 1998; Abebe, 1989) while little work was done in remote areas like Afder zones. Further more the contribution of camel reproduction in terms of calf crop and herd growth to pastoralist's household, and the traditional breeding management was not well studied. Therefore, the present study was initiated with the objectives of generating baseline information on traditional reproduction and breeding management of the camel in Afder zone of Somali Regional State.

Material and methods

The study was undertaken in Afder Zone in south east of Ethiopia bordering the Republic of Somalia. The altitude of the study area varies from 250m to 600m asl. The zone comprises eight district/Woredas (West-Imey, El-kari, Gorobagagsa, Gouradamole, Hargelle, Jarati, Barey, Dollo-bay) (Figure 1) inhabited dominantly by Somali pastoralists while Agro-pastoralism is also practiced along the edges of Ganale, Web and Shabele rivers where crop production (sorghum and maize) mainly depends on erratic rainfall. Livestock products particularly milk provides most of the daily energy requirement of the pastoralists supplemented by locally produced grains. Petty trading also helps in generating additional income for the households. Although the accurate figure of livestock population is not available, the camel population estimate done by the Southeast Rangelands Project (SERP) in 1998 showed that there were 260,000 heads of camel.

Sampling Procedure

The stratified random sampling technique was used for selection of herd size based on accessibility, security situation and population number. Accordingly, five Woreda's (Dollo-Bay, Jarati, Hargelle, Barey and El-kari) out of eight Woredas of Afder zone were selected.

In this study herd size was stratified in to three categories: large herd size = household owning above 50 heads of camel; medium herd size = household owing 21-50 heads of camel, and small herd size = households that own 10 –20 heads of camel regardless of other livestock they have. Usually households owned less than 10 camels were considered poor camel owners that do not herd separately and independently. As a result it was believed that these group of herd owners may not able to provide valuable information about their herds and were excluded from the study. The household was used as the unit of investigation, and 15 households from each Woreda's and a total of 75 households for the five Woreda were selected.

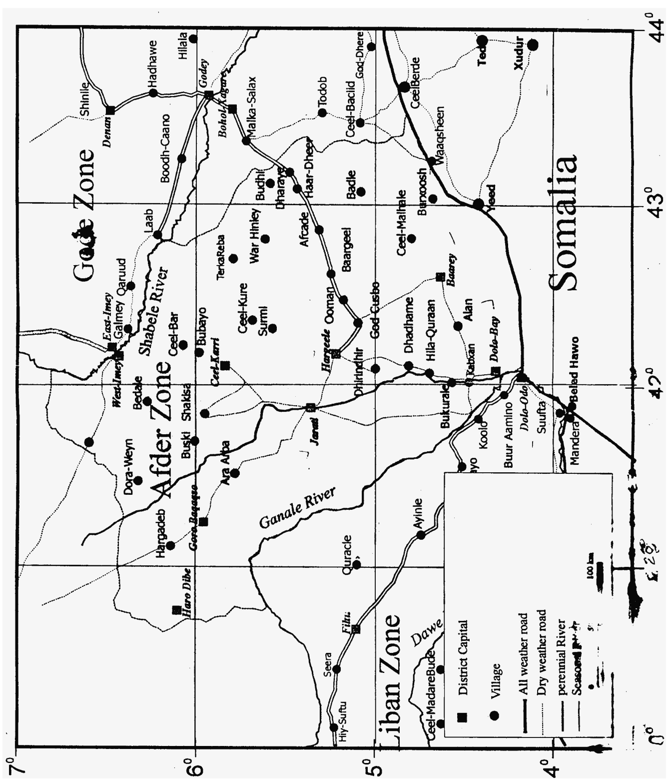

Figure 1. Location of the study area

Data collection

A single visit formal survey method (ILCA, 1992) was employed to collect information on traditional practices on reproduction management, breeding females and bulls, and Breeding management. Data on camel's abortion cases were collected from different Woreda's by selecting two camel dams representing each household. In addition development agents at Zone and Woreda levels and officials of the Ministry of Agriculture were also consulted.

Statistical analysis

Descriptive statistics of the statistical package for Social Science SPSS version 10 were used to analyze data collected by single visit survey.

Results and discussion

Female camels

The owner reported that female camels reach puberty at an average age of 3.9 years ranging three and five years. Previous studies made by Dahl and Hjort (1976) and Payne (1990) were reported that female camels become sexually mature at about three years of age, but they were not generally bred until four years old. The puberty age of females reported in the current study lied within the range reported by Musa and Merkt (1990).

Puberty in female camels in East Africa was known to depend on factors such as nutrition, breed type, animal body conditions and health status (Dioli et al., 1992). These are indication of better management, which enables camels to reach puberty at early age.

Estrus

As reported by all respondents, estrus occurs only during wet season. However, 20% of medium sized herd owners in Hargelle reported that estrus can occur any time when feed availability is good, which is in agreement with report from Ethiopia (Abebe, 1991; Bekele, 1995), Israel (Yagil and Etzion, 1984), Libya (Musa 1991), Niger (Wilson, 1984 b), Saudi Arabia (Abdel-Rahim and Nazier 1993), Somalia (Baumann and Zessin, 1992; Herren, 1993), and United Arab-Emirates (Aboul-Ela, 1994). The overall mean duration of estrus was reported to be 7 days (Table 1). The duration of estrus observed in the present study is higher as compared to mean estrus reported in Egypt by Wilson (1998) where it lasted 4.6 days with a range of 1-15 days. The variation may be due to the season and weather that may consequently affected follicular activity as reported by Wilson (1998), in Egypt.

Age of first calving

The mean age at first calving was 5.2 years. The result is inline with the previous findings in Horn of Africa (Hortaly, 1979; Sato, 1976; Schwarz et al 1982; Tezera, 1998), in Niger (Wilson, 1984b), and in Israel (Yagil, 1985) where the age of first calving varied from five to six years. The mean calving intervals observed in this study was 2 years while post-partum anestrus period was 7.9, 8.1, and 6.9 days in small, medium and large herds, respectively. But dams are not allowed to breed till they complete 300-365 days. The later exercise is in agreement with Mukasa-Mugerwa (1981), who reported a similar breeding practice after parturition in Ethiopia. This practice was explained by the pastoralists in such a way that if the dams bred during early lactation milk yield will go down and lactation length will be shortened, which result in reduction of availability of milk to the household and for the proper growth of calf

Age of highest fertility

Though the age at first breeding varies from 3.9 to 4.5 years, the age of highest fertility in terms of obtaining the calf is 5-6 years according to the herders. It is in complete agreement with different research reports in Sudan (El-Amin 1979), in Chine (Dangwei, 1979), and in Israel (Yagil, 1985).

Table 1. Features of some of reproduction traits of female as reported by camel owners (days)

Herd size	Traits	N	Mean	S.D
Small	First breeding age	23	1424	153.00
	Estrus duration	24	6.7	1.20
	Age of first calving	23	1825	146.00
	Post-partum anoestrus	22	7.9	0.90
	Calving interval	23	720	114.00
	Age at highest fertility	23	1825	124.10
Medium	First breeding age	26	1643	318.00
	Estrus duration	26	7.5	4.90
	Age of first calving	24	1971	321.00
	Post-partum anoestrus	26	8.0	4.00
	Calving interval	25	681	144.00
	Age of highest fertility	24	1825	73.00
Larger	First breeding age	25	1606	146.00
	Estrus duration	25	6.6	0 .95
	Age of first calving	25	1825	329.00
	Postpartum anoestrus	24	7.0	0.46
	Calving interval	25	720	27.00
	Age of highest fertile	25	1825	73.00

Pregnancy and Abortion

On average out of eight confirmed conceptions two times abortion was observed in different Woredas (Table 2). However, there was no significant difference among the herd sizes. The mean number of abortion for confirmed pregnancies is indicated in Table 2 and Figure1. Higher rate of abortion was observed in the current finding than the finding reported by Tezera (1998), in Southern Ethiopia (8.1 percent in Jijiga).

Table 2. Rate of abortion in 30 selected camel cows in each Woreda.

Woreda		Mean	S. D
Jarati	Pregnancy (N0)	8.03	2.2047
	Abortion number (N0)	2.27	1.66
Dollo-bay	Pregnancy (N0)	7.23	2.73
	Abortion number (N0)	2.03	1.75
Hargelle	Pregnancy (N0)	8.67	2.63
	Abortion number (N0)	2.00	1.60
Barey	Pregnancy (N0)	8.03	3.02
	Abortion number (N0)	1.82	1.70
El-kari	Pregnancy (N0)	7.87	2.89
	Abortion number (N0)	2.50	1.41

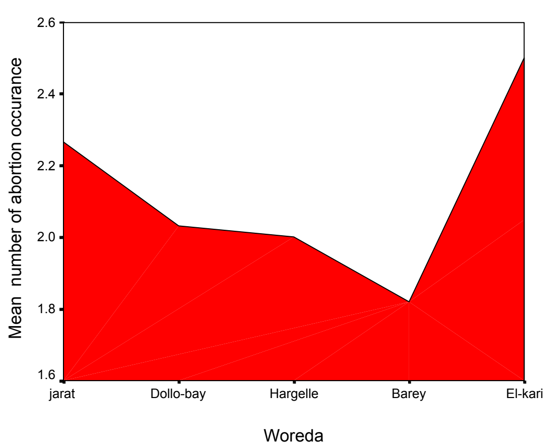

Figure 1: Opinion of the respondent on abortion occurrence by Woreda.

The pastoralist report indicated that disease contributed for the major stress factors during gestation with more than 50% of total abortions said to be due to Trypanasomiasis. It was also reported that any disease with high temperature and trauma around the abdomen could be possible cause of abortion (Bekele and Getu, 1998). The interviewed pastoralists (n=61) reported that most of camel abortions were observed during early stages (2 to 6 months) of pregnancy. The result is in agreement with previous findings in Niger (Wilson, 1984 b), in Southern Ethiopia (Tezera 1998), and contradicts the report of Bekele and Getu (1998), in Ethiopia who reported trypanasomiasis contributed only three percent of abortion.

Calf crop during productive life

There are normally variations in the number of calves born per dam in her reproductive lifespan (Table 3). About 42.9, 62.5 and 54.2% for small, medium, and large herd owners (N=69), respectively reported that ten calves are expected during the dam's productive life. About 8.3% of the large herd owners reported that camels could give birth up to 15 calves during its reproductive life, while 14.3% of small herd owners reported only eight calves. The number of calves born per dam observed in the present study is also within the range reported by Hussian, (1993) and Tezera (1998). These authors stated that about 11 calves are expected during dam's productive life.

Table 3. Average of expected calving per dam during its average reproductive life span.

Herd size	N	Frequency	Percent
Small	21		
8 calves		3	14.3
9 calves		1	4.76
10 calves		9	42.9
11 calves		2	9.5
12 calves		3	14.3
13 calves		3	14.3
Medium	21		
9 calves		4	16.7
10 calves		15	62.5
12 calves		3	12.5
13 calves		2	8.3
Large	24		
9 calves		4	16.7
10 calves		13	54.2
11 calves		1	4.2
12 calves		3	12.5
13 calves		1	4.5
15 calves		2	8.3

Breeding bulls

Selection

Depending on the required trait selection of the male calves starts from early ages and continues up to two years after weaning. In this study, it was noticed that bull calves were selected usually at the age of one to two years. Sometimes the final selection could be attained when animals are at three years of age. In some cases, selection was done when bulls were 5 years old. Selection of breeding bulls is normally based on body size, tallness of the bull, color and the performance of his father. In addition to physical appearance, the important trait that commonly considered was potential to service dams e.g. number of mating per day. The current findings are in agreement with earlier works of Hashi (1987), Bekele and Getu (1998), Tezera (1998), and Alemayehu (2001).

Sexual maturity

The interviewed herders reported that though male camels reach their first service at about 5.5 years of age, full sexual maturity reached around seven year with range of 5-11 years in all the herds (Table 4). This finding is in agreement with previous study by Dioli et al., (1992) in East Africa while differs from previous work by Yagil (1985) and Payne (1990). The discrepancy here could be attributed to previous findings, which considered the age of puberty as first mating 5-6 years for males, while the present study considered full sexual maturity that is extensively used for breeding, to be 7 years.

Table 4. Reported some reproductive traits of breeding bulls

Herd size	Trait	N	Mean	S.D
Small	Age at first service (year)	24	5.5	0.59
	Age at full sexual maturity (year)	22	6.7	1.30
	Services per day (no)	23	5.0	2.00
	Services per night (no)	22	6.0	1.90
	Conception per season (no)	23	60.8	22.70
	Length of reproductive life (year)	23	19.7	4.60
Medium	Age at first service (year)	25	5.5	0.59
	Age at full sexual maturity (year)	24	7.0	1.30
	Services per day (no)	26	4.9	2.20
	Services per night (no)	26	6.9	3.30
	Conception per season (no)	25	65.1	32.00
	Length of reproductive life (year)	24	17.9	3.90
Large	Age at first service (year)	25	5.6	0.50
	Age at full sexual maturity (year)	25	7.2	1.40
	Services per day (no)	25	4.8	2.00
	Services per night (no)	24	5.8	2.40
	Conceptions per season (no)	24	66.9	25.00
	Length of reproductive life (year)	25	18.4	3.60

Ability of bulls to serve

The ability of bulls to serve depends on factors such as age, condition and type of the bull, number of female in heat and the season. The survey result showed that good bull able to mate maximum of 11 camels during both day and night time, when adequate browsing is available in the field. The mean number of female covered by a bull in a breeding season was varied among the Woredas and herd sizes (Figure 2).

Number of service per day and night

The number of services per night was higher than number of service per day (Table 4). The reason may be that during the night time bulls are able to identify almost all females that are in heat since all animals were gathered in enclosures. According to the response of camel owners, there are variations in number of dams that one bull can breed in one breeding season (Table 4).

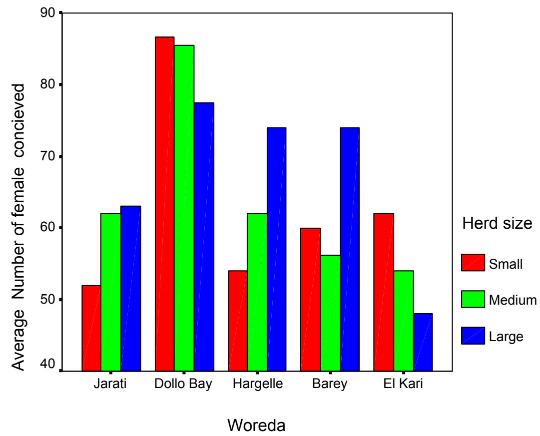

Figure 2. Reported average number of females covered in breeding season.

Mean number of dams that bulls can serve in one breeding season was reported to be 60.8, 65.1 and 66.9 for small, medium, and large herd size, respectively. As suggested by owners, number of females covered in breeding season depends on the season, age, fertility of the bull and female and the breeding management. The result of the current study is higher than previous observation of Dioli et al., (1992) in East Africa where a bull at the age 7-13 years old can serve up to 50 females during the breeding season, and lower than the mean annual reproductive rate for the bull reported by Alemayehu (2001) and Tezera (1998) in Ethiopia, who reported 80 to 100 female in one breeding season.

Reproductive age of bull

According to the respondents, the mean reproductive life of male was 19.7, 17.9 and 18.4 years in small, medium and large herd sizes, respectively. It is within the range reported by Hashi (1987**),** which was more or less similar to male reproductive age in Somalia (18 years).

Breeding management

Camels usually breed during the two wet seasons called *Gu* and *Deyr,* when feed is plenty (Table 5). During the wet season, camels come to heat and seek the bull. The rutting bull will be able to identify female in heat by smelling genital organs. Herders are also able to identify female in heat by observing certain symptoms such as restlessness and urination. Camel owners reported that they distinguish the intensity of estrus in their animals: an animal in extreme estrus (Abasax) and the second type of heat is mild one and the females are called qooq.

Table 5. Opinion of herders on seasonal sexual activities of camel.

Herd size		Frequency	Percent
Small	Wet season	23	95.8
	Any time when feed is surplus	1	4.2
	Total	24	100.0
Medium	Wet season	25	96.2
	Any time when the feed is surplus	1	3.8
	Total	26	100.0
Large	Wet season	25	100.0

Female under intensive estrus sits in front of the bull and easily accepts the bull without intervention of the owner. In case of mild estrus only the bull can identify receptive females and force it to sit down. As reported by the owners, fertility rate of the Abasax types is 98 percent.

Wilson (1998) classified four phases of the follicular wave in camels such as the non-follicular stage, the growing follicular stage, mature follicular stage, and the atretic follicular stage. He further indicated that female camels accept the male only during the mature follicular stage. It may be the case that Abasax (intensive) occurs mature follicular stage. Almost 100 percent of the household studied reported that they assist the young and inexperienced breeding bull during mating. Experienced bulls are able to mate without intervention of the human. The current finding is in agreement with Hashi (1987) and Tezera (1998).

Ownership of bulls

About 37.5%, 76.9%, and 100% small, medium and large herd owners (Table 6) had their own breeding bull, indicating that as herd size increases availability of bulls and a chance of selecting a good breeding bulls also increase. The herders who do not have their own bull were always in problem and they find it hard to get an appropriate bull**.** Therefore, from this study it is possible to conclude that providing breeding bulls to small herd owners, and some of the medium camel herd owners, is the best intervention to help the herd growth.

Table 6. Ownership of breeding bulls by herd size

Herd size		Frequency	Percent
Small	Yes	9	37.5
	No	15	62.5
	Total	24	100.0
Medium	Yes	20	76.9
	No	6	23.1
	Total	26	100.0
Large	Yes	25	100.0

The selected camel bull is not used for any purpose other than breeding. Similar practices were reported by Abebe (1991) in Ethiopia. However, as expressed by some herders if there is a shortage of active bull especially during the dry season, they would use breeding bull to transport household material during migration. Hashi (1987) also reported a similar practice in Somalia.

Conclusion and Recommendation

The present finding is intended only to generate baseline information on camel managed under traditional reproduction management, therefore camel reproduction and production under improved and controlled management should be studied. Cases of camel abortion require thorough investigation, and also the effect of trypanasomiasis on the gestation should be worked out.

Pastoralists who had enough herd size practice selection of bull, but herders with small and some of the medium herd need source of selected bull and provision of bull is the best intervention to help the herd growth of these camel owners.

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Traditional Milk and Milk products Handling Practices and Preservation Methods in three Districts of East Shoa Zone of Oromia.

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Abstract

A survey was conducted in three districts of the East Shoa Zone of Oromia (Arsi Negelle, Adami Tulu Jido Kombolcha and Lume) to know the traditional milk and milk products handling practices and to identify the traditional milk and milk products preservatives in the area. Thirty women from each district, a total of ninety from the three districts were individually interviewed using semi-structured questionnaire. The majority of the women (85.5 percent) practice limited sanitary procedures before milking. Only few women (14.5 percent) washed the udders of their cows before milking. In most instances, during milking women dip their fingers into the milk bucket and moisten the teats of the cows to facilitate milking. This practice may allow microbial contamination of the milk from the milker's hand. About half of the women (53.3 percent) in Lume district used "Guftee" (Sida cuneifolia) and "Hiddii hoolotaa" (Cucumis prophetarum) for cleaning utensils used for milking, storing and processing milk while about 47 and 40 percent of the women in Adami Tulu and Arsi Negelle used "Kosorata" (Ocimum hardiense) and a lesser proportion used "Bargamoo adii" (Eucalyptus globulus). Few women seldom wash milk handling and processing utensils in Adami Tulu (13.3%) and in Arsi Negelle (10.0%) districts. Olea africana was the most frequently used plant for smoking milk vessels in all the three districts followed by Juniperous procera and Ocimum hardiense. Almost 100 percent of the women in Adami Tulu and Arsi Negelle and 63.3 percent in Lume district used preservatives of plant origin to keep butter for longer time. Trachyperimum copticulm, Aframomum angusti-folium, Nigella sativa, Trigonella foenum and Eucalyptus globulus were the most commonly used butter preservatives in the areas. The active ingredients of these preservatives, their effectiveness in keeping butter for longer periods without deterioration or spoilage and the amount and methods of utilization deserve further investigation. Milk vessels cleaning plants identified in this study particularly the use of "Gurra harree" (Verbascum sinaiticum) as a cleaning plant to regulate fermentation of milk deserves further investigation.

Key words: Milk, Milk products, Traditional, Handling, Preservation, Spices.

Introduction

Storage stability problems of dairy products exacerbated by high ambient temperatures and distances that producers have to travel to bring the products to market places make it necessary for smallholders to seek products with a better shelf-life or to modify the processing methods of existing once to get products of better shelf-life. The first step that the producers or product handlers can take to ensure a high quality product is to make sure that the production and the manufacturing process are hygienic. These will result in fewer spoilage organisms in the dairy products and thus better quality with longer shelf life in the final products. Another option to ensure good quality is to take maximum care in handling and storage of the products during transport and marketing. The fact that milk is relatively perishable and a high percentage of it is consumed in a relatively natural state, handling of milk and its products to preserve its natural and desired characteristics is very important (Duane and Cunningham, 1991). The less perishable the products, the longer the smallholders can retain it to obtain good price and surplus made during the production season can be stored for consumption during the season in which the products are in short supply. Smallholders add different spices to butter as a preservative and /or to enhance its flavor for cooking (ILCA, 1992).

In areas where the climate is hot and humid, the raw milk spoils easily during storage unless it is cooled or when possible treated with preservatives. But these preservatives are not readily available in rural areas and cooling systems are not feasible because of lack of facilities (O Mahony and Peters, 1987). In these areas, the farmers have to rely on traditional technology to increase the storage stability of milk and milk products either by converting the milk to its stable products like butter or by treating with traditional preservatives. Identification and characterization of these traditional herbs and determination of the active ingredients and methods of utilization could be very crucial in developing appropriate technologies for milk handling and preservation in the country.

Objectives:

- To know the traditional milk and milk products handling practices in the area.
- To identify the traditional milk and milk products preservatives in the area.

Materials and methods

Description of the study area

The study was conducted in three districts of East Shoa zone of Oromia (Arsi Negelle, Adami Tulu-Jido Kombolcha and Lume). These three districts are purposively selected based on the survey result of ATRC (1997) that, they are potential milk shed areas. The districts are found in the Mid-Rift Valley of Ethiopia. The altitudes range from 1500 to 2300 m. above sea level and have semi-arid type climate. The Mid-Rift Valley has an erratic, unreliable rainfall pattern that is low averaging between 500 and 900 mm per annum. The rainfall is bimodal with the short rains from February to May and long rains from June to September. The predominant agricultural production system in these areas is mixed crop-livestock farming. Cattle are the most important livestock species in all the areas.

Adami Tulu-Jido Kombolcha district

The area is located some 167 km from Addis Ababa on the way to Awassa. It has area coverage of 140,325 ha. It receives an average annual rainfall of 771 mm. The minimum and maximum average temperatures are 12.8 and 27.3°C respectively. It is situated at an altitude of 1650 m above sea level. The predominant crops are maize, haricot bean, teff and wheat. Among the crops produced, maize is the most important both in terms of the proportion of farmers growing it and the area coverage (ATRC, 1997, unpublished).

Arsi Negelle district

It is located about 231 km south of Addis Ababa. It has an altitude ranging from 1500 to 2300 m asl, area coverage of 189,587 ha and receives an average annual rainfall of 800 mm (500-1000 mm). The minimum and maximum average temperatures of the area are 10 and 23°C respectively. The major crops grown are wheat, maize, haricot bean and teff.

Lume district

It is located about 75 km south east of Addis Ababa. It has an altitude ranging from 1500-2250 m asl, receives an average annual rainfall of 900 mm (457-1400 mm). It has a total area coverage of 78,003 ha and the minimum and maximum average temperatures of 18 and 25ºC, respectively. The predominant crops grown are teff, wheat, maize and barley.

Sampling procedures:

Six peasant associations from each district were randomly selected. Accordingly, Oitu, Arba, Andola, Wayiso, Goba Jochoo and Abine Garmamaa from Adami Tulu district; Arangama, Daka, Kararu, Gubata, Ali Wayo and Gambelto from Arsi Negelle and Koka Nagawo, Ejersa Jorro, Fatole, Dungugi, Sharara Dibandiba and Gode from Lume were selected. From each PA's five women who owned milking cows and process milk were purposively picked up and interviewed. Accordingly, thirty women from each district and a total of ninety participants from the three districts were individually interviewed using a semi-structured questionnaire in the study undertaken.

Results and discussion

Milk and milk products handling practices

The majority of the women (85.5%) practice limited sanitary practices before milking whereas only 14.5% practices udder washing before milking. Calves are allowed to suckle prior to milking. About 8.9 percent of the women washed the udders of their cows and let the calves to suckle their dams for sometime before milking (Table 1).

Table 1. Milking procedures in the three districts of East Shoa zone of Oromia.

	Percent in each districts			
Milking procedures	Adami Tulu	Arsi Negelle	Lume	Mean
Udder washing and milking	-	6.7(2)	10.0(3)	5.6(5)
Udder washing, suckling and milking	16.7(5)	10.0(3)	-	8.9(8)
Suckling and milking	83.3(25)	83.3(25)	90.0(27)	85.5(77)

Numbers in parenthesis indicate the number of observations in each district.

Milking was mostly performed twice a day in all the three districts. However, there were exceptions to this, during the dry seasons milking operation is limited to once per day. Few farmers who had crossbred cows reported milking three times per day. Depending on the availability of green forage, the newly born calf is allowed to suckle all the milk for the first two to three weeks. In most instances, women dip their fingers into the milk bucket and moisten the teats of the cow to facilitate milking. This practice may allow microbial contamination of the milk from the milker's hand.

Plants used for cleaning milk utensils

About 53.3% of the women in Lume district used "Guftee" (*Sida cuneifolia*) and "Hiddii hoolotaa" (*Cucumis prophetarum*) leaves to clean the milk vessels used for milking, storing and processing while about 47% and 40% of the women in Adami Tulu and Arsi Negelle, respectively, used "Kosorata" (*Ocimum hardiense*). A lesser proportion of women used "Bargamoo adii" (*Eucalyptus globulus*). "Kosorata" (*Ocimum hardiense*), "Waahalle" (*Withania somnifera*) and "Gurra harree" (*Verbascum sinaiticum*) were also commonly used as cleaning plants in Lume district (Table 2).

The most commonly used cleaning plants in Lume district (Table 2) such as *Sida cuneifolia, Verbascum sinaiticum* and *Withania somnifera* were not used as cleaning plants in both Adami Tulu and Arsi Negelle. Cleaning plants differ from place to place and even from household to household based upon preferences indicating the variety of materials that need to be exhaustively studied. Respondents claimed that these cleaning plants of their choice were being used as they are known to improve flavor and increase butter production. Some respondents in Lume district reported that *Verbascum sinaiticum* is used to normalize or extend fermentation time. In cases when fermentation rate increase, the milk storage vessels are washed with the plants to retard the fermentation rate. This herb may act by helping to inoculate some desirable organisms in the milk or selectively inhibit the growth of undesirable acid forming organisms and create ideal environment for the former groups to grow and take the advantage for proliferation. This needs further study.

13.3% of the farmers in Adami Tulu and 10.0% in Arsi Negelle districts seldom wash milk-processing vessels (Table 2). In these areas, milk processing vessels are simply scrubbed using a special rubbing material known as '**foksoo**'. Such practice may allow for the retention of lactic acid bacteria in the vessels and facilitate natural inoculation for desired fermentation to take place. However, one cannot be certain on the quality and safety of the product from such fermentation.

Table 2. Plant leaves used for cleaning milk vessels in three districts of East Shoa zone.

Types of plants		Districts					
Local name	Scientific name	Adami Tulu N	%	Arsi Negelle N	%	Lume N	%
Darguu	Achynthes aspera	5	16.7	4	13.3	-	
Hiddii	Solanum spp	6	20.0	6	20.0	5	16.7
Waahalle	Withania somnifera	-	-	-	-	6	20.0
Guftee	Sida cuneifolia	-	-	-	-	16	53.3
Gurra Harree	Verbascum sinaiticum	-	-	-	-	6	20.0
Urgeechaa	Premna resinosa	-	-	-	-	2	6.7
Hiddii Hoolotaa	Cucumis prophetarum	2	6.7	-	-	16	53.3
Saara	unidentified	-	-	-	-	3	10.0
Bargamoo-adii	Eucalyptus globulus	12	40.0	5	16.7	4	13.3
Kosorata	Ocimum hardiense	14	46.7	12	40.0	11	36.7
Caarotaa	Ruta chalepensis	-	-	3	10.0	1	3.3
Basobilaa	Ocimum sanctum	-	-	1	3.3	4	13.3
Kasee	Ocimum lamifolium	2	6.7	-	-	1	3.3
Sariitii	Asparagus asiaticus	-	-	1	3.3	1	3.3
Hixichoo	unidentified	6	20.0	4	13.3	-	-
Bakkanniisa	Croton macrostachyus	1	3.3	2	6.7	-	-
Araddoo	unidentified	1	3.3	-	-	-	-
Qantalama	unidentified	2	6.7	3	10.0	-	-
Qurxee	unidentified	1	3.3	-	-	-	-
Qoshee	unidentified	1	3.3	-	-	-	-
Xiixiyee	unidentified	1	3.3	-	-	-	-
Xaaxessaa	Rhus natalensis	-	-	5	16.7	-	-
Gaalee kormaa	unidentified	-	-	2	6.7	-	-
Gatamee	Schefflera abyssinica	-	-	2	6.7	-	-
Qadiidaa	unidentified	-	-	1	3.3	-	-
Gorgorroo	Hypericum revolutum	-	-	2	6.7	-	-
Gaattiraa	Juniperous procera	-	-	3	10.0	-	-
Anshaa	Schefflera volkensii	-	-	1	3.3	-	-
Different grasses		5	16.7	2	6.7	-	-
Do not clean		4	13.3	3	10.0	-	-

N = Number of respondents in each district.

According to observations made by (Coppock *et al.*, 1992) in the semi-arid pastoral system of Ethiopia, a "Gorfa" may be scrubbed with leaves of Endostemen tereticaulis or Ocimum hardiense before being filled with milk. Plants used for rubbing milking vessels deserve further investigation to determine their active ingredient and the efficacy of the active ingredients on the desirable and /or undesirable microorganisms.

Plants used for smoking the milk vessels

Olea africana was the most frequently used plant for smoking milk vessels in all the three districts followed by *Juniperous procera* and *Ocimum hardiense* (Table 3). These plants were used to impart good flavor to the milk and milk products. Besides these, it is claimed that they are known to increase the shelf life of milk when used. The use of such plants differs from place to place and even from household to household. For example, "Yuubdoo" (*Protea gaguedi*), "Hixichoo" and "Hiddii" (*Solanum spp)* were not reported from Arsi Negelle and Lume districts. Similarly, "Anshaa" (*Schefflera volkensii)*, "Gatamee" (*Schefflera abyssinica)* and "Qadiidaa" were reportedly used only by small proportion of women in Arsi Negelle. Households in semi-arid pastoral system of Ethiopia smoke their milk processing vessels with burning chips of *Acacia nilotica, Cordia glarfa, Cordia ovalis* or *Combertum molle* (Coppock *et al.*, 1992). *Deinbollo kilimandshorica* (Dabaqaa), *Syzygium guinecnse* (Baddessa), *Heeria reticulala* (Gaarrii) and *Olea africana* (Ejersa) were the most commonly used smoking plants in Eastern Wollega (Alganesh, 2002).

According to most respondents, smoking of milking and storage vessels is frequently done in order to extend the fermentation time in order to accumulate the desired volume of milk for churning. This agrees with the finding of Mogessie and Fekadu (1993) that smoking reduced the undesirable microbial contamination that enhances the rate of fermentation. Whenever there is high production of milk, the milking and storage vessels are not smoked to increase the rate of fermentation. Coppock *et al* (1992) in semi-arid pastoral system of Ethiopia also reported that sterilization helps to obtain an appropriate rate of fermentation. In cases where containers are limited and /or people need to sour fresh milk daily, Gorfa may be reused without scrubbing or fumigating. Women in the area have also another mechanism to prolong the fermentation periods. They select the coolest area in their home, dig a hole, put sand and sprinkle water over it and put the clay pot in the hole and collect milk in it for four to five days until the required volume for churning is obtained. This procedure is followed only if the amount of milk available daily is small. Otherwise, they are forced to churn a small volume of milk everyday since fermentation takes only one day in most areas. This is due to the high temperature in the Mid Rift Valley area. During the cold season some households put the milk close to fireplace in order to facilitate fermentation within the shortest time possible if they have surplus milk and want to churn everyday.

Spices used as butter preservative

In all the three districts, surplus butter produced during high production season was either sold at lower price or preserved and stored by mixing with spices for later use. 100% of the women in Adami Tulu and Arsi Negelle and 63.3% in Lume district used different preservatives to keep butter for longer period of time (Table 4). According to the respondents, butter can be preserved for about 3.0 years if properly worked i.e. if it is kept clean and mixed with fresh butter from time to time. Butter is preserved and stored as a sign of wealth, for use during dry periods when its production is low. It is known that butter gets rancid when kept for a longer period of time. However, some people prefer rancid butter to fresh for consumption as they think rancidity increases the medicinal value of butter. Rancid butter is reportedly used as a treatment for tuberculosis, common cold, malaria and internal parasites when melted and drunk with honey. *Trachyperimum copticulm*, *Aframomum angusti-folium*, *Nigella sativa*, *Trigonella foenum* and *Eucalyptus globulus* were the most commonly used butter preservatives in the areas studied (Table 4). The use of "Shuuqoo" (*Trigonella foenum*) as butter preservative depends on whether the preserved butter is to be used for cooking "wot" or to be eaten with porridge. If the butter is to be eaten with porridge "Shuuqoo" is not used as preservative. Salting of butter is not common in all the area surveyed.

Table 3. Plant species used for smoking/ fumigating milk vessels in the study areas.

Type of plant		Districts					
		Adami Tulu		Arsi Negele		Lume	
Local	Scientific name	N	%	N	%	N	%
Ejersa	Olea africana	29	96.7	26	86.7	30	100
Gaattiraa	Juniperous procera	6	20.0	21	70.0	1	3.3
Yuubdoo	Protea gaguedi	3	10.0	-	-	-	-
Ruukessaa	Dracaena afromontana	-	-	-	-	2	6.7
Anshaa	Schefflera volkensii	-	-	3	10.0	-	-
Gatamee	Schefflera abyssinica	-	-	4	13.3	-	-
Kosorata	Ocimum hardiense	8	26.7	2	6.7	-	-
Gaarrii	Heeria reticulala	1	3.3	1	3.3	-	-
Qadiidaa	unidentified	-	-	2	6.7	-	-
Hixichoo	unidentified	2	6.7	-	-	-	-
Hiddii	Solanum spp	3	10.0	-	-	-	-
Do not smoke		-	-	1	3.3	-	-

Butter storage equipments

Clay pot, "buqqee" (gourd), plastic bucket and metal containers were the most commonly used butter storage equipments. About 94.4 percent of the women in the areas preserve butter in a small clay pot though the kind of utensils to be used depends on the amount of butter to be preserved. The effect of these materials on the shelf- life of stored or preserved butter deserves further investigation.

Summary and conclusion

The majority of the women (85.5 percent) practice limited hygienic practice before milking. Only few women (14.5 percent) washed the udders of the cows before milking. About 53.3 percent of the women in Lume district used "Guftee" (*Sida cuneifolia*) and "Hiddii hoolotaa" (*Cucumis prophetarum*) to clean the milk vessels while the majority of the women in Adami Tulu and Arsi Negelle used "Kosorata" (*Ocimum hardiense*) and "Bargamoo adii" (*Eucalyptus globulus*). "Waahalle" (*Withania somnifera*) and "Gurra harree" (*Verbascum sinaiticum*) were the most commonly used cleaning plants in Lume district. Less than 14 percent of the women in the study area did not practice any form of milk vessels cleaning at all.

Table 4. Herbs used to preserve butter in three districts of East Shoa zone.

Type of herbs		Distícts					
		Adami Tulu		Arsi Negelle		Lume	
Local name	Scientific name	N	%	N	%	N	%
Shuuqoo	Trigonella foenum	3	10.0	12	40.0	12	40.0
Kororimaa	Aframomum angusti-folium	23	76.7	26	86.7	7	23.3
Qullubbii adii	Allium ursinum	-	-	1	3.3	2	6.7
Kusaayee	Lantana trifolia	-	-	2	6.7	8	26.7
Urgoo adii	Trachyperimum copticulm	30	100	26	86.7	4	13.3
Urgoo gurraacha	Nigella sativa	18	60.0	12	40.0	3	10.0
Axunbaarree	unidentified	-	-	-	-	1	3.3
Jinjibila	Zingiber officinale	-	-	-	-	1	3.3
Qundobarbarree	Mentha piperita	-	-	-	-	2	6.7
Irdii	Curcuma longa	-	-	-	-	2	6.7
Makallashaa	unidentified	-	-	-	-	1	3.3
Caarotaa	Ruta chalepensis	-	-	-	-	1	3.3
Basobilaa	Ocimum sanctum	-	-	-	-	1	3.3
Xoosinyii	Satujera sp.	-	-	1	3.3	1	3.3
Firee Bargamoo	Eucalyptus globulus	8	26.7	9	30.0	-	-
Dinbilaala	Cordiandrum sativum	6	20.0	-	-	-	-
Garambee	Brassica integrifolia	-	-	2	6.7	-	-
Qurunfudii	Eugenia caryophylla	-	-	1	3.3	-	-
Hixichoo	unidentified	-	-	2	6.7	-	-
Do not preserve		-	-	-	-	11	36.7

Olea africana was the most commonly used smoking plant in all the three districts followed by *Juniperous procera* and *Ocimum hardiense*. Milk vessel cleaning plants identified in this study particularly the use of "Gurra harree" (*Verbascum sinaiticum*) as a cleaning plant to regulate fermentation of milk deserves further investigation.

Trachyperimum copticulum, Aframomum angusti-folium, Nigella sativa, Trigonella foenum and *Eucalyptus globulus* are the most commonly used traditional butter preservatives in all the areas. The active ingredients of these preservatives, their effectiveness to keep butter for longer periods without deterioration and the amount and methods of utilization deserve further investigation. The impact of spices on human health arising from their uses as butter preservatives also requires further study.

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Nature and phenology of honeybee plants in the central highlands of Ethiopia

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Abstract

To determine honey plants in the central highlands of Ethiopia, survey work and case studies were conducted. For the survey work, honey plant species visited by foraging honeybees were collected, botanically identified and the necessary data about the honey plant species was registered. Accordingly, 52 honey plant families comprising 143 honey plant species were identified in the region. Asteraceae, Leguminaceae and Lamiaceae are the major honey plant families in the region comprising 35.7% of the honey plant species. Honey plants of the region are predominantly herbaceous in nature and grow mainly in open and cultivated lands.

Herbaceous and shrub honey plants mainly flower after the big rainy season (September – November), while tree species flower during the small rainy season (March – May). There is correlation between the intensity of rainfall and the flowering of honey plants. Reproductive swarming and migration occur during both high and low intensity of flowering respectively.

Key words: Honey plant/ phenology/ central highlands/ Ethiopia

Introduction

Ethiopia has diverse climatic conditions and topography which favor the growth of a wide range, about 7000 species, of cultivated and uncultivated plants including trees, shrubs, herbs and undergrowth or climbers (Geremew et al., 1999). The wide variety of vegetation and other conducive environmental conditions make the country highly favorable for honeybees.

As honeybees do not visit all plants for nectar and/or pollen, identification of the plants which supply these resources, plant communities and the phenological relationship between honey plants and honeybees are of paramount importance for practical beekeeping and in assessing the potential of an area for beekeeping. However, such knowledge in Ethiopia in particular and in Africa in general is at an elementary stage. The present study focuses on the central highlands of Ethiopia, where beekeeping is a widely practiced and economically important farming activity to determine honey plants, their habitat, nature, time of flowering and the relation of intensity of flowering and phenology of reproductive swarming and migration of honeybees.

Materials and methods

The study was conducted in the central highlands of Ethiopia between 5^0 16' 40.4" N to 8^0 11' 30.1" N latitude and 34^0 16.07'E to 37^0 3' 33.3" E longitude. Plants visited by honeybees for nectar and/or pollen were collected from Holetta, Sorofta (Bale zone), Mararo, Boterbacho, Roge, Hossaina, Effo Yachi, Gado Lama, Boke Toko and Alage, and identified either at National Herbarium, Addis Ababa University or using reference texts in the field (Fichtl and Adi, 1994; Woldemichael, 1987). Data about the nature and habitat of plants and as a source of forage as nectar and/or pollen were recorded during the survey work. The flowering times of the plants were recorded through interviewing farmers of the area.

To facilitate the comparisons rainfall, temperature and flowering data of each study site were standardized. Firstly, all rainfall and temperature frequency distributions were plotted according to months of the year, giving 12 classes. Then the simple arithmetic means and standard deviations were calculated. The mean was subtracted from each monthly value. The remainder was divided by the standard deviation and the product simply expressed a positive or negative percentage value for each month. The reproductive swarming and migration times of each locality were plotted against the months of the year and compared to the intensity of flowering time.

Results

143 plant species representing 52 plant families were identified as honey plants in the central highlands. Asteraceae, Lamiaceae and Leguminosae were the dominant honey plant families comprising 16.8%, 11.2% and 9.1% of the total honey plant species identified in the region respectively (Table 1 and 2). Honey plants of the region offer nectar and/or pollen to honeybees. About 88.8% of the species provide both nectar and pollen together, while 9.1% of the species supply only pollen and the balance supply nectar or exudates (Table 1). Honey plant species of the region include trees, shrubs, herbs and undergrowth growing in open land, forestlands, bush lands and wetlands. About 65% of the identified species were herbaceous, while trees accounted for 17.5% and shrubs 16.8% of the species (Table 3). Moreover 35.7% and 32.8% of the honey plant species grow on open land and cultivated lands respectively, while forestland, bush land and wetland habitats comprise 14%, 7.7% and 7.7% of the species and the balance occur on both open land and forestland (Table 2).

87.5%, 81.3% and 76.9% of honey plant species in the Asteraceae, Lamiaceae and Leguminosae families respectively are herbaceous. About 61.5% of Leguminous honey plant species grow on cultivated land. 43.8%, 25.0%, 18% and 12.5% of honey plants of family Lamiaceae grow on cultivated lands, open land, wetland and forestland habitats respectively. Honey plant species in the Asteraceae family are found growing in open land (58%) and cultivated lands (21%). Thus, the honey plants of the region are predominantly herbaceous in nature and grow mainly in open and cultivated lands (Table 2).

The flowering times of honey plants vary from species to species depending on the climatic conditions of their habitat. 76.9% of Leguminosae, 71.4% of Lamiaceae and 83.3% of Asteraceae honey plant species flower during September to November. Approximately 61.5% of honey plant species flower during September through November, 5.6% during the dry season (December to February), 12.6% during the rainy season (June to August), 12.6% during spring (March to May), and the balance, flower at different periods of the year (Tables 1 and 3). The greater proportions of trees were in flower during March through May (39.1%) while 77.0% of herbaceous and 50% shrub were in flower during September to November (Table 3).

Rainfall occurs in all months of the year but varies in intensity. There are two main rainy seasons: the big rainy season, which occurs during mid-June through mid-September, is characterized by a high intensity of rainfall, and the small rainy season which occurs from mid-February through to April. In most cases, it merges with big rainy season. The intensity of the both rainy seasons varies with longitude and increasing towards the west (Table 5). With few exceptions, areas receiving a high intensity of rainfall during the big rainy season also receive a high intensity rainfall during the small rainy season (Table 4).

Flowering intensity coincides with the rainfall intensity during the small rainy season but immediately follows the high intensity rainfall during the big rainy season (Table 5). About 58% of flowering occurs during September to November right after the highest intensity of rainfall (June to August), while the second highest intensity of flowering (18%) occurs during the small rainy season (March to May). Like rainfall, flowering of honey plant intensity varies with longitude.

Reproductive swarming periods of honeybees corresponds with high flowering intensity but migration coincides with low intensity of flowering (Table 4).

Discussion

Due to its favorable climatic conditions and edaphic factors, a wide range of species of cultivated and uncultivated honey plants grow in the central highlands of Ethiopia from the smallest herbaceous plants to giant trees. However, the proportion of species of herbaceous honey plants is greater than that of trees and bushes. This is attributed to the fact that the central highlands are densely populated both with people and livestock, and as a result, pressure is put on the forests, which are degraded and replaced by herbaceous plants. Most of the existing forests are not natural (i.e. cultivated ones) and are composed of a few selected species of plants like *Pinus spp*. and *Eucalyptus spp*. The habitat distribution of honey plant species of the region confirms the above-mentioned results: the greater proportions of honey plant species in the region grow in open and cultivated land habitat. The forest and bush land habitats comprise only 13.3% and 7.0% of the total honey plant species. Moreover, the habitat distributions of the dominant families of the region (Asteraceae, Leguminoceae and Lamiaceae) also support the conclusion that honey plants of the region are predominantly herbaceous and growing on open and cultivated lands. In the highlands of Ethiopia, few tree species are found and they are mainly Asteraceae and Compositae (Leguminoceae) family (Mammo, 1976). This reflects the situation throughout the entire country because 40% of Ethiopia, which used to be forest only 3 decades ago, now has been reduced to 3.5% (Svensson, 1991). This would also substantiate the rapid replacement of forest trees by herbaceous plants in the country. This is in agreement with the results of Hepburn and Radloff (1998) who indicated that the principal bee trees are gradually replaced by shrubs and herbs on both sides of the equator and these changes ratio of trees to shrubs and herbs are also reflected throughout the whole African continent (White, 1983).

Honey plant species grown on cultivated land include weeds and crops. This indicates that weeds and crops are among the honey plants, which contribute to bee forage in the region. This is consistent with Amssalu (1997, 1999) who indicated that weeds and cultivated crops contribute considerably to the pollen and honey production around Holetta, a center of the central highland region. Cultivated plants constitute important competition for native flora where both occur (Amoaka, 1997).

Of the 52 honey plant families identified Asteraceae, Lamiaceae and Leguminosae account about 35.7% of honey plant genera in the region. This is partially in agreement with Hepburn and Radloff (1998) who indicated that of 354 families of plants in Africa (Bamps, 1994) four families Acantaceae, Legumunosae (including sub-family Caesalpiniodeae and Mimosaceae), Euphorbiaceae and Rubiaceae account for about 40% genera of bee flora in Africa.

Herbaceous plants and shrubs mainly flower during September through November while tree species bloom during March through May. That is the phenology of honey plants corresponding to the intensity of rainfall and temperature. As mentioned above the region has two rainy seasons: the main rainy season which provides the larger proportion of rainfall occurring during mid-June to mid-September, and the small rainy season which occurs during mid-February to April. Towards the end of these rainy seasons, the temperatures get hot and induce flowering (Ethiopian Mapping Authority, 1988). This may explain why about 61% of honey plant species mainly herbaceous, flower after the big rainy season (September to November) and others during the small rainy season (March to May). There is honey plant flowering overlap during September to November and March to May. This is in agreement with the findings of Amssalu (1997) who noted that in the Holetta highland areas, the predominant source of honey during autumn (September – November) are herbaceous honey plants while the main source of honey during May to June are tree species. Moreover, reproductive swarming and migration of honeybees of the region is associated to the flowering intensity and phenology of honey plants. The former occurs during the higher intensity of flowering while the latter occurs during the low intensity of flowering when no sufficient forage is available. This supports the fact that the seasonal cycle of the honeybee is related to the phenology of honey plants and flowering phenology is sufficient to provide accurate predictions of honeybee activities (Hepburn and Jacot Guillarmod, 1991). The temporal correspondence between flowering bee flora and brood-rearing cycle is 88% for entire Africa continent (Hepburn and Radloff, 1995).

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Table 1. Botanical name, family, nature, food source, flowering time and habitat distribution of honey plants in the central highlands of Ethiopia.

No.	Botanical name	Family	Plant nature	Food source	Flowering time	Habitat
1	Acacia abyssinica	Leguminoceae	Tree	Nectar and pollen	Jan - May	Open land & forestlands
2	Achyranthes aspera	Amaranthaceae	Herb	Nectar and pollen	Year round	Forestlands
3	Adhatoda shimperiana	Acanthaceae	Shrub	Nectar and pollen	Sept - Nov	Open land
4	Agiatoche rangesa	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
5	Ajuga integrifolia	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Wetlands
6	Albizia gummifera	Leguminoceae	Tree	Nectar and pollen	Feb - April	Forestlands
7	Anagallis arvensis	Primulaceae	Herb	Nectar and pollen	August - Jan	Open land
8	Anchusa officinalis	Boraginaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
9	Aningeria altissima	Sapotaceae	Tree	Nectar and pollen	April - May	Forestlands
10	Anthirrinum majusa	Scrophulariaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
11	Apodytes dimidiata	Icacinaceae	Tree	Nectar and pollen	January	Forestlands
12	Arckangelica officinallis		Herb	Nectar and pollen	Sept - Nov	Cultivated land
13	Aspilia africana	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Wetland
14	Aspilia mossambicensis	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Wetland
15	Barleria ventricosa	Acanthaceae	Herb	Nectar and pollen	Sept - Nov	Forestlands
16	Berkheya spekeana	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
17	Bidens ghedoensis	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
18	Bidens macroptera	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
19	Bidens Pachyloma	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
20	Bidens prestinaria	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
21	Bothriocline schimperi	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
22	Brassica napus	Brassicaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
23	Caesalpinia decapetala	Leguminoceae	Shrub	Nectar and pollen	Sept - Nov	Bush land
24	Carissa edulis	Apocynaceae	Shrub	Nectar and pollen	May - August	Bush land
25	Carthamus tinctorium	Asteraceae	Herb	Nectar and pollen	October	Open land
26	Caylusea abyssinica	Resedaceae	Shrub	Pollen	Sept - Nov	Open land
27	Celosia argentea	Amaranthaceae	Herb	Nectar and pollen	Sept - Nov	Open land
28	Cirsium schimperi	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Wetland
29	Citrius spp.	Rutaceae	Shrub	Nectar and pollen	March - May	Cultivated land
30	Clerodendrum myricoides	Verbenaceae	Herb	Nectar and pollen	March - May	Open land

No.	Botanical name	Family	Plant nature	Food source	Flowering time	Habitat
31	Commelina benghalensis	Commelianaceae	Herb	Pollen	Sept - Nov	Wetland
32	Cordia africana	Boraginaceae	Tree	Nectar and pollen	Sept - Nov	Open land & forestlands
33	Coriandrum sativum	Apiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
34	Crassocephalum vitellinum	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Bush land
35	Croton machrostachyus	Euphorbiaceae	Tree	Nectar and pollen	March - May	Open land & forestlands
36	Cucurbita pepo	Cucurbitaceae	Herb	Nectar and pollen	June - August	Cultivated land
37	Cynotis barbata	Commelianaceae	Herb	Nectar and pollen	August - Sept	Open land
38	Datura arborea	Solanaceae	Shrub	Nectar and pollen	Sept - Nov	Open land
39	Delphinium dasycaulon	Ranunculaceae	Herb	Nectar and pollen	Sept - Nov	Open land
40	Dianthus spp.	Caryophyllaceae	Herb	Nectar and pollen	Feb - March	Cultivated land
41	Digitaria spp.	Poaceae	Herb	Pollen	Sept - Nov	Open land
42	Dracocephalum moldavica	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
43	Echinops spp.	Asteraceae	Herb	Nectar and pollen	Oct - March	Open land
44	Ekebergia capensis	Meliaceae	Tree	Nectar and pollen	May - June	Forestlands
45	Eleusine floccifolia	Poaceae	Herb	Pollen	Sept - Nov	Open land
46	Erica arborea	Ericaceae	Shrub	Nectar and pollen	Sept - Feb	Bush land
47	Eucalyptus camaldulensis	Myrtaceae	Tree	Nectar and pollen	April - June	Cultivated land
48	Eucalyptus citriodora	Myrtaceae	Tree	Nectar and pollen	April - June	Cultivated land
49	Eucalyptus globulus	Myrtaceae	Tree	Nectar and pollen	April - June	Cultivated land
50	Euphorbia abyssinica	Euphoribiaceae	Shrub	Nectar and pollen	Sept - Nov	Open land
51	Fagopyrum esculentum	Polygonaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
52	Ficus sur	Moraceae	Tree	Exudates	Sept - Nov	Open land
53	Galinsoga parviflora	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
54	Galium simense	Rubiaceae	Herb	Nectar and pollen	Sept - Nov	Wetland
55	Galium spurium	Rubiaceae	Herb	Nectar and pollen	Sept - Nov	Forestlands
56	Geranium spp.	Geraniaceae	Herb	Nectar and pollen	Sept - Dec	Bush land
57	Glycine wightii	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Open land
58	Grevillea robusta	Proteaceae	Tree	Nectar and pollen	April - June	Cultivated land
59	Guizotia abyssinica	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
60	Guizotia scabra scabra	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
61	Guizotia scabra schimperi	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
62	Helianthus annuus	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land

No.	Botanical name	Family	Plant nature	Food source	Flowering time	Habitat
63	Helinus mystacinus	Rhamnaceae	Climber	Nectar and pollen	Feb - April	Open land
64	Hagenia abyssinica	Rosaceae	Tree	Pollen	Sept - Nov	Forestlands
65	Hypericum peplidifolium	Clusiaceae	Herb	Pollen	Sept - Nov	Wetland
66	Hypericum revolutum	Clusiaceae	Shrub	Nectar and pollen	April - May	Forestlands
67	Hypoestes trifolora	Acanthaceae	Herb	Nectar and pollen	June - August	Open land
68	Impatiens rothii	Balsaminaceae	Herb	Nectar and pollen	June - August	Open land
69	Jasminum abyssinicum	Oleaceae	Shrub	Nectar and pollen	Sept - Nov	Bush land
70	Kalanchoe petitiana	Crassulaceae	Herb	Nectar	Sept - Nov	Open land
71	Lactuca inermis	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
72	Lathyrus sativus	Leguminoceae	Herb	Nectar and pollen	Dec - Jan	Cultivated land
73	Leonotis ocymifolia	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Open land
74	Leucas martinicensis	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Open land
75	Linum usitatissimum	Linaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
76	Lepidium sativum	Brassicaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
77	Lippia adoensis	Verbenaceae	Shrub	Nectar and pollen	June - August	Bush land
78	Maytenus arbutifolia	Celastraceae	Shrub	Nectar and pollen	Sept - Nov	Forestlands
79	Medicago polymorpha	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
80	Medicago sativa	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
81	Melilotus alba	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
82	Nicotiana tabacum	Solanaceae	Herb	Nectar and pollen	June - August	Cultivated land
83	Nigella sativa	Ranunculaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
84	Ocimum basilicum	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
85	Ocimum urticifolium	Lamiaceae	Shrub	Nectar and pollen	Sept - Nov	Open land
86	Olea capensis	Oleaceae	Tree	Nectar and pollen	April - June	Forestlands
87	Olinia rochetiana	Oliniaceae	Tree	Nectar and pollen	Jan - May	Forestlands
88	Otostegia integrifolia	Lamiaceae	Shrub	Nectar and pollen	Sept - Nov	Forestlands
89	Oxygonum sinuatum	Polygonaceae	Herb	Nectar and pollen	Sept - Nov	Open land
90	Phacelia tanacetifolia	Hydrophyllaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
91	Phaulopsis imbricata	Acanthaceae	Herb	Nectar and pollen	Sept - Nov	Open land
92	Physalis peruviana	Solanaceae	Herb	Nectar and pollen	June - August	Open land
93	Phytolacca dodecandra	Phytolaccaceae	Shrub	Nectar and pollen	Oct - March	Open land
94	Pinus spp.	Pinaceae	Tree	Nectar and pollen	Jan - April	Cultivated land

No.	Botanical name	Family	Plant nature	Food source	Flowering time	Habitat
95	Pisum sativum	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
96	Pittosporum viridiflorum	Pittosporaceae	Tree	Nectar and pollen	Nov - April	Forestlands
97	Plantago lanceolata	Plantaginaceae	Herb	Pollen	Year round	Open land
98	Plectranthus punctatus	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Wetland
99	Plectranthus spp.	Lamiaceae	Herb	Nectar and pollen	June - August	Wetland
100	Polyscias fluva	Araliaceae	Tree	Nectar and pollen	Nov - April	Forestlands
101	Prunus persica	Rosaceae	Tree	Nectar and pollen	Sept - Nov	Cultivated land
102	Pygeum africanum	Rosaceae	Tree	Nectar and pollen	June - August	Forestlands
103	Ranunculus multifidus	Ranunculaceae	Herb	Nectar and pollen	Sept - Nov	Open land
104	Raphanus raphanistrum	Brassicaceae	Herb	Nectar and pollen	Sept - Nov	Open land
105	Ricinus communis	Euphorbiaceae	Tree	Nectar and pollen	Sept - Nov	Cultivated land
106	Rhamnus prilods	Rhamnaceae	Shrub	Nectar and pollen	August - Sept	Cultivated land
107	Rhus vulgaris	Anacardiaceae	Tree	Nectar and pollen	June - August	Open land
108	Rorippa nasturtium-aquaticum	Brassicaceae	Herb	Nectar and pollen	Sept - Nov	Wetland
109	Rosa abyssinica	Rosaceae	Shrub	Pollen	June - August	Bush land
110	Rosmarinus officinalis	Lamiaceae	Shrub	Nectar and pollen	March - May	Cultivated land
111	Rubus apetalus	Rosaceae	Shrub	Nectar and pollen	March - May	Bush land
112	Rubus rosifolius	Rosaceae	Shrub	Nectar and pollen	Sept - Nov	Bush land
113	Rubus steudneri	Rosaceae	Shrub	Nectar and pollen	March - May	Bush land
114	Rumex bequaertii	Polygonaceae	Herb	Nectar and pollen	Sept - Feb	Open land
115	Ruta chalepensis	Rutaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
116	Salvia leucantha	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
117	Salvia nilotica	Lamiaceae	Herb	Nectar and pollen	June - August	Open land
118	Salvia splendens	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
119	Sambucus candensis	Caprifoliaceae	Tree	Nectar and pollen	June - August	Forestlands
120	Satureja paradoxa	Lamiaceae	Herb	Nectar and pollen	June - August	Forestlands
121	Schefflera abyssinica	Araliaceae	Tree	Nectar and pollen	March - May	Forestlands
122	Silybum marianum	Asteraceae	Herb	Nectar and pollen	June - Dec	Open land
123	Sinapis alba	Brassicaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
124	Solanum indicum	Solanaceae	Herb	Pollen	Sept - Nov	Open land
125	Solanum nigrum	Solanaceae	Herb	Pollen	Sept - Nov	Open land
126	Solanum tuberosum	Solanaceae	Herb	Pollen	Sept - Nov	Cultivated land

No.	Botanical name	Family	Plant nature	Food source	Flowering time	Habitat
127	Sonchus asper	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Open land
128	Syzygium guineense	Myrtaceae	Tree	Nectar and pollen	Jan - March	Forestlands
129	Tagetes patula	Asteraceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
130	Thunbergia abssinica	Acanthaceae	Herb	Pollen	Sept - Nov	Open land
131	Thymus vulgaris	Lamiaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
132	Trifolium Qurtinianum	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
133	Trifolium spp.	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Open land
134	Tropaeolum majus	Tropaeolaceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
135	Uritica simensis	Uriticaceae	Herb	Pollen	March - May	Open land
136	Verbascum sinaiticum	Scrophulariaceae	Herb	Nectar and pollen	Sept - Nov	Open land
137	Vernonia adoensis	Asteraceae	Shrub	Nectar and pollen	Sept - Nov	Open land
138	Vernonia amygdalina	Asteraceae	Shrub	Nectar and pollen	Dec - Feb	Open land
139	Vernonia urticifolia	Asteraceae	Shrub	Nectar and pollen	Sept - Nov	Wetland
140	Veronica abyssinica	Scrophulariaceae	Herb	Nectar and pollen	Sept - Nov	Open land
141	Vicia faba	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
142	Vicia sativa	Leguminoceae	Herb	Nectar and pollen	Sept - Nov	Cultivated land
143	Zea mays	Poaceae	Herb	Exudates and Pollen	August - Sept	Cultivated land

Table 2. Family, nature and habitat distribution of honey plant species in the central highlands of Ethiopia.

Family	Spp	%	Tree	Herb	Shrub	Climber	Forestland	Open land	Cultivated	Wetland	Bush land	Open la2
Leguminoceae	13	9.10	15.38	76.92	7.69	0	7.69	15.38	61.54	0	7.69	7.69
Amaranthaceae	2	1.40	0	100	0	0	50	50	0	0	0	0
Acanthaceae	5	3.50	0	80	20	0	20	80	0	0	0	0
Lamiaceae	16	11.19	0	81.25	18.75	0	12.50	25.00	43.75	18.75	0	0
Primulaceae	1	0.70	0	100	0	0	0	100	0	0	0	0
Boraginaceae	2	1.40	50	50	0	0	0	0	50	0	0	50
Sapotaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Scrophullariaceae	3	2.10	0	100	0	0	0	66.67	33.33	0	0	0
Icacinaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Asteraceae	24	16.78	0	87.5	12.5	0	0	58.33	20.83	16.6667	4.17	0

Family	Spp	%	Tree	Herb	Shrub	Climber	Forestland	Open land	Cultivated	Wetland	Bush land	Open la2
Brassicaceae	5	3.50	0	100	0	0	0	20	60	20	0	0
Apocynaceae	1	0.70	0	0	100	0	0	0	0	0	100	0
Resedaceae	2	1.40	0	0	50	50	0	100	0	0	0	0
Rutaceae	2	1.40	0	50	50	0	0	0	100	0	0	0
Verbenaceae	2	1.40	0	50	50	0	0	50	0	0	50	0
Commelianaceae	2	1.40	0	100	0	0	0	50	0	50	0	0
Apiaceae	1	0.70	0	100	0	0	0	0	100	0	0	0
Euphorbiaceae	3	2.10	66.67	0	33.33	0	0	0	33.33	0	0	66.67
Cucurbitaceae	1	0.70	0	100	0	0	0	0	100	0	0	0
Solanaceae	6	4.20	0	83.33	16.67	0	0	66.67	33.33	0	0	0
Ranunculaceae	3	2.10	0	100	0	0	0	66.67	33.33	0	0	0
Caryophyllae	1	0.70	0	100	0	0	0	0	100	0	0	0
Poaceae	3	2.10	0	100	0	0	0	66.67	33.33	0	0	0
Meliaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Ericaceae	1	0.699	0	0	100	0	0	0	0	0	100	0
Myrtaceae	4	2.80	100	0	0	0	25	0	75	0	0	0
Polygonaceae	3	2.10	0	100	0	0	0	66.67	33.33	0	0	0
Moraceae	1	0.70	100	0	0	0	0	100	0	0	0	0
Rubiaceae	2	1.40	0	100	0	0	50	0	0	50	0	0
Geraniaceae	1	0.70	0	100	0	0	0	0	0	0	100	0
Proteaceae	1	0.70	100	0	0	0	0	0	100	0	0	0
Rosaceae	7	4.90	42.86	0	57.14	0	28.571	0	14.29	0	57.14	0
Clusiaceae	2	1.40	0	50	50	0	50	0	0	50	0	0
Balsaminaceae	1	0.70	0	100	0	0	0	100	0	0	0	0
Oleaceae	2	1.40	50	0	50	0	50	0	0	0	50	0
Crassulaceae	1	0.70	0	100	0	0	0	100	0	0	0	0
Linaceae	1	0.70	0	100	0	0	0	0	100	0	0	0
Celastraceae	1	0.70	0	0	100	0	100	0	0	0	0	0
Oliniaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Hydrophyllaceae	1	0.70	0	100	0	0	0	0	100	0	0	0

Family	Spp	%	Tree	Herb	Shrub	Climber	Forestland	Open land	Cultivated	Wetland	Bush land	Open la2
Phytolaccaceae	1	0.70	0	0	100	0	0	100	0	0	0	0
Pittossporaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Plantaginaceae	1	0.70	0	100	0	0	0	100	0	0	0	0
Araliaceae	2	1.40	100	0	0	0	100	0	0	0	0	0
Rhamnaceae	1	0.70	0	0	100	0	0	0	100	0	0	0
Anacardiaceae	1	0.70	100	0	0	0	0	100	0	0	0	0
Caprifeliaceae	1	0.70	100	0	0	0	100	0	0	0	0	0
Tropaeolaceae	1	0.70	0	100	0	0	0	0	100	0	0	0
Uriticaceae	1	0.70	0	100	0	0	0	100	0	0	0	0
Pinaceae	1	0.70	100	0	0	0	0	0	100	0	0	0
Missing	1	0.70	17.02	65.25	17.02	0.71	14.18	34.75	31.91	7.80	7.80	0.70

NB. Open lan2 = Forest lands and open land

Table 3. Plant nature and flowering period (numbers in brackets reflect percentages, while others represent the number of species)

Plant nature	Number of spp.	Percent	Sep-Nov	Dec-Feb	Mar-May	Jun-Aug	Other
Trees	25	17.5	4 (17.4)	4 (17.4)	9 (39.1)	4 (17.4)	4 (8.7)
Shrubs	24	16.8	12 (50)	2 (8.3)	5 (20.8)	4 (16.7)	1 (4.2)
Herbs	93	65.0	72 (77.4)	2 (2.1)	4 (4.3)	10 (10.8)	5 (5.4)
Other	1	0.7					1 (100)
Total	143	100	88 (61.5)	8 (5.6)	18 (12.6)	18 (12.6)	11 (8.2)

Table 4. The standardised temperature, rainfall, flowering intensity and reproductive swarming and migration periods of honeybees in the central highlands of Ethiopia.

Localities and co-ordinates	N	Climate	Months of the year											
			1	2	3	4	5	6	7	8	9	10	11	12	Mean + Sd
Holetta, 9.1N, 38.6E		T	-92.3	38.5	107.7	130.8	130.8	53.8	0	7.7	-15.4	-69.2	-14.6	-176.9	14.1 ± 1.3
		R	-108.6	-79.2	-55.5	-36.3	-50.8	-0.7	150.5	173.6	23.4	129.1	-118.6	-119.8	113 ± 88
	100	F	-61.3	-61.3	-38.3	-38.3	-38.3	-65.1	-65.1	-65.1	164.8	164.8	164.8	-61.3	20 ± 26.1
Swarming and migration			M	M				M	M	M	S	S	S	M	
Serofta, 6.5N, 39.1E		T	-13.2	26.3	105.3	131.6	157.9	52.6	-39.5	-65.8	-78.9	-65.8	-131.6	-144.7	15 ± 0.76
		R	-85.5	-67.7	-0.4	63	-2.4	13.5	165.9	122.4	108.5	17.4	-89.5	-107.3	73.2 ± 50.5
	12	F	-21.4	-92.9	-92.9	-21.4	-92.9	-21.4	-92.9	-92.9	121.4	192.9	121.4	50	2.3 ±1.4
Swarming and migration			M	M				M	M	M	S	S	S	M	
Mararo, 7.2N, 39.1E		T	0	98.8	148.1	135.8	98.8	24.7	-74.1	-11.1	-74.1	-74.1	-98.8	-98.8	12.4 ± 0.81
		R	-107.7	-71.1	-15.5	19.5	7.3	40.4	174.6	167.6	57.8	-46.7	-90.2	-137.3	93.8 ± 57.4
	13	F	-50	-85.7	-14.3	-50	-50	-50	-50	-50	200	164.3	128.6	-85.7	2.4 ± 2.8
Swarming and migration								M	M	M	S	S	S		
Boter Bacho, 8.2N, 37.1E		T	-210	100	140	140	70	-30	-70	-80	-50	-30	-20	-10	12.9 ± 1.0
		R	-134.6	-95.8	-40.1	-2.3	17.6	88.3	129.1	158.9	104.2	-40.1	-101	-113.7	137.3 ± 100.5
	7	F	180	-20	-20.5	80	80	80	80	-120	-120	-120	-120	-20	1.2 ± 1.0
Swarming and migration					S	S	S	M	M	M	S	S	S		
Roge, 8.3N, 37.6E		T	10	100	150	140	110	-20	-90	-120	-80	-60	-80	-90	16.9 ± 1.0
		R	-101.1	70.6	-29.8	2.3	4.6	96.3	166.4	160	59.4	-80.8	-99.8	-106.2	92.4 ± 78.5
	10	F	-69.2	-69.2	-69.2	-69.2	-69.2	7.7	7.7	-69.2	-30.8	200	200	46.2	1.8 ± 2.6
Swarming and migration			M	M	S	S	S				S	S	S	M	
Hossaina, 7.3N, 37.5E		T	11.4	136.4	193.2	125	56.8	-45.5	-90.9	-113.6	-68.2	-56.8	-45.5	-56.8	16.4 ± 0.88
		R	-113.7	-95.6	-1.6	72.5	34.6	56	120.3	145	90.6	-51.1	-126.8	-126.8	97 ± 60.7
	9	F	-30.6	-30.6	71.4	173.5	-132.7	-30.6	71.4	71.4	71.4	71.4	-30.6	-30.6	1.3 ± 0.98
Swarming and migration								M	M	M	S	S	S		
Effo Yachi, 7.6N, 36.3E		T	-23	92	160.9	160.9	69	-23	-114.9	-126.4	-80.5	-46	-50	-46	19.1 ± 0.87
		R	-115	-99.7	-58.8	-25.1	41.3	113.8	132.2	135.2	102.6	-23.1	-84.4	-119.1	141.6 ± 97.9
	11	F	-35.7	-35.7	-35.7	107.1	178.6	35.7	-107.1	-107.1	107.1	107.1	-107.1	-107.1	3.5 ± 1.4

Swarming and migration					S	S	S	M	M	M	S	S	S		
Gado Lama, 7.4N, 39.4E		T	140	-40	60	100	110	90	-10	-20	0	-50	-160	-190	17 ± 1.0
		R	-120.3	-96.5	-16.5	42	-10	18.2	152.4	163.2	98.3	-20.8	-77.1	-133.3	70.6 ± 46.2
	11	F	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	-75.9	-202.5	-202.5	3.6 ± 0.79
Swarming and migration					S	S	S	M	M	M	S	S	S		
Boke Toko, 8.4N, 40.4E		T	-126.7	-46.7	33.3	80	120	146.7	33.3	13.3	53.3	0	-113.3	-160	21.2 ± 1.5
		R	-114	-95.4	-35	54	5.5	31.8	173.5	137	96.6	-51.2	-77.5	-126.1	75.3 ± 49.4
	9	F	-23.1	-100	-100	-100	-23.1	-23.1	53.8	207.7	53.8	130.8	53.8	-100	2.3 ± 1.3
Swarming and migration					S	S	S	M	M	M	S	S	S		
Alage, 7.4N, 38.2E		T	-33.7	67.4	179.8	146.1	78.7	11.2	-67.4	-78.7	-56.2	-33.7	-101.1	-134.8	18.6 ± 0.89
		R	-104.8	-72.8	-6.6	27.6	45.9	41.3	171.5	121.2	96.1	-75.1	-11.6	-132.2	63.9 ± 43.8
	10	F	-132.7	-132.7	71.4	71.4	-30.6	173.5	-30.6	-30.6	71.4	71.4	71.4	-132.7	2.3 ± 0.98
Swarming and migration								M	M	M	S	S	S		
Total mean		T	-59.5	47.6	142.9	142.9	119	35.7	-39.5	-71.4	-47.6	-59.5	-119	-142.9	16.4 ± 0.84
		R	-113.4	-88.3	-32.5	13.8	9.3	59.4	157.4	157	85	-20.2	-103.1	-126.1	95.8 ± 64.3
	194	F	-57.4	-72.5	-39.3	-27.2	-30.2	-45.3	-60.4	-120.8	178.2	178.2	139	-78.5	40 ± 33.1

The effect of embossed wax foundation sheets, made by a European casting mould, on the central highland Ethiopian honeybee (*A. m. bandasii*)

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Abstract

Plain and embossed wax foundation sheets were given to four groups of honey bee colonies (three colonies in each group), having the same strength to envisage the effects of embossed wax foundation sheets made by a European casting mould on the activities of central highland honeybees, Apis mellifera bandasii. Cell sizes and number per 100 cm² and other necessary data were collected and analysed using ANOVA. The correlation among cell sizes and number of cells per unit area were analysed using Pearson correlation procedures.

The result revealed that the embossed wax foundation sheets made by European casting mould forced the local honeybees to construct larger worker cells than their normal sizes and thus slows the build up of colonies.

Keywords: European casting mould embossed foundation sheets plain foundation Sheets, central highland honeybees, *A. m. bandasii,* Ethiopia

Introduction

In Ethiopia, beekeeping is one of the oldest agricultural sector, and a deep-rooted cultural practise that begun between 5000 and 5500bp. Even though traditional beekeeping methods are the predominant ones, an improved beekeeping (movable frame hives) is also practised by few farmers, hobby and semi-commercial beekeepers. The introduction of movable frame hives necessitates the use of wax foundation sheets that save time, energy and labour required to construct wax combs so that more bees take part in foraging instead of wax secretion and comb building (Dadant and Sons, 1957). This is evidenced by the fact that colonies provided with wax foundation are able to develop their nests and commence brood rearing quicker and store more surplus honey than colonies given no wax foundation or strip of wax (Kwame, 1991). Good combs are a pre requisite to successful beekeeping since they provide the inner home where the colony is reared to maximum strength and honey crop is stored (Dadant & Sons, 1957).

The most widely used wax foundation sheet in Ethiopia is the embossed one, having a pattern of hexagonal cell base embossed on both sides. This is printed or made by casting mould imported from Europe designed for European honeybees. This casting mould was introduced into the country 30 years ago and still on use. However, the effects of this casting mould on the activities of honeybees of Ethiopia in particular, African honeybees in general were not investigated and the effort to replace this expensive equipment in Ethiopia as well as in Africa is at an infancy stage. Therefore, the objective of present study is to determine the effect of embossed foundation sheets made by this casting mould on normal activities of Ethiopian honeybees.

Materials and methods

Twelve *A. m. bandasii* colonies reared from the same mother colonies were used to investigate the influence of embossed comb foundations made by a European casting mould on their activities. All colonies were on the same strength and randomly assigned into four groups (three colonies in each group). The 1st and 2nd groups were given plain and embossed comb foundations respectively.

The 3rd and 4th groups were given equal numbers of both plain and embossed comb foundations placed alternatively. In the 3rd group the combs placed started from plain while in the 4th group it started with embossed foundation sheets from right to left to see the influence of position, if any, on the draw out of comb foundations. All colonies were placed in Langstroth hives and all necessary managerial operations were carried out. Supers were given to colonies when necessary in the same procedure above. All colonies were inspected every two weeks for data collection until all comb foundations were drawn out. The diameter and depth of 50 drawn out cells from six combs of each group were measured using micrometer. Similarly the number of drawn out cells in 100 sq. cm (10 cm X 10 cm) on six combs of each group was counted. All data were statistically analysed using ANOVA, at $P > 0.05$ significance level. The correlation between cell numbers and cell sizes (depth and width or diameter) were analysed using Pearson correlation and at 0.01 significance levels.

The plain comb foundations were made using wooden board of 23cm X 43cm size. This wooden board was first soaked in soapy water for 24 hours before use for easy removal of plain foundations from the board. The board is dipped into molten beeswax for about 3 seconds and then dipped in cold water to cool and remove the plain foundation sheets. Two foundations were made at the same time.

Results

The result indicated that both types of comb foundation sheets (plain and embossed) were drawn out by honeybees, *Apis mellifera bandasii*. No significant preference difference was observed ($P > 0.05$). However the sizes of cells (depth and diameter) and the total numbers of cells built on both types of comb foundations were significantly different ($P < 0.001$).

The cells built on the embossed comb foundation sheet (made by a European casting mould) were deeper than that of cells built on the plain comb foundation sheets (made by wooden board) ($F(1,598) = 59.53$; $P < 0.00001$). The depth of drawn out cells from the embossed comb ranges from 9 to 22.5 mm with an average of 12.09 ± 2.55 mm and that of cells on the plain comb foundation ranges from 8.4 to 19.52 mm with an average of 10.80 ± 1.35 mm (Fig. 1).

Similarly the diameter of the cells drawn out from the embossed comb foundation was wider than that of cells from plain foundation sheets ($F(1, 598) = 263.123$; $P < 0.001$). The diameters of cells of the embossed comb foundation ranges from 4.12 to 6.38 mm with an average of 5.08 ± 0.273 mm while that of cells from the plain comb foundation ranges from 3.7 to 5.74 mm with an average of 4.70 ± 0.292 mm (Fig. 2).

On the other hand the number of cells built per unit area (100 cm^2) on the plain comb foundation sheets was significantly higher than the number of cells on the embossed comb foundation sheets ($F(1, 498) = 447.642$; $P < 0.001$). The mean number of worker size-cells on plain and embossed comb foundation was 436.4 (range 420 – 460) and 415.2 (range 402 – 425) respectively (Fig. 3)

The depth of cells on both comb foundations (embossed and plain) was not significantly different when both combs (5 embossed and 5 plain comb foundation sheets) were given to the same colonies ($P > 0.05$). However the cell diameter and the number of cells per unit area remained significantly different ($P < 0.001$).

The number of cells on the combs was negatively correlated to the diameter and depth of the cells ($P < 0.05$). But the correlation between cell number and cell diameter ($r = -0.32$) is stronger than correlation between cell number and cell depth ($r = -0.26$). About 37% of the variation in number of cells on the comb was explained by both diameter and depth of cells ($R^2 = 0.37$) (Figs. 4 & 5).

The annual mean honey yields of colonies worked on embossed, plain and both embossed and plain foundation sheets were not significantly different (P = 0.119). The average annual honey production per colony was 21.7 kg (range 20.78 – 22.78 kg), 25.90 kg (range 23.05 – 29.05 kg) and 23.8 kg (range 22.25 – 25.54 kg) in the above order (Fig. 6).

Discussion

The central highland honeybees of Ethiopia, *Apis mellifera bandasii*, draw out the worker-size cells on plain foundation sheets, as they do on embossed comb foundation sheets. No significance difference in the number of drone-size cells was observed on both types of comb foundation sheets. However, the worker cell size (width and depth) drawn out on the embossed comb foundation was larger than the cells on plain comb foundation sheet. As the result the number of the worker cells on embossed comb foundation is lower than the number of cells on the plain comb foundation. Both sides of embossed comb foundation measuring 44 cm X 23cm contains 429 fewer worker cells than the same size of a plain comb foundation. Fewer worker-size cells on the embossed comb secure less space for the queen to lay eggs compared to the plain ones. This means new colonies worked on embossed comb foundations attained their colony strength slower than colonies worked on plain comb foundations. The primary need of a new colony is an ample amount of combs that can be used to rear their young and store their food.

The embossed comb foundation sheets made by European casting mould forced bees to construct larger worker cells than their normal size of African honeybees. This is in agreement with Hepburn (1983, 1986), Hepburn & Radloff (1998), Smith (1960), Crane (1990), Alber (1957), Ruttner (1975) and Anderson (1960). The larger cells contain more wax and thicker cell wall than the normal worker-size cells (Hepburn, 1983). That is bees spend much more time, wax and energy to draw out cells on embossed than on plain comb foundations. This may explain why the plain foundation sheets during the study period were observed fully drawn quicker than the embossed ones and also may partially explain why newly transferred colonies to movable hives provided with embossed foundation sheet mostly abandon after few days.

Even though, it has been claimed that bees reared in larger cell size are larger with longer proboscis, bigger wing and large nectar capacity and produce large honey production (Grout, 1937), the latter was not observed under Ethiopian conditions. Statistically there was no significant difference in annual honey yields from colonies worked on plain and embossed comb foundations (Fig. 6). Moreover, the casting mould used to produce embossed foundation sheets is highly expensive costing more than 500 USD (more than 4000 birr) that many beekeepers found it difficult to afford and not readily available on domestic market for those who afford to buy.

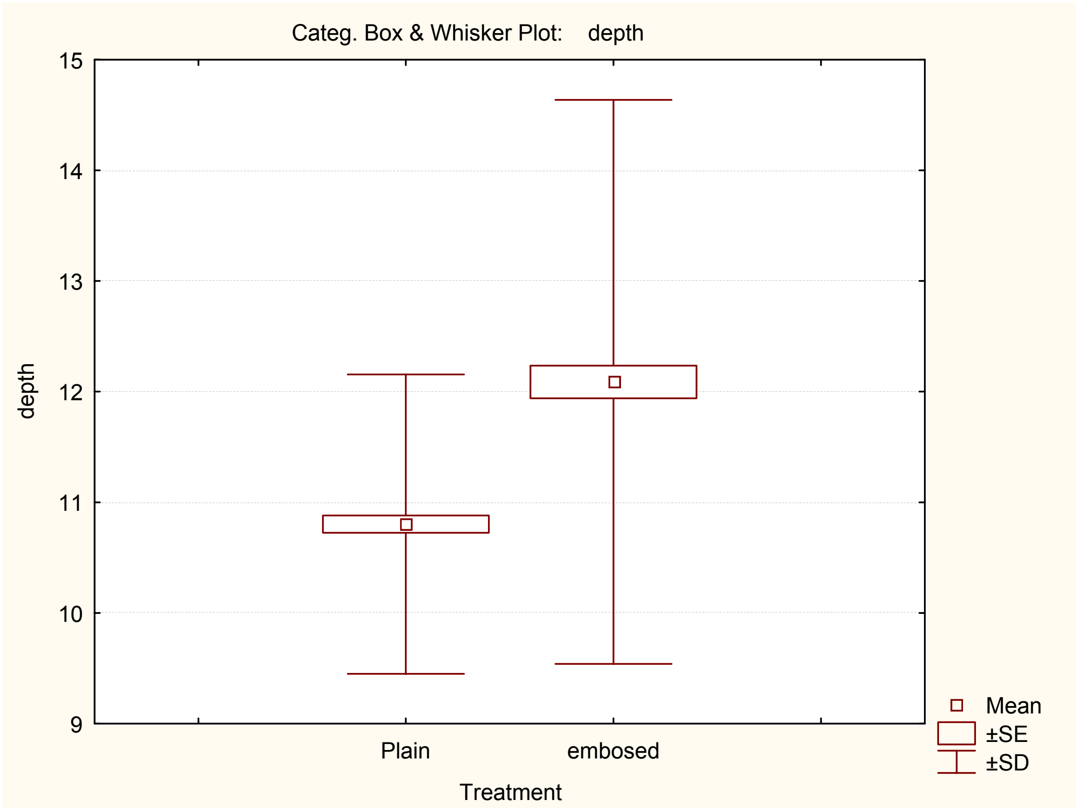

Figure 1 The mean depth of the cells on embossed and plain comb foundations built by honeybees, *A. m. bandasii* (measurements in mm)

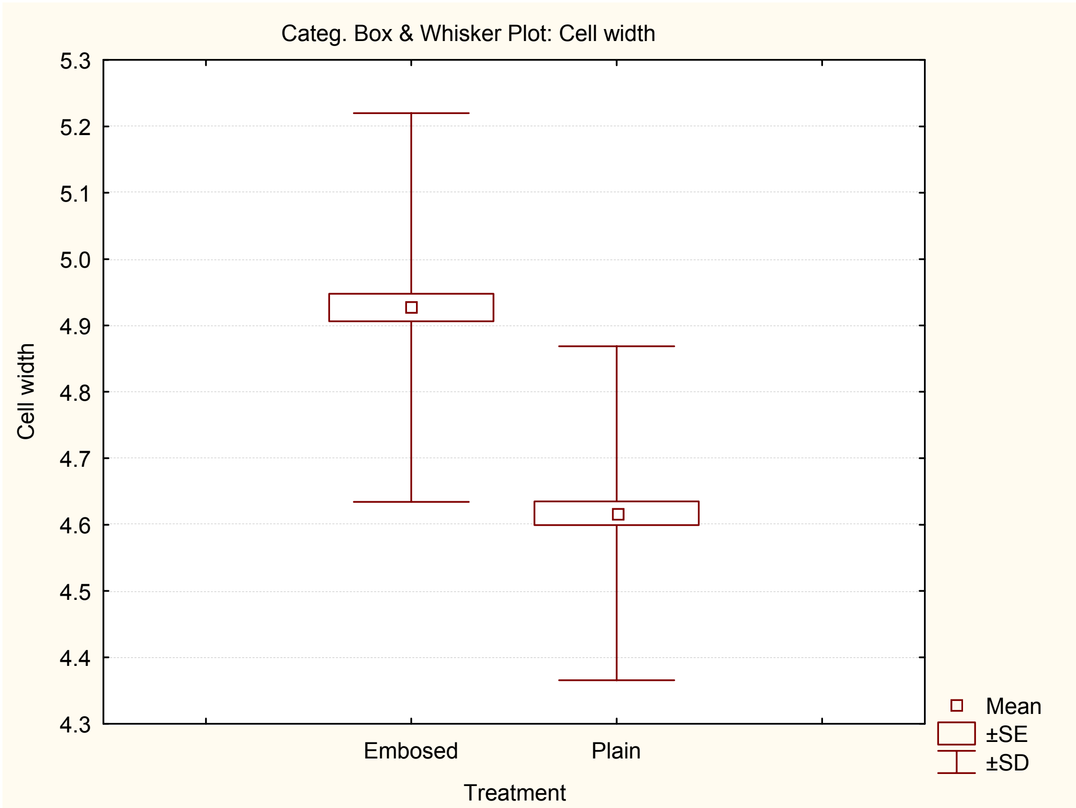

Figure 2 The mean width of cells on embossed and plain comb foundations built by central Ethiopian honeybees, *A. m. bandasii* (measurements in mm).

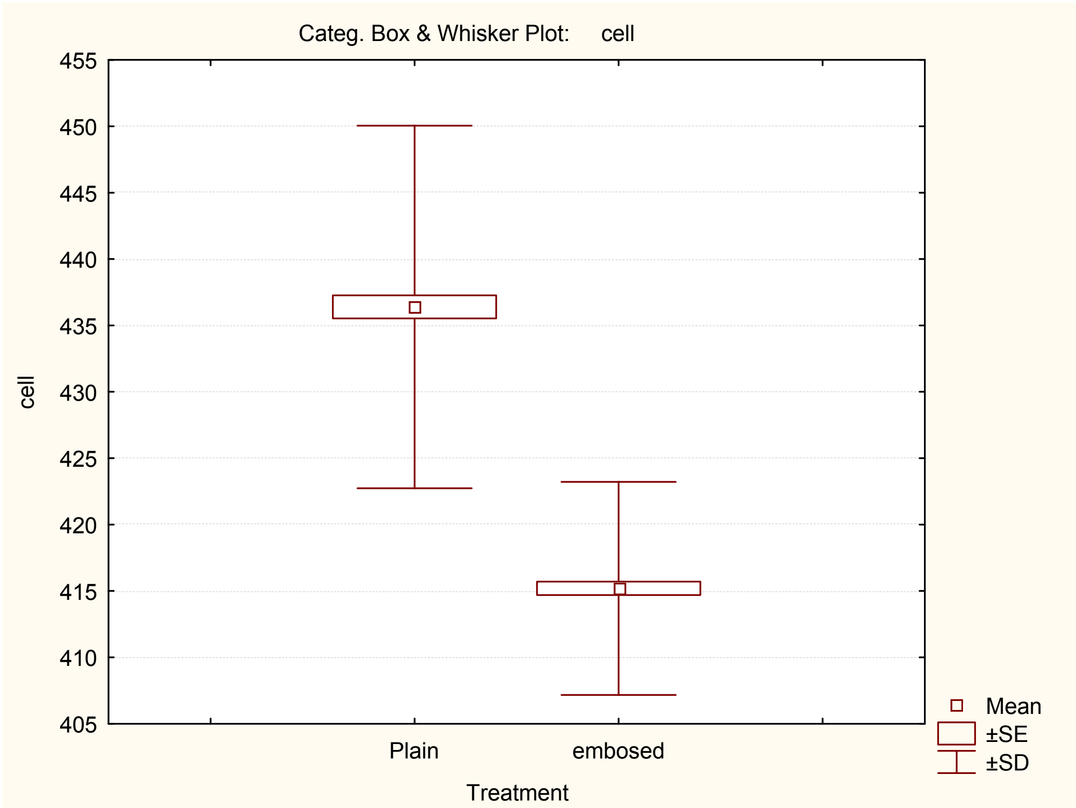

Figure 3. The mean number of cells built by *A. m. bandasii* on plain and embossed comb foundations.

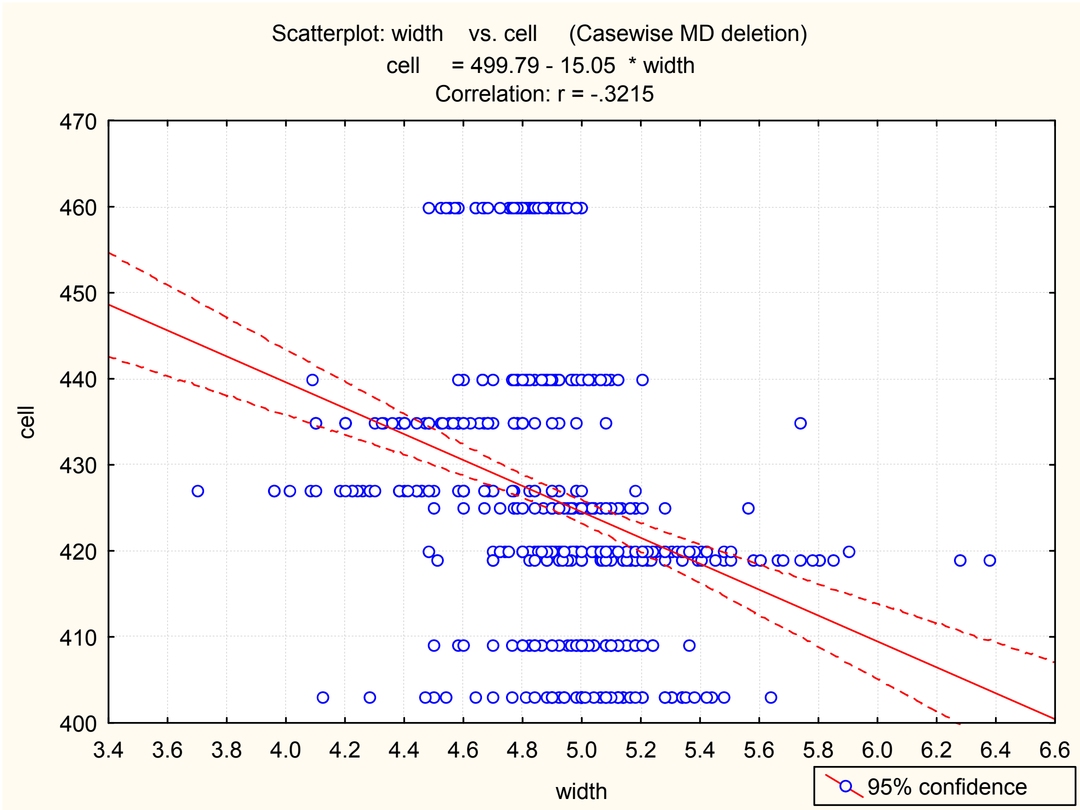

Figure 4 The correlation between width and number of cells

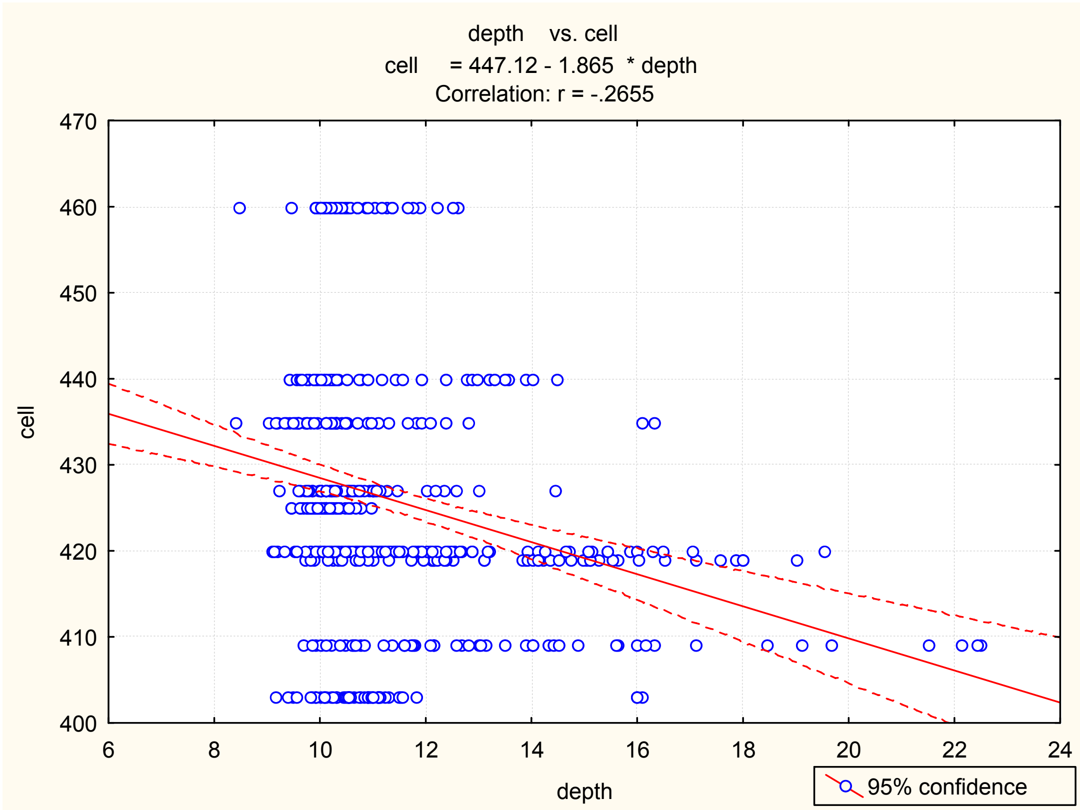
depth vs. cell
cell = 447.12 - 1.865 * depth
Correlation: r = -.2655
cell
depth
470
460
450
440
430
420
410
400
6
8
10
12
14
16
18
20
22
24
95% confidence

Figure 5 Correlation between depth and number of cells

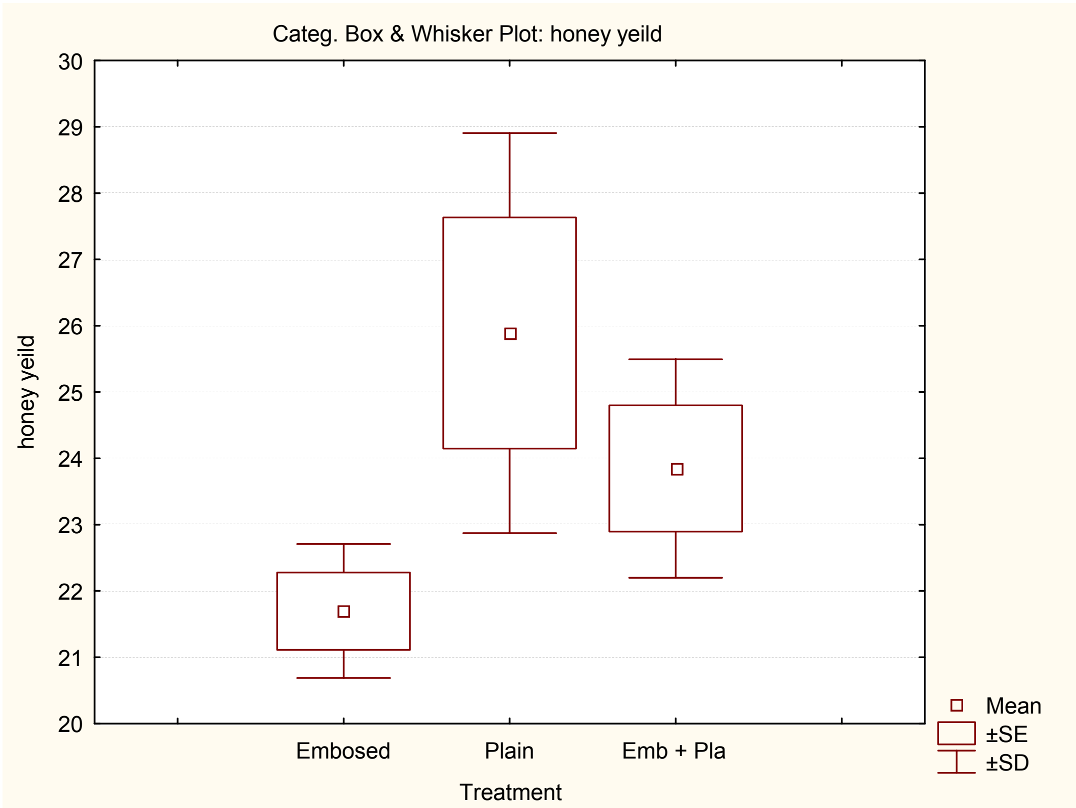

Figure 6. The annual honey production from colonies worked on embossed, plain and both plain and embossed comb foundations (measurements in Kg)

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Solar drying of fish fillet using simple tent in Ziway

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Abstract

Improved method of drying fish fillet using solar dryer tent was investigated at Ziway Fishery Resource Research Center (ZFRRC).

The solar dryer tent was measured 1.5m high, 2.5m long and 1.5m wide with a carrying capacity of 8kg $^{m-2}$ of prepared fish. Two commercially important fish species, Tilapia nilotica (Oreochromis niloticus) and catfish (Clarias gariepinus) were used in two treatment combinations - i.e, salted and unsalted. The solar dryer tent was placed in open sunny area away from shade and strong wind or air movement. All the solar dried fish were good quality and were marketable products. The texture was hard and well dried and the products had a pleasant odour. The product can be stored over one year without being affected by bacteria or moulds. The time taken to dry the fish to a moisture content of 9.6-10.7% using this technique was shorter than the time required for sun drying (3 days). The dried fillets were also free from either insect or mold contamination. It is concluded that solar dryer tent is appropriate and suitable for small-scale fishermen in Ziway area.

Key words: Tilapia nilotica, Catfish, solar tent dryer, salt, moisture content and drying

Introduction

Fish is one of the most popular food. It is the source of quality protein. In less developed countries fish represents a significant proportion of animal protein in their diet. Fish can also be seen as a renewable natural resource, provided that the seas and lakes are not over fished (Ames *et al.,* 1991).

Unfortunately, fish is one of the most perishable foods, particularly in tropical climates of less developed nations. If proper care is not taken immediately after capture, it can be spoiled in few hours. Even using traditional methods fish can be still subjected to various forms of spoilages (Clucas *et al.,* 1996).

Salting and drying are traditional methods of preserving fish that have been used for centuries. Dried salted products are popular in many countries of Africa, SE Asia and Latin America. If the moisture content of fresh fish is reduced during drying to around 25%, bacteria cannot survive and autolytic activity will be reduced greatly, but to prevent mould growth, the moisture content must be reduced to 15% and below. The presence of salt retards bacterial action and also aids the removal of water by osmosis (Waterman, 1976).

Traditionally, many fishermen dry fish in open ground, or on rocks in the sun. Some fish processors use mats or reeds laid on the ground to prevent contamination of the fish by dirt, mud and sand. Drying fish in this way has many problems and, in recent years, the use of raised sloping drying racks has been introduced as a simple and effective technique (Clucas and Sutcliffe, 1981). Thus, the major objective of the present study was to test the use of simple tent dryer and prolong the shelf life of fish fillet.

Material and methods

Study area

The experiment was conducted at Ziway Fishery Resource Research Center, 160km South of Addis Ababa. It is located in mid rift valley at an altitude of 1500 meter above sea level. The average annual rainfall of the area is about 688 mm and its mean maximum and minimum temperatures are 27.2 and 14.4°C, respectively. Its mean relative humidity and wind speed were recorded to be 55% and 1.66 m/second, respectively. Data was obtained from Ziway metrological station between October, 2001 and September, 2002

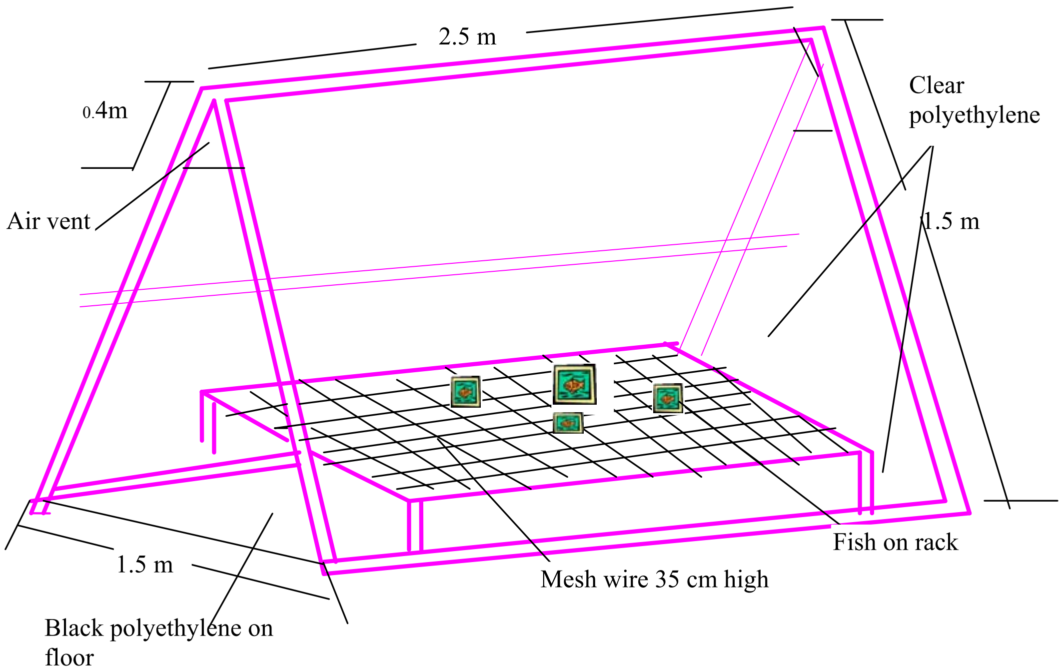

Figure 1. Diagram showing the tent dryer used in the study

The dryer was constructed, using a wooden framework and plastic sheet. Black polythene was used for the base of the tent and clear ultra-violet resistant polyethylene for sides and ends. Staples were used to attach the plastic sheet to the framework. The drying rack was built along one side of the tent using wooden frames and mesh wire. Construction time for the dryer tent was about 2 man-hours. Material cost for solar tent dryer was 175.00 birr.

The principle of operation of the dryer tent is that air inside the drier is heated as it flows over the dark surfaces, which absorb the sunlight resulting in air temperatures higher than that of ambient air. Up ward flows of air takes place as air flows from the vents located at floor to those located at the top of the structure. The fish, which are placed on wire racks, are dried by this flow of air, which gets progressively warmer as it rises upwards and leaves the structure by the top vents. Depending on the design of the solar dryer, temperatures of 70°c and over can be achieved if there is no ventilation (Szabo, 1970). The temperature can be lowered by opening the air vents thus allowing free movement of air. During sunny days, vents of the dryer were fully opened to prevent fish from being cooked or case-harding.

Fish preparation

Fish used for experimental purpose was fresh with convex eyes, bright red gills, strong fresh gill and good body odours. Thus only high quality fish were used for the drying experiments. The range of preparation methods and pretreatment were as follows.

Treatment 1

Dry salted tilapia fillets: Two single fillets were removed from each fish. The fillets were washed and scored before salting by soaking in 10% brine for 40 minuets and then packed in a dry salt using 1kg salt to 3kg fish by weight and left over night (approximately for 12 hours). Number of observations was 12 for each treatment.

Treatment 2

Dry salted catfish: Two single fillets were removed from each fish. The fillets were washed and scored prior to slating by soaking in 10% brine for 40 minuets and then packed in a dry salt over night (approximately for 24 hours)

Treatment 3

Unsalted tilapia fillets: The fish was filleted according to local customs. That is two single fillets wee removed from each fish but after washing with clean water were kept to dry with out salting.

Data for unsalted catfish was not included under the present study because the flesh of the fish is tick and was not possible to reduce the moisture content of unsalted fish fast enough to retard spoilage. By the second day of drying, this unsalted fish was putrid and, there fore the trial was discontinued.

A total of 36 fish fillet samples were taken from two species, freshly caught fish, tilapia nilotica (*Oreochromis niloticus*) and cat fish (*Clarieas gariepinus*). Out of the 36 drying experiments, 12 tilapia and catfish samples were prepared with salt and 12 tilapia samples were prepared with out salt.

During the experiment, locally produced salt was used for dry salting. After salting fillets were carefully washed to remove excess salt crystals from the surface and were allowed to drain. The solar tent dryer was exposed to direct sun away from shade area. The dryer was heated prior to the start of the experiment. Vents and openings were closed early in the morning and late afternoon in order to raise internal temperatures as quickly as possible. Care was also taken during the hottest periods of the day to maintain the internal temperatures between 48^{o}C-55^{o}C to avoid casehardening. Over the 12 months period of operation, the fish were placed in the dryer in the morning (8:30 - 9:00 am) and removed in the early evening (4:30 - 5:00 pm). All fillets were turned regularly three times a day, to ensure even drying. At night, the fish were collected and stored in plastic bag.

Each batch of fish was weighed at intervals of 24 hour until it is completely dried. When successive weighing indicated little or no change in weight, the fish were considered dry and were removed from the dryer, allowed to cool, and were stored in plastic bags.

Moisture content

Samples of all dried salted and unsalted products were analyzed for moisture contents. Moisture contents of 5gm dried fillet were determined relative to the weight of oven dried fish at 105^{o}C for 24 hours. (Bostock *et al*, 1987)

Chemical analysis

Samples were analyzed for dry matter (DM), Ash, Organic matter (OM), nitrogen (N), Crude protein (CP), Phosphorus (P), ether extract (EE), Potassium (K), Calcium (Ca) and Magnesium (Mg).

Total nitrogen was determined by kaladhal method (AOAC, 1990). Dry matter content was determined by oven drying all the samples at 105^{o}C. Ash was determined by igniting the samples in a muffle furnaces at 550oc over night (AOAC, 1990), nitrogen and phosphorus (P) contents were determined by auto analyzes (Chemlab, 1978 and 1984) and crude protein (CP) was calculated as Nx6.25. Calcium (Ca), Potassium (K) and Magnesium (Mg) were determined by atomic absorption spectoro photometer (Perkin Elmer, 1982). Ether extract was determined

by the method recommended by the (AOAC, 1990) and the difference between dry matter (DM) and ash gives the organic matter (OM).
All chemical analyses were done at International Livestock Research Institute (ILRI) nutrition laboratory in Addis Ababa, Ethiopia.

Table 1. Weight of fillets taken at intervals of 24 hour to show drying time

Sample No	Weight of fish	Type of fish					
		Tilapia wt (g)	% of total wet wt	Catfish wt (g)	% of total wet wt	Unsalted tilapia wt (g)	% of total wet wt
1	Total wet weight	5200	-	5000	-	5000	-
	Processed weight	1600	100	1760	100	1240	100
	After 1 day salting	1400	875	1480	40.1	-	
	Drying time						
	1st day drying	560	35	600	34.1	680	54.8
	2nd day drying	440	27.5	480	27.3	400	32.3
	3rd day drying	420	26.3	410	23.3	310	25
2		2800	-	3000	-	4880	-
		1200	100	1200	100	1560	100
		440	36.7	960	80	-	
		220	18.3	400	33.3	360	23.1
		200	16.7	320	26.7	350	22.4
		160	13.3	290	24.2	340	21.8
3		4000	-	4400	-	2600	-
		1280	100	1720	100	1000	100
		840	65.1	1360	79.1	-	
		460	35.9	560	32.6	400	40
		360	28.1	440	25.6	360	36
		320	25	420	24.4	240	24
4		4840	-	4000	-	3600	-
		1640	100	1520	100	1240	100
		1240	78	1240	81.3	-	
		520	31.7	400	28.6	440	35.5
		440	26.8	360	23.7	320	25.8
		410	25	360	23.7	280	22.5
5		3600	-	3800	-	5280	-
		1000	100	1680	100	1760	100
		900	96	1360	80.9	-	
		320	32	640	38	560	31.8
		280	28	520	30.9	440	25
		276	27.5	460	27.4	400	22.7
6		7320	-	6520	-	3640	-
		2560	100	3600	100	1200	100
		2480	96.9	1800	50	-	
		1080	42.2	880	24.4	280	23.3
		640	25	580	16.1	240	20
		630	24.6	560	15.6	240	20
7	Total wet wt	3600	-	3800	-	6800	-
	Processed weight	1000	100	1680	100	2320	100
	After 1 day salting	960	96	1360	80.9	-	
	Drying time 1st day drying	320	32	640	38	600	25.9
	2nd day drying	280	28	520	30.9	560	24.1
	3rd day drying	276	27.5	420	25	260	22.4
8		5640	-	7760	-	6000	-
		1720	100	3440	100	1840	100
		1440	83.7	3160	91.7	-	
		680	39.5	1680	48.3	600	32.6
		480	27.9	920	26.7	400	21.7
		440	25.6	880	25.6	360	19.6
9		7800	-	3080	-	8000	-
		2560	100	1200	100	2640	100
		2360	92.2	620	53.3	-	

Sample No	Weight of fish	Type of fish					
		Tilapia wt (g)	% of total wet wt	Catfish wt (g)	% of total wet wt	Unsalted tilapia wt (g)	% of total wet wt
		920	35.9	240	20.7	780	28.8
		720	21.1	100	16.7	640	24.1
		680	26.6	90	15	600	22.7
10		5880	-	4880	-	5480	-
		1840	100	1960	100	1680	100
		1640	91.3	1620	83.7	-	
		640	34.8	720	36.7	600	30
		520	28.3	520	26.5	400	23.8
		480	26.1	460	23.5	360	21.4
11		3880	-	4200	-	3960	-
		1200	100	1560	100	1200	100
		1040	86.7	1200	76.9	-	
		400	33.3	560	35.9	440	36.7
		360	30	440	28.2	280	23.3
		320	26.7	380	24.4	200	16.7
12		2660	-	4320	-	2680	-
		880	100	1640	100	920	100
		400	90.9	1320	80.5	-	
		360	39.1	560	34.1	320	34.8
		240	26	440	26.8	200	20.2
		200	20.2	360	22	160	10.8

Statistical analysis

Moisture content of salted and unsalted fish (tilapia and catfish) were statistically tested using analysis of variance (ANOVA).

Result and discussion

As shown in Table 2. Crude protein content of *clarias gariepinus* was higher than that of *Oreeochromis niloticus* fillet. This may be attributed to differences in the feeding habits of fish (Zenebe Tadesse *et al*, 1998). *Clarias gariepinus* are carnivorous fish, feeds on fish, insects, zooplankton, which are rich in protein where as *oreochromis niloticus* are herbivores feeding mainly on phytoplankton or algae. Hence food of animal origin contains more protein than algae and this in turn may reflect on the tissue of the consumer fish (Zenebe Tadesse, 1988)

Table 2: Chemical composition of salted fish

Type of sample	DM %	Ash %	OM %	N %	CP %	P %	EE %	K %	Ca %	Mg %
Catfish, Lake Ziway	91.53	12.99	87.01	13.62	85.14	1.14	1.94	1.99	0.24	0.14
Tilapia, Lake Ziway	93.77	41.09	58.91	9.13	57.06	0.62	2.55	1.23	0.14	0.10

DM = Dry matter, CP = Crude protein = Nitrogen, EE = Ether Extract, OM = Organic Matter

P = Phosphorus, K = Potassium, Ca = Calcium, Mg = Magnesium

Tilapia and catfish treated with salt have significantly lower moisture content ($P<0.05$) than unsalted tilapia (Table 3). The water content of fresh fish is about 80%. If this is reduced to 25% spoilage bacteria can't survive because low moisture content inhibits growth of bacteria and molds. The result obtained from the study shows that lower final moisture contents were achieved and the average moisture content of the solar dried salted and unsalted fish were approximately 10%-11%.

The recorded data indicated that the difference in moisture content between salted and unsalted fish was relatively small. It can also be seen that to dry salted and unsalted (tilapia) fish to the final moisture content the solar dryer required 3 days (Table 1). This is due to the combined effect of the dryer and the presence of salt in the fish. Therefore salted solar dried fish has longer shelf life than unsalted fish and less susceptible to spoilage caused by bacteria and molds.

Table 3. Moisture content of solar dried salted and unsalted fish

Treatment	N	Mean dry weight ±se	Df.	F value	P value
1. Dry salted tilapia	12	9.48 ± 0.19^{b}			
2. Dry salted catfish	12	9.66 ± 0.22^{b}	2	7.38	0.0022
3. Unsalted tilapia	12	10.67 ± 0.28^{a}			

Treatment mean bearing the same letter are not significantly different ($P<0.05$).

The final result of salted and dried products indicated that the solar-dried fish were of good quality and were marketable products. The texture was hard and well dried and the products had a pleasant odor. The dry salted fish were of a light yellow color. None of the experimental products showed evidence of mould invasion, "pinking" caused by salt-tolerant bacteria, beetle infestation, or case- hardening.

Scott (1957) reported that the stability of salted and dried food products depends on their water activity. This is a measure of free or available water in a food, which react chemically or in spoilage, to support the growth of microorganisms, such as moulds and bacteria (Waterman, 1976). For salted dried fish it is necessary to consider both the moisture content and the salt content when calculating water activity (Doe *et al*, 1982). High concentration of salt has inhibiting effect on growth of microorganisms, except the red halophilic bacteria that are salt-tolerant. The water activity of pure water is 1 and of food is expressed as a fraction relative to pure water. Fresh fish have a water activity of above 0.95. Most spoilage bacteria cease to grow in a food whose water activity is below 0.90 and the growth of most moulds is inhibited below 0.80. However, halophilic bacteria can grow at a water activity of 0.75 and some yerophilic moulds as lower 0.65 (Bone, 1969).

Both salting and drying have the effect of reducing water activity. During storage, dried fish flesh will absorb moisture from the air at high humidity until equilibrium is reached. At humidity of above 75%, any salt in the fillet will also absorb moisture. Therefore, during storage, the product becomes wetter, thus increasing the water activity and it will become more susceptible to spoilage by moulds and bacteria.

Poulter *et al* (1982) reported that the product could have mould free shelf life over one year (450 days) for the fish treated with 20% salt and dried to 15% moisture content. The present study also approved that with moisture content of 11% and salt content of 20% the dried fillet can be stored over one year (480 days) without any spoilage

No evidence of beetle attack was observed on any of the batches of fish at the end of the drying period, because the elevated temperature of the dryer would kill any insect or larva present on the fish (Sazabo, 1970)

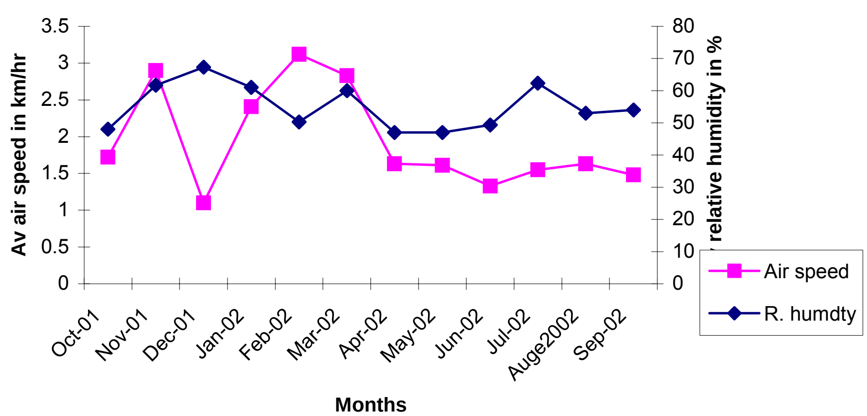

Figure 2. Average air speed and relative humidity

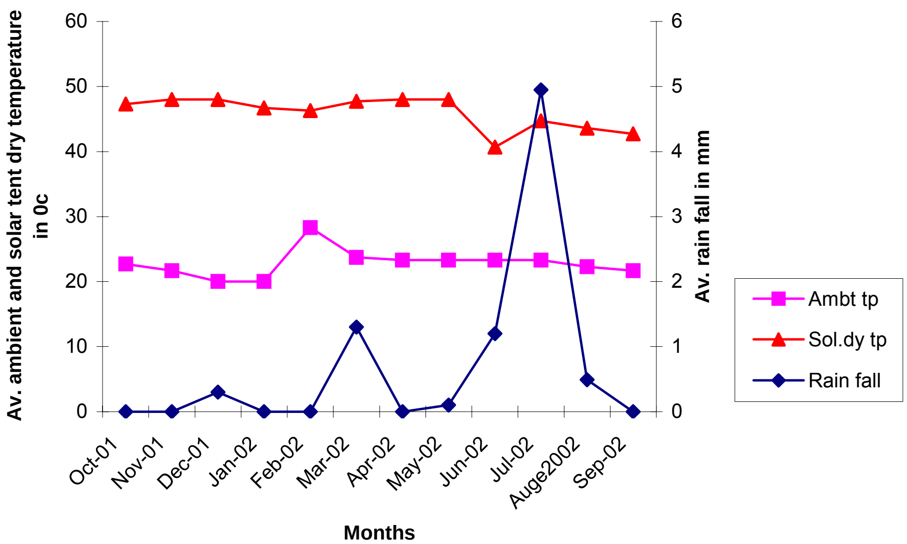

Figure 3. Average ambient and solar tent dry temperature and rain fall

Conclusions and recommendation

The solar tent dryer helps production of a low moisture product with a long storage life. Therefore, it is concluded that fish dried in solar tent dryer under fine and sunny condition, tilapia or cat fish (salted and unsalted) would be expected to dry in about 3 days to achieve a final lower moisture content. Also it was considered that fish dried in solar tent dryer was good quality and marketable products. Hence, it is recommended that solar tent dryer is appropriate and suitable for small-scale fishermen in the rift valley area. Because the energy from the sun is free, the drying time is short and the temperature is very high enough to kill flies, insect infestation and used as disinfectant for those fish dried in the sun.

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Growth Performance of Yearling Menz Ram Lambs Fed on Different Pulse Crop Residues.

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Abstract

To improve the scarce livestock feed in the highlands it is very important to consider locally available feed resources specially crop residues. An experiment was conducted to evaluate the performance of sheep fed with pulse crop residues. Thirty-two yearling Menz ram lambs with an average initial body weight 15.05±0.33kg were used for the experiment in completely randomized design for the experimental period (116 days). The experimental animals were allocated to four treatments (lentil, grass pea, chick pea & faba bean crop residues) randomly with eight sheep per treatment. Crop residues, water and mineral lick were provided adlib. Feeding was in an individual pen with no grazing. Average daily body weight gain of 62.770gm, 26.479gm and 18.320gm was obtained for lentil, grass pea, and chickpea crop residues respectively. Sheep that were fed on faba bean crop residue suffered serious weight loss and three of the animals were died. Thus the trial with this treatment was interrupted after 21 days of the beginning of the actual experiment. Average daily net DM intake for lentil, grass pea and chickpea crop residues was 838.906gm, 631.871gm and 580.588gm respectively. Both average daily body weight gain and daily net DM intake for the three treatments are significantly different (P<0.05).

Introduction

The main objective of keeping livestock in the mixed crop-livestock farming system of cool highlands of north Shoa is for draft purpose as it holds true to other parts of the country. Farmers in North Shoa highlands of the Amhara National Regional State is used to fatten cattle and sheep using locally available feed resources such as pulse crop residues, spent grain and left over food.

A feed supplementation study for fattening highland sheep by Sisay and Melaku (1994) revealed that both energy and protein are equally important during the dry season for optimum weight gain. However, protein is more detrimental in the area since most of the farmers are not in a position to purchase commercially available protein supplements. Meanwhile farmers used to fatten their animals traditionally using feeds that are available in the locality. This situation necessitates to develop legume based forage and pasture, and improved utilization of legume crop residues as a potential alternative to commercial concentrate feeds for fattening sheep.

Residues of pulse crops are rich in protein and minerals. Traditionally these feed resources have played a great role in the cool highland areas of north Shoa. They have been used as local supplement to fatten animals during the dry season. In north Shoa intake of these feeds and their values as a fattening diet was not yet evaluated. Therefore, this trial was conducted to evaluate the potential of pulse crop residues (lentil, grass pea, chickpea and fababean) as protein source feed for sheep fattening.

Materials and Methods

Animal Management

Thirty two yearling Menz rams with an average initial body weight 15.05±0.33kg were used for the experiment in a completely randomized design. The experimental animals were allocated to four treatments (lentil, grass pea, chickpea and faba bean crop residues) and 8 sheep per treatment. Before the commencement of the experiment the animals were treated against internal parasite. The actual experiment was started after 15 days of adaptation period to maintain constant feed intake per day for each feed type having 10-15% left over. Grazing and other supplement were not allowed except water and mineral lick provided adlib. The experiment was conducted for 116 days from February to June 2002.

Data Collection and Statistical Analysis

The amount of feed offered for each treatment and left over was recorded every day. Body weight gain was recorded fortnightly till the end of the experiment. Based on the collected data average daily net dry matter intake, average daily weight gain and final weight were calculated for each treatment. Data was analyzed using one-way ANOVA model (MSTATC).

Crop residues

Crop residues from lentil, chick pea and grass pea were yellowish in color and composed of stem, leaf and pod sheath. Crop residue from faba bean was pale-green in color and the leaf component was very low due to defoliation loss during harvesting.

Results and Discussion

The average daily net dry matter intake for each treatment was 838.906±23.95 gm for lentil, 631.871±25.60 gm for grass pea, & 580.588±27.65 gm for chickpea crop residues. Laboratory chemical analysis result for each crop residue is indicated in Table1. The average initial weight, final weight, daily body weight gain & daily net DM intake is indicated in Table 2. Chemical analysis result for the nutritive value of the feeds was found to be similar with the values given by Seyoum and Zinash (1989).

After 116 days of the experiment an average daily body weight gain of 62.77±3.93gm, 26.48±4.21gm, and 18.320±4.54gm was obtained for lentil, grass pea and chickpea crop residues respectively. The weight gain obtained specially for experimental animals under lentil crop residues (62.77gm) was greater than that reported by Sisay and Melaku (1994), 43gm during the dry period for 60 days on Menz ram lambs by using 50:50 ratio of Oat grain:Noug (Guizotia abyssinica) cake mixture with crude protein content of 22% in DM basis and is much lower as compared with 111gm average daily body weight gain during the post-rain period for 45 days by using 25:75 ratio of Oat grain:Noug cake mixture with CP content of 29% in DM basis.

Sheep that were fed on faba bean residue, suffered serious weight loss up to 25% of the initial weight and 3 of the animals were died. Thus the trial with this treatment was interrupted after 21 days of the beginning of the actual experiment. This indicates that faba bean residue cannot fulfill the minimum nutrient requirement for maintenance when used as sole diet.

The result of this experiment has shown that the higher the CP contents of the pulse crop residues the better the performance of sheep. Crop residue from lentil was with higher CP content (12.72%) followed by grass pea (10.99%) and chickpea (7.25%). But this positive relationship was not necessarily true for invitro digestibility and weight gain. Sheep under chickpea crop residue performed better than sheep under Grass pea crop residue with invitro digestibility value of 49.16 and 60.72% for Grass pea and Chickpea crop residues, respectively. Even invitro digestibility value of Faba bean crop residues was higher than grass pea crop residues (Table 1). From this experiment we can see that the CP content was more important than invitro digestibility.

Average final weight, daily weight gain and daily net DM intake for the three treatments was significantly different (P<0.05). Average final weight, daily weight gain and daily net DM intake was higher for lentil crop residue followed by grass pea crop residue and chickpea crop residue (Table 2). Average daily weight gain and average net DM intake were positively correlated.

Mean comparison was made to evaluate the statistical difference among the three treatments (lentil, grass pea and chickpea crop residues) for average final weight, daily weight gain and daily net DM intake. Average final weight, daily weight gain and daily net DM intake from lentil crop residue was significantly different from grass pea and chickpea crop residues (P<0.05). The performance of sheep under the treatments of grass pea and chickpea crop residues for average final weight, daily weight gain and daily net DM intake was not significantly different (P>0.05), though the performance of sheep under grass pea crop residue was better than chickpea crop residue.

Table 1. Laboratory chemical analysis of the different pulse crop residues used.

Treatments	DM(%)	CP(%)*	Ash(%)*	Invitro Organi Matter Digestibility(%)*
Lentil crop residue	92.25	12.72	7.58	65.09
Grass pea crop residue	91.49	10.99	6.03	49.16
Chick pea crop residue	92.20	7.25	7.76	60.72
Faba bean crop residue	91.43	6.48	8.69	54.42

*The values are calculated in DM basis.

Table 2. Summary of the mean (± standard error) initial weight, final weight, daily weight gain and daily net DM intake.

Treatments	Initial weight (kg)	Final weight (kg)	Daily weight gain (gm)	Daily net DM intake (gm)
Lentil crop residue	14.938±0.68 a	22.500±0.67 a	62.770±3.93 a	838.906±23.95 a
Grass pea crop residue	14.969±0.68 a	17.929±0.72 b	26.479±4.21 b	631.871±25.60 b
Chick pea crop residue	15.429±0.73 a	16.333±0.77 b	18.320±4.54 b	580.588±27.65 b
Faba bean crop residue	14.906±0.68 a	-	-	-
CV%	12.76	9.87	29.31	9.73
LSD(5%)	NS	1.991	11.690	71.150

Values with same letter are not significant (P>0.05).

Recommendation

From the study result it can be concluded that crop residue from lentil can contribute to minimize the burden of protein shortage in the diet for sheep fattening. Thus, it can be used as a protein source diet in areas where protein is limiting for optimum body weight gain. However, further work has to be done on how to incorporate it in the ration of sheep fattening so that maximum benefit could be obtained from this crop residue.

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Fish species diversity and the current status of fish production in five rivers of Western Ethiopia.

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Abstract

Although Ethiopia has abundant water resources, studies on the fish species diversity and the potentials of fish production are limited. Complete list of fish species of the country is not yet available and a number of drainage basins still remain unexplored. The objectives of this study were to identify fish species diversity of five rivers namely Abay, Beles, Dabus, Afa and Gabba belonging to the White Nile and Blue Nile drainage systems and to assess fish production in the study areas. The study was conducted in different occasions from December, 2000 to April, 2003.The fishing gears used to catch the fish were gill nets, castnet, framenet and traps. Four monofilament gillnets with stretched mesh size of 4,6,8 and 10 centimeters and each having a length of 20 meters and a height of 1 meter were used. The castanet used had a radius of 1.5 m and a stretched mesh size of 1cm. The frame net used had 0.75 m² frame area and 2 meters long cod end. Two cylindrical metallic traps with an area of 0.5 m² were also used to catch the fish. The sampling habitats were pools and riffles which had soft silt, gravel and boulder rock bottoms, riffles which had shallow depth (i.e 5-15 cm), pools which had a depth ranging from 0.4 m to 2m, and segments of the river course shores with and without vegetation. Standard fish identification keys were used to identify the fishes caught. The total number of fish species identified from rivers Abay (Blue Nile), Beles, Dabus, Afa and Gabba were 24, 25, 3, 4 and 5 respectively. The Cyprinids are the most dominating groups in the fish community inhabiting the sampled localities of Beles, Gabba and Afa rivers. Fish species belonging to the families Mormyridae, Characidae and Cyprinidae are the dominating groups in Blue Nile river. In Dabus river three fish species which belong to three families (Cyprinidae, Cichilidae, and Clariidae) were identified. Although great fish resource exists in the study areas, fish production is still at a subsistent level. Fishing is conducted using locally constructed gears that are labor intensive and less efficient.

Key words: Fish species diversity, fish production, White Nile and Blue Nile.

Introduction

The territory of Ethiopia encompasses part of the catchment areas of two oceans separated by the northern portion of the Great African Rift.. Two major biogeographic units, the Nilo-Sudan and East Coast ichthyofaunal Provinces, are in contact with this region (Roberts, 1975; skelton, 1994). Ethiopia is endowed with abundant water resources. The total area of the lakes and reservoirs is about 7400 km² (NFLARRC, 1999). Similarly, the total length of the country's major rivers is estimated at 7000 km (NFLARRC, 1999).

The country is believed to harbor diverse fish species. Prelimenary data indicate that the total number of freshwater fish species occurring in Ethiopian waters is substantially higher than those recorded from the Sudan, Egypt or Somalia (Golubtsov and Mina, 2003). Diversity and composition of fish species vary greatly over the territory of Ethiopia (Golubtsov and Mina, 2003). In addition to its role for production, the rich fish species diversity can creat opportunity to utilize the resource for such purposes as ecoturism and biological control.

In contrast to the rich water resources, studies on the fish and other aquatic biotic resources diversity, distribution, quantity and economic potential of these resources are scarce. Main focus of the limited researches that have been conducted so far are on lakes and reservoirs and running water systems are the least explored aquatic ecologies (NFLARRC, 1999). Similarly literatures are too scarce, and if available, are limited to accessible areas. Therefore, complete list of fish species of the country is not yet available. In order to achieve effective management and conservation of Ethiopian fish fauna, it is imperative to document the existing species diversity (Golubtsov and Mina 2003).

This paper is prepared to contribute information to the existing limited knowledge on fish species diversity and current status of fish production in Ethiopia. The study was conducted in five rivers of western Ethiopia which belong to the White Nile and Blue Nile drainage systems. The white Nile drainage harbors 106 fish species, the highest fish species diversity in Ethiopia. (Golubtsov and Mina, 2003). The lowland part of the drainage (the Gambella, region) has developed flood plains. It is in this part of the drainage the fish fauna are most diverse. It is not surprising because the reproductive and feeding cycles of most of the local fish species are closely tied to the flood plains inundated during the rainy season (Lowe – McConnell, 1977 : 1987).

The Blue Nile system, on the other hand, has relatively less developed floodplains and harbors 64 fish species (Golubtsov and Mina 2003).

The objectives of the study were to :

1. Study fish species diversity of five rivers found in White Nile and Blue Nile drainage systems and
2. Assess the current status of fish production in the study areas.

Materials and Methods

The Study Areas

The study areas are located in western Ethiopia. The study was conducted at selected sites of five rivers, namely; Abay, Beles, Dabus, Afa and Gabba that are found in White and Blue Nile drainage systems. From the White Nile drainage system; Gabba river, a tributary of the Baro river, was sampled at the bridge along Metu-Gimbi road, some 25 km NE of the town of Metu at 8^0 28' 40'' N 35^0 38'45''E. Beles river; one of the tributaries of the Blue Nile, was sampled at a site located some 25 km SE of the town of Mankush at 11^0 7' N 35^0 24' 30'' E. The Blue Nile (Abay) was sampled at the town of Bamza, some 35 km SW of the town of Mankush and at 11^0 14' N 34^0 59' E. Dabus river; a tributary of the Blue Nile was sampled near the bridge along the Nekemte – Asosa road, some 17km SE of Asosa at 9^0 57'30'' N 34^0 39'15'' E. Afa river; a tributary of Dabus river, was sampled at the bridge along the Nekemte – Asosa road some 17 km south east of the town of Asosa, at 9^0 57' 30'' N and 34^0 39'15'' E.

The study period

The study was conducted in different occasions from December, 2000 to April, 2003. The period was selected because it was only possible to fulfill the logistic requirements of the study at that time.

Fishing gears and methods of Fishing

Fishing gears used to catch the fish were gill nets, cast net, frame net and traps. Four monofilament gill nets with stretched mesh size of 4, 6, 8 and 10 centimeters and each having a length of 20 meters and a height of 1 meter were used. The cast net used had a radius of 1.5 meter and a stretched mesh size of 1centimeter. The frame net used had 0.75 m^2 frame area and 2 meter long cod end. Two cylindrical metallic traps with an area of 0.5 m^2 were used. Gillnets were shot early in the morning and were checked every two hours for their catch until late afternoon. In each river five gill net fishing sites were selected. The sites were pools which had a depth of at least one meter. On each site gill nets were shot at least once. In addition, sites which had better fish catch were sampled up to three times. Overnight gill net setting was done only in two selected sites of Blue Nile (Abay) river.

Since different fish species have different habitat requirements, the sampling sites were selected based on structural habitat characteristics. In addition, suitability of the sites for the fishing gears used and their accessibility was considered during site selection. The structural habitat characters considered during selection were : depth, river flow structure (pool or riffle), sediment type of the river bed (soft silt/sand, gravel or boulder), and presence or absence of shoreline vegetation. Based on these criteria the habitats selected for sampling were: pools and riffles which had soft silt, gravel and boulder rock bottoms, riffles which had shallow depth (i.e 5-15 cm), pools which had a depth ranging from 0.4 m to 2m, and segments of the river course shores with and without vegetation.

Taxonomic classification of fish

To identify the taxa to which they belong, fishes caught were subject to morphological taxonomic studies following the fish identification key developed by Golubtsov et. al. in 1995. The morphological features considered in the study were: presence or absence of teeth, type of teeth, presence or absence of barbells, number of gill rakers, number of fins and number of branched and unbranched rays in the fins, shape and position of the fins, shapes of mouth, presence or absence of adipose fin, presence of scales, number of scales on the lateral line, type of scale, fin length, snout length, standard fish length, length and type of barbell, coloration of the body and fin, specific features of the fin such as if the fish is elongated or deep bodied and if head is dorso-ventrally flattened (Golubtsov et. al. 1995).

Specimens which were difficult to identify on site as well as those identified, were preserved in 5% formalin solution and the former were subject to further laboratory examination, and all the specimens were stored in Sebeta Fishery and Aquaculture Research Center.

The status of fish production in the study areas was assessed based on the secondary information collected from Federal and Woreda bureau of agriculture offices. Moreover, observations and semi structured interviews were made to qualify the secondary data and assess the situation of the fisheries.

Result and Discussion

Fish Species Diversity

Findings of the ichthyofaunal surveys that have been made on the middle reaches of the Blue Nile at the Sudanese border, lower reaches of the Beles river, the middle reaches of Gabba, Dabus and Afa rivers demonstrated that the rivers are inhabited by fish communities composed of typical Nilotic species. A total of 37 fish species were identified from the five rivers. All of the identified fish were found in the Blue Nile drainage system while only five species were found in the White Nile system. The identified fish species in each sampled river are presented in Table 1.

At sampled localities of the Blue Nile river, 24 species belonging to 8 families were identified, while 25 fish species belonging to 9 families were identified from Beles river. From the sampling locality of Gabba river 5 fish species belonging to 3 families, from Dabus river 3 fish species belonging to 3 families, and from Afa river 4 fish species belonging to 1 family were also identified. The highest fish species diversity was recorded from Beles river, followed by Blue Nile, Gabba, Afa and Dabus rivers respectively.

The Cyprinids are the most dominating groups in the fish community inhabiting the sampled localities of Beles, Gabba and Afa rivers. Fish species belonging to the families Mormyridae, Characidae and Cyprinidae are the dominating groups in Blue Nile river. In Dabus river three fish species which belong to three families (Cyprinidae, Cichilidae, and Clariidae) were identified.

Status of Fish Production

Annual fish production potential of the running water systems of Ethiopia is estimated at 5000 tons (NFLARC, 1999). However the current utilization of the fishery is much lower than the estimated amount (NFLARC, 1999). According to the Ministry of Agriculture and Rural Development report current fish production of the Blue Nile drainage system is 10% of the estimated annual fish production potential of the drainage system. Similarly, the current fish production in the studied areas in the Blue Nile system is 10% of their potential production. Despite the existence of diverse fish species and abundant fishery resource the study areas are one of the food deficient areas of the country and the contribution of fish in the diet households is low and fish consumption is often restricted to dwellers that live close to the rivers and is often targeted to fulfill the household requirement.

The main reasons for the underutilization of the fishery resource in the studied areas are:

- rudimentary and labor intensive fishing gears,
- inaccessibility to potential market areas
- absence of the use of methods that could prolong the shelf life of products for safe
- transportation to distant potential market,
- absence of efficient fishing gears and,
- lack of training and extension services.

Fishing is conducted in artisenal way. The fishing gears used in the studied areas were locally made spears, traps, and hooks. Such fishing gears are labor intensive, time consuming and inefficient. Locally made gillnets were observed only in the lower reaches of the Blue Nile. The gillnets were not made following standard twin sizes and hanging ratio and their catching efficiency was low. In addition to these fishing gears the use of poisonous plants to harvest fish was found to be common practice in the studied areas. In this regard, it has been learnt that the fruits and leaves of *Melitia sp.* are the commonly used fish poisoning plant materials. Fish poisoning is disasters to the sustainable utilization of fisheries (NFLARC, 1999). It kills both juveniles and adults, indiscriminately. It threatens replacement and existence of the resource.

In the studies areas, fishing is predominated by men and the roles of women are mostly limited to preparing and selling (MOA, 2003). Although fishing is predominantly meant for household consumption, it is common to see fish in local markets during the fasting season that is practiced by the followers of the Ethiopian orthodox church. In addition to the seasonality of fish supply to the markets, the fish products available in such markets are usually of poor quality and unhygienic. The far distance the fish products have to be transported coupled with the lack of basic knowledge of preserving and processing fish has made products in the local market to be of low poor quality and unhygienic.

In Ethiopia fish species which are regarded as commercially most important are Nile Perch (*Lates niloticus*), African Catfish (*Clarias gariepinus*), Barbus sp., Nile Tilapia (*Oreochromis niloticus*) and Labeo sp.. As it has been shown in Table 1, all of the commercially important fish species of the country except the Nile Perch are available in the studied areas. Given the possibilities of developed infrastructure and adequate facilities for processing, handling and transportation, the locals of these areas can benefit from these resources by selling fish products to towns where there is a higher fish demand and a better purchasing power. Therefore, due attention should be given by bureaus of ministry of agriculture and rural development and non-governmental organizations operating in the areas to develop the infrastructure of the areas and to give training and extension service to develop the fishery.

Conclusion and Recommendation

Present findings of the ichthyofaunal surveys that have been made on the middle reaches of the Blue Nile at the Sudanese border, lower reaches of the Beles river, the middle reaches of Gabba, Dabus and Afa rivers demonstrated that the rivers are inhabited by fish communities composed of typical Nilotic species. At sampled localities of the Blue Nile river, 24 species belonging to 8 families were identified, while 25 fish species belonging to 9 families were identified from Beles river. From the sampling locality of Gabba river 5 fish species belonging to 3 families, from Dabus river 3 fish species belonging to 3 families, and from Afa river 4 fish species belonging to 1 family were also identified. A Total of 37 fish species were identified from the five rivers.

The Cyprinids are the most dominating groups in the fish community inhabiting the sampled localities of Beles, Gabba and Afa rivers. Fish species belonging to the families Mormyridae, Characidae and Cyprinidae are the dominating groups in Blue Nile river. In Dabus river three fish species which belong to three families (Cyprinidae, Cichilidae, and Clariidae) were identified.

The sampling period of the study was chosen mainly for logistic reasons and it was not ideal for ichthyofaunal studies because it coincided with the rainy season of the studied areas. Consequently, due to high water level and current in the sampled rivers during the study, the fish species diversity was less than expected. Therefore, it is believed fish species diversity found in the drainage systems may be more than it has been recorded during the study. Personal communication with local people has suggested the existence of the Nile Perch (*Lates Niloticus*) and the electric Catfish (*Malapterurud sp.*) in the Blue Nile drainage system.

Although the study areas are endowed with rich fish resources, it has been found that the contribution of fish to the diet of households is very little. Fish is produced at a subsistent level using locally made fishing gears. The underdevelopment of infrastructure and the inaccessibility of the areas, absence of efficient fishing gears, and lack of fishery training and extension service are the major factors contributing to the underutilization of the resource. Therefore, due attention should be given by bureaus of ministry of agriculture and rural development and non-governmental organizations operating in the areas to develop the infrastructure of the areas and to give training and extension service to develop the fishery.

Extension in terms of organizing fishermen associations and credit services for covering initial fishing investments and purchasing fishing gears should be provided to the local people. In addition, training should be given regarding modern fishing gears, fish harvesting, fish processing, fish preservation , fish products transportation and marketing. The food deficient areas can have a cheap source of high quality protein and additional household income generation mechanism if adequate attention is given from responsible governmental and non governmental bodies to develop the fishery.

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Table 1 Fish species of five rivers of the White Nile and Blue Nile drainage systems.

No	Fish Species	Blue Nile River	Beles river	Dabus River	Afa river	Gabba river
1	Mormyrops anguilloides, Linnaeus, 1758	X	X			
2	Mormyrus cashive, Linnaeus, 1758	X	X			
3	Mormyrus hasselquistii, Valenciennes, 1846	X	X			X
4	Mormyrus kannume, Forskal, 1775	X	X			
5	Pollimyrus pethericі, Boulenger, 1898	X				
6	Alestes sp.	X				
7	Brycinus macrolepidotus Valenciennes, 1849	X	X			
8	Brycinus nurse Ruppell, 1832	X				
9	Hydrocynus forskahlii, Cuvier, 1819	X				
10	Micralestes acutidens, Peters, 1852	X	X			
11	Nannocharax sp.	X				
12	Garra sp.	X	X		X	
13	Leptocypris niloticus de Joannis, 1835	X	X			X
14	Labeo coubie, Ruppell, 1832	X	X			
15	Labeo cylindricus, Peters, 1852	X	X			X
16	Labeo niloticus, Forsskall, 1775	X	X			
17	Bagrus docmakm, Forsskall, 1775	X	X			X

No	Fish Species	Blue Nile River	Beles river	Dabus River	Afa river	Gabba river
18	Bagrus bajad, Forsskall, 1775		X			
19	Schilbe mystus, Linnaeus, 1758	X	X			
20	Schilbe uranoscopus, Ruppell, 1832	X				
21	Synodontis frontosus, Vaillant, 1895	X				
22	Synodontis schall, Bloch and Schneider, 1801	X	X			
23	Synodontis serratus, Ruppell, 1829	X	X			
24	Synodontis sorex Gunther, 1864	X				
25	Oreochromis niloticus, Linnaeus, 1758	X	X	X		
26	Labeo forskalii, Ruppell, 1835		X	X		X
27	Barbus cf. intermedius				X	
28	Barbus pludinosis, Peters, 1852				X	
29	Barbus small sp.		X			
30	Varichorinus beso, Ruppell, 1836				X	
31	Clarias gariepinus, Bruchell, 1822			X		
32	Distichodus engycephalus, Gunther, 1864		X			
33	Chelaethiops bibie, de Joannis, 1835		X			
34	Labeo horie, Heckel, 1846		X			
35	Chiloglanis niloticus		X			
36	Chiloglanis sp.		X			
37	Tetraodon lineatus, Linnaeus, 1758		X			

X indicate the presence of the stated fish species.

On-farm verification of sheep finishing technology in Eastern Wollega zone

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Abstract

An 84-day fattening study was conducted on five locations of three woredas of East Wollega zone (Digga, Leqa Dullacha and Jimma Arjo) to verify and demonstrate sheep feeding technology on-farm. The technology involves finishing young sheep using concentrate supplementation of 49.5% ground maize, 49.5% noug cake (Guizotia abssynica) and 1.0% common salt. Finished rams were by 16.3% (4.0kg) heavier and in a better condition at the end of the experiment than the control group. The supplemented group also grew approximately 62.1% (47 g/day) faster during the course of the study period. A net return of Birr 40.24/head/84 day was obtained in the current study. The Marginal Rate of Return (MRR) analysis indicated that concentrate supplementation at the rate of 400g/head/day yielded a MRR of 58%. Thus, in areas where noug cake and maize grain are available, like the western region of the country, supplementation of yearling Horro rams at a level of 400g/head/day for about three months is profitable particularly if the finishing activity is performed right after harvest.

Key words: on-farm, sheep finishing, verification

Introduction

Western Ethiopia (Wollega, Jimma, Ilu-Abbabora and part of Western Shoa) accounts for about 17 % of the sheep population of the country (Tesfaye, 1991). In this region, sheep are part of the crop-livestock mixed production system and are raised under traditional management system based on grazing natural pasture and use of crop aftermath. Under this type of management increase in production is mainly achieved through increase in animal number and not through enhanced productivity per animal. With rapid increase in population farm size gets smaller and less pastureland is available. Thus increase in productivity through increasing the number of animals is not a viable option. Intensified feed and livestock production may be one way to raise production per land and livestock unit in a sustainable fashion (Shapiro *et al.*, 1994).

In the western region as it is common else where in the country, the great majority of sheep sent to market for slaughter are unfinished milk tooth lambs with liveweights ranging between 10 and 18 kg (Galal *et al.*, 1979). According to Solomon *et al*. (2004; unpublished data) in East Wollega and West Shoa zones, only 39.0 % of the farmers owning small ruminants practice some form of fattening before marketing and majority of farmers sale their animals early before attaining optimum market weight. That means, the meat yield and the income farmers acquire from this category of animals is indeed low and it may be a wasteful system for it does not make use of the growth potential of these lambs through finishing practice for larger weights. Introduction of finishing technology to this areas help to acquire self-sufficiency in meat consumption for the increasing human population, to increase export earnings and to improve the standard of living of the large number of poor farmers in rural areas.

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At Bako Research Center, profitable feeding systems based on concentrates have been developed to finish young sheep (Solomon *et al.*, 1993; Solomon and Solomon, 1995). The existence of oil extracting small scale meals ensures the supply of by-products and recently there is a trend of boost in maize production (particularly in this region of the country), both of which are an encouraging condition to practice concentrate feeding when ever it is profitable to do so. On farm studies done in the central highlands have shown that concentrate feeding could become more profitable than feeding cultivated forage (Shapiro et al., 1994). The purpose of the present study was, therefore, to verify and demonstrate a sheep finishing technology on-farm based on concentrate.

Materials and Methods

A total of 53 farmers (in five peasant associations) from Digga (Jirenya and Qajela), Leqa Dullacha (Badho and Qawwisa) and Jimma Arjo (Lalo Hinne) districts of East Wellegga zone have participated in the project. Six of the farmers were women family heads. Participating farmers were selected in co-operation with agricultural development workers in the area. A revolving fund was established for the purchase of lambs to be fattened. Two hundred ten rams were bought from the nearby markets and distributed to the farmers. The farmers themselves have selected the ram lambs and did the negotiation of the price and then the payment was made from the project. Each participating farmer received four ram lambs (except for one farmer who had only received two rams because of his inability to buy the allowed number within the given time), of similar size. The farmers were randomly assigned to two treatments by drawing lot: control and finishing group. Sheep in the finishing group received a supplement of 400g/head/day concentrate for a period of 84 days while the control group were maintained only on grazing. The formulation of the finishing ration was noug (*Guizotia abyssinica*) cake (49.5%), ground maize grain (49.5%) and common salt (1%). Feed was introduced gradually with increment from 100g to 400g/h/day within ten days period. The feeding period was reduced from 90 to 84 days to allow farmers sell their animals the week before Easter. Weight gain was monitored and input costs for each individual sheep was recorded. The experimental animals were treated for internal parasites at the beginning of the experiment. At the end of the experiment price was estimated by forming a panel of three local live sheep dealers and the average estimate was used for economic analysis. Partial budget analysis was used to analyse the profitability of sheep finishing. The actual market price (i.e. when this experiment was conducted) of maize grain and noug cake was taken for the economic analysis. Feed cost for a 90 day feeding was considered in the economic analysis though animals were actually fed only for 84 days.

Data were analysed using the GLM Procedures in SAS (1996). The model of analyses included treatment (control and supplemented) and location (five locations of the three woredas) as independent variables. Initial weight was also fitted as linear covariable.

Results and Discussion

Analysis of variance for liveweight measured in the middle of the experiment, final liveweight, total weight and average daily gain is presented in Table 1, while least squares means (±SE) for the same traits are shown in Table 2. Eleven lambs (9 from the finishing and 2 from the control group) have died and hence data from these animals were not included in the analysis. The effect of feeding treatment was significant ($p<0.001$) for all traits considered. Both groups have gained weight but animals in the finishing group were by 10.6% (2.4kg) and 16.3% (4.0kg) heavier than the control group by the middle (at about 45 days) and end of the experiment (at 84 days), respectively. They also grew approximately 62.1% (47 g/day) faster than the control group during the course of the study period. The total weight gain for the control and the finished groups were

3.1 and 7.1 kg (about 61.5% superiority), respectively. Previous studies (Solomon *et al*., 1993a; Solomon and Solomon, 1995) on the same breed have demonstrated that concentrate supplementation improves the growth performance of growing lambs. Solomon *et al*. (1994) also reported that lambs given no supplementary feeds and grazed on natural pasture in the dry season lost liveweight while the supplemented lambs gained liveweight. The gain of unsupplemented lambs in the current study could be a result of good pasture conditions in most of the areas the study was conducted. Galal *et al*. (1979) and Mohammed and Demissie (1991) also reported significantly higher liveweight and average daily gain in supplemented groups, on performance study conducted on highland and Arsi lambs, respectively. The over all mean total weight gain (about 15 kg) and mean average daily gain (105 g/day) reported by Solomon *et al*. (1993a) for 120 days fattening period were higher than those obtained in the current study. The previous study was undertaken under station management where the animals were fed ad-lib hay and for longer period than in the current study (only 84 days). Mohammed and Demissie (1991) from a high level (600g/h/d) of feeding of Arsi lambs have reported a total weight gain of 18.5 kg which is higher than reported in the current study. Nevertheless, the feeding period (two years and four months) and daily weight gain (29 g/day) reported in their study were by far longer and lower than 84 days and 75.7 g/day in the present study, respectively.

Table 1. Analyses of variance of liveweight, total gain and average daily gain of on-farm finished rams from on-farm finishing study.

Source	Df	IMWT (kg)	FWT (kg)	TWG (kg)	ADG (g/day)
Treatment	1	168.600***	474.108***	474.108***	65620.436***
Location	4	222.927***	103.435**	103.435**	14316.258**
Initial liveweight (kg)	1	946.092***	956.528***	9.529^{NS}	1318.827^{NS}
EMS		3.477	6.086	6.086	842.358
C.V. (%)		8.23	10.04	38.32	38.32

IMWT=weight taken in the middle of the experiment; FWT=final weight; TWG=total weight gain; ADG=average daily gain; **=p<0.01;***=p<0.001; NS=not significant

Location had significant (p<0.001) effect on liveweight and growth rates evaluated. Animals maintained at Badho were heavier than animals maintained at other locations. The least performing animals were those fattened at Qajela (Table 2). This could be a reflection of differences in feed availability (quality and quantity) from natural pasture arising from differences in agro ecology. Fore instance, Qajela is relatively a lowland area as compared to the other locations. Alemu and Lemma (1993) from a botanical composition study of natural pasture close to areas addressed in the current study have reported that the composition of the different grasslands changes with change in altitude. They have also reported that areas below 2000 m.s.l. have low proportion of grasses of good grazing value. This may explain why sheep in Qajela (lowland) have gained less and sheep in Badho (highland) have gained more than gains in the other areas.

Initial live weight of rams, which was fitted as a linear covariable, was significant (p<0.001) only for liveweight changes measured in the middle and at the end of the experiment. It did not show significant difference on total and average daily weight gains of the animals.

Table 2. Least squares means (± SE) of liveweight, total weight gain and average daily gain of rams as affected by treatment and location

Source		N	PWT (kg)	IMWT (kg)	FWT (kg)	TWG (kg)	ADG (g/day)
Overall mean		210	18.1	22.7	24.6	6.5	75.7
Treatment							
	Control	40	18.1(2.24)	20.6 ± 0.32^{a}	21.2 ± 0.42^{a}	3.1 ± 0.42^{a}	36.6 ± 4.94^{a}
	Supplemented	170	18.1(2.62)	23.0 ± 0.15^{b}	25.2 ± 0.20^{b}	7.1 ± 0.20^{b}	83.6 ± 2.41^{b}
Location							
	Badho	40	16.7(1.90)	23.6 ± 0.31^{d}	24.5 ± 0.41^{c}	6.3 ± 0.41^{c}	74.6 ± 4.87^{c}
	Jirenya	40	18.3(2.41)	20.3 ± 0.33^{a}	22.5 ± 0.44^{ab}	4.4 ± 0.44^{ab}	51.7 ± 5.16^{ab}
	Lalo Hinne	72	18.9(2.26)	22.2 ± 0.24^{c}	23.4 ± 0.32^{ab}	5.2 ± 0.32^{ab}	61.7 ± 3.81^{ab}

Qajela	26	17.4(2.06)	21.1±0.41[ab]	22.2±0.55[a]	4.1±0.55[a]	48.0±6.48[a]
Qawwisa	32	18.3(3.50)	21.7±0.38[bc]	23.6±0.50[bc]	5.5±0.50[bc]	64.5±5.90[bc]

N=number of observations; other acronym as indicated earlier

Results from partial budget and Marginal rate of return (MRR) analysis are presented in Table 3. The partial budget analysis indicated that yearling Horro lambs finished for 84 days with 400g/hd/day of maize and Noug cake was found to give an average net return of Birr 40.24. Solomon *et al*. (1993) from on-station study reported a net return of Birr 21.0 per head for 120 days feeding period using yearling Horro rams. At the time the on station study was done price of maize was very high relative to selling price of sheep and selling price per unit liveweight was assumed to be the same as purchasing price at the beginning of the finishing period. Informal observation of market price shows that finished animals with good condition fetch much higher price per unit liveweight than unfinished lambs. To determine what the farmers can expect to gain, on the average, in return for their investment when they decide to change from the usual practice to the new practice, MRR was used. MRR indicated that the change from the first practice to the second practice was found to increase net return by 58.0%. This shows that Birr 1 invested on finishing of yearling Horro rams could cover the investment cost and result in a return of Birr 0.58.

Table 3. Partial budget and marginal rate of return analysis

Variable	Treatments	
	Control	Supplemented
Purchase price (Birr/animal)	93.50	96.80
Average final liveweight (kg)	21.20	25.20
Adjusted final liveweight (kg)	20.95	24.99
Selling price (Birr/head)	98.13	159.54
Additional variable costs (Birr)		
Maize grain	0.0	16.20
Noug cake	0.0	6.30
Total variable cost (Birr)	0.0	22.50
Net return per head (Birr)	4.63	40.24
Marginal Rate of Return (MRR) (%)	158.27	

N.B.: Assumptions: a) MAAR (Minimum Acceptable Rate of Return)=50%, b) Adjusted weight by 1%

c) Maize price per 100kg= 90 Birr, d) Noug cake price per 100kg=35 Birr

Changes in price of input and out put are likely to occur any time in the future. Therefore to evaluate the effect of these changes on the profitability of the technology sensitivity analysis was done (Table 4). Sensitivity analysis confirmed that if input and output price changes by 10.0%, either separately or jointly, fattening yearling Horro lambs for 90 days will remain profitable, and result in a net return ranging from Birr 38.24 to 69.0. The current recommendation holds true to the extent the increase in noug cake and maize price is not more than 33% and the decrease in sheep price is not more than 20.0%. In the previous study conducted by Solomon *et al.* (1991) sensitivity analysis indicated that fattening yearling Horro rams was profitable when input price is not increased above 70.0% and sheep price does not decrease by more than 28.0%.

Though the weight gain difference between finished and control lambs is only 4 kg, the selling price difference is very wide amounting to 61.4 birr. This is a result of good body condition possessed by finished lambs as opposed to control lambs. Selling price per kg of liveweight was estimated to be Birr 6.33 for finished lambs while it was only Birr 4.63 for control lambs. Solomon *et al*. (1993b), who conducted a 133 days feeding trail using Adal goats, reported a significantly higher price per kilogram of body weight (amounting to an extra Birr 4.97 per each castrated goat) in the absence significant differences in body weights or between castrated and entire males. They attributed the price difference to the improved dressing percentage, which is actually related to improved body condition. Shapiro *et al* (1994) have also observed that consumers are willing to pay considerably, higher prices per kg live weight for sheep with high body weight.

Table 4. Sensitivity analysis of price of input and output in a 90 days fattening under different feeding levels

Variable (input/output)	Net return (Birr/head)	
	Control	Supplemented
a) Input price increases by 10%	4.63	38.24
b) Output price decreases by 10%	-ve	24.29
c) Both a and b, at a time	-ve	15.69

Conclusion

From the results of the current study, it can be said in areas where noug cake and maize grain are available at required time and quantity and reasonable price, finishing of yearling Horro rams with noug cake and ground maize at a level of 400g/head/day for about 3 months is highly profitable. To make the margin higher, however, it is imperative to consider strategic time of fattening. Furthermore, sheep fattening is very sensitive to the price of input (maize grain and noug cake). Hence, as maize and noug cake price is relatively low during harvest, fattening yearling Horro rams would be more advantageous if it starts immediately after harvest. The fattening programme should also coincide with socio-cultural and religious ceremonies when demand for sheep is high and selling price is also high. One limitation to the adoption of the technology could be acquisition of feed for the small number of lambs each farmer is finishing. Formation of co-operatives among farmers or increased scale of production by individual farmers could be considered as likely solutions. Informal observations based on opinion of farmers have shown that farmers are highly attracted to the technology. However it appears that farmers lack the finance required to undertake the finishing activity. Therefore provision of adequate credit is fundamental to adoption of the technology by the smallholder farmers. Extension work to popularise the technology should also get the attention of development workers. Marketing information with regard to price of different categories of sheep (e.g. price for different condition, weight or size) would be of much help to make decision with regard to adoption of the current finishing technology or similar other technologies.

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Growth performance of Horro lambs supplemented with different levels of wilted Leucaena (*Leucaena Pallida*) leaf

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Abstract

This study was conducted at Bako Agricultural Research Center to investigate the effect of different levels of wilted Leucaena (Leucaena pallida) leaf supplements on growth performance of lambs for a period of three month (10/12/03 to 10/03/04). Forty-eight, 4-month old, Horro rams from sheep research unit of the center was used for the experiment. The treatments were 150g/h/d ground maize + Rhodes grass (Chloris gayana) hay adlib (T1), 272g/h/d wilted Leucaena pallida leaf + T1 (T2), 410g/h/d wilted Leucaena pallida leaf + T1 (T3) and 150g/h/d noug cake + T1 (T4). Body weight of lambs was recorded fortnightly. Treatment has significantly (at least at $p < 0.05$) affected the fortnightly body weight, final body weight, total weight gain and average daily gain while initial body weight has significantly ($p<0.001$) affected only fortnightly and final body weight. In the current study, final body weight, total weight gain and average daily gain were superior for lambs in T3 and T4. Lambs fed on Rhodes grass hay supplemented with 150g/h/d ground maize alone was found to lose body weight at Bako condition. From the results obtained it can be suggested that wilted Leucaena pallida leaf can be used as an alternative protein supplement to smallholder small ruminant producers in the rural areas which have little or no access to conventional protein supplements.

Key words: Growth, Horro lambs, *Leucaena pallida and Noug cake*.

Introduction

Maximization of livestock productivity in the tropical regions largely depends on the efficiency of utilization of local protein sources (Seyoum et al., 1996). Protein supplementation may affect dry matter intake through its effect on digestion in the rumen (Adeneye and Oyenuga, 1976). Several experiments with sheep and goats have shown that performance can be improved by protein supplementation (Mtenga and Nyaky, 1985; Mtenga and Kitally, 1990). Noug cake is one of the most important and commonly used protein supplements in the western region of the country. Nevertheless, it is expensive and frequently not readily available to farmers due to the fact that small-scale oil extracting industries are only found in urban areas.

Leguminous multipurpose trees and forages such as Leucaena offer the best alternative cheap source of protein supplement. *Leucaena pallida* can be easily established and grows at a faster rate. It holds the most potential for introduction to waste lands, roadsides, community lands and farm boundaries. Leucaena leaf hay or fresh leaf can form a good source of protein supplement, but fresh leaf of Leucaena may contain high anti-quality components, which reduce the quality of feed consumed. Wilting has the advantage of reducing anti-quality components. Therefore, this study was conducted to investigate the effect of different levels of wilted *Leucaena pallida* leaf supplements on growth performance of Horro lambs.

Materials and methods

The study was conducted at Bako Agricultural Research Center that is located at about 250 km west of Addis Ababa. It is situated at an altitude of 1650m asl (9^o 06'North and 37^o 09'East).

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Bako has a hot and humid climate and receives a mean annual rainfall of about 1219mm, of which more than 80% is recorded in the months of May to September. Mean monthly minimum and maximum temperatures are about 14^0C and 28^0C, respectively, with an average monthly temperature of 21^0C. The daily mean minimum and maximum temperatures are 9.4^OC and 31.1^OC, respectively.

Forty-eight, 4-months old Horro rams obtained from the sheep research unit of Bako Agricultural Research Center were assigned to four treatments. Stratified random procedure was followed on the basis of their body weight and type of birth. The treatments were 150g/h/d ground maize + Rhodes grass (*Chloris gayana*) hay *ad lib* (T1), 272g/h/d wilted *Leucaena pallida* leaf + T1 (T2), 410g/h/d wilted *Leucaena pallida* leaf + T1 (T3) and 150g/h/d noug cake + T1 (T4).

Leucaena pallida was established previously in the center for experimental purpose. *Leucaena pallida* leaf was harvested and wilted for two hours in the sun, and then given to lambs everyday throughout the experimental period.

Animals were kept in-door and fed their respective treatment for a period of three months. Water was provided *ad lib* twice a day (at 9.00a.m in the morning and 3.00p.m in the afternoon). Feeds offered and refused were recorded daily. The animals were weighed at the beginning of the experiment and fortnightly there after until the end of the trial.

The General Linear Model Procedures of the Statistical Analysis System (SAS, 1996) was used in the analysis of the data. Initial body weight of the animals was fitted as a linear covariable during analysis.

Results and Discussion

In this experiment except few days at the beginning all the supplementary feeds (wilted *Leucaena pallida* leaf and other concentrate) offered to lambs were consumed without refusal.

Of a total of 48 lambs assigned to the experiment only 41 lambs survived to the end. 4, 0, 2 and 1 lamb from T1, T2, T3 and T4, respectively, died during the experiment. The death of the animals could not be attributed to treatment effect because of the absence of any detectable symptoms, which can be traced to wilted *Leucaena Pallida* leaf feeding, or other treatments. Alinson et al (1990; as cited by Akingbade et al., 2001) reported that absence of any detectable adverse effects on the health of animals assigned to Leucaena treatment and non-incidence of symptoms of mimosine toxicity throughout a feeding trial on goats. In the current study either the level of Leucaena supplement is below a threshold level at which toxicity symptoms couldn't appear or the sheep may have ruminal microorganism, which could detoxify mimosine and its toxic metabolite (2-3-DHP and 3,4-DHP).

Analysis of variance and least squares means (±SE) of fortnightly and final body weight, total weight gain and average daily gain were shown in Tables 1 and 2, respectively. Treatment has significantly (at least at $P < 0.05$) affected fortnightly and, final body weight, total weight gain and average daily gain, while initial body weight has significantly ($P<0.001$) affected only fortnightly body weight and final body weight. This justifies inclusion of initial weight in the model as a covariate. Lambs assigned to T4 and T3 gave significantly higher body weight compared to lambs assigned to T2 and T1.

Growth performance of lambs was significantly different between treatments through out the experimental period, but no significant difference was observed between T3 and T4. The higher body weight gain of lambs assigned to T3 and T4 might be due to high level of protein supplementation. In agreement to this study Van Eys et al (1986) reported that supplementation with tree legume foliage improved goat growth rates at ages from four month to ten month. It was also reported that supplementation of tree legume foliage has raised growth and survival rates of lambs up to 24 weeks (Reynolds and Adediran, 1988; as cited by Reynolds, L. 1990).

Lambs assigned to T1 and T2 were not significantly different in growth performance in the first two and half month of experimental period. But, lambs assigned to T2 were significantly higher in final body weight, total weight gain and average daily gain as compared to T1. This might be due to the wilted *Leucaena pallida* leaf (protein source) supplementation. Jones and Jones (1984) reported that inclusion of Leucaena in sub-tropical pastures gave better animal weight gains in beef cattle.

Lambs assigned to T1 (control) lost an average of 3g/h/d body weight indicating that they couldn't maintain their body weight on Rhodes grass hay supplemented with small quantity of ground maize alone at Bako conditions. Rhodes grass has low protein content. Thus it is essential to supplement protein sources to optimize rumen fermentation of the grass and to maintain body weight of growing lambs. Lemma (1993) who used the same sheep breed reported that an average growth rate of lambs supplemented with Leucaena (80g/day), Sirato (67g/day) and Desmodium Uncinatum cv Silver leaf (50g/day) to Tef straw basal diet. Van Eys et al (1986) reported that roughage diets must be supplemented with feeds of higher nutritive value if animal growth and reproduction are to be improved.

In the current study, total weight gain of lambs was positive and higher in T4 and T3, but negative in T1. Total weight gain and average daily gain of lambs had increased either with increasing level of wilted *Leucaena pallida* leaf supplementation or supplementation of protein source concentrate (noug cake) in the diet. No significant (P>0.05) difference was observed between lambs assigned to T3 and T4 both in total weight gain and average daily gain. This could indicate the possibility of using leaf of wilted *Leucaena pallida* at a level of 410g/h/d instead of using 150g/h/d noug cake in concentrate supplementation composed of 49.5% ground maize, 49.5% noug cake (Guzotia abyssinica) and 1% common salt. Lemma and Alemu (1991) reported that growth rates of supplemented lambs increased approximately linearly from 45 to 64 g/day on Leucaena gradually replaced noug cake as the source of crude protein in the supplement.

Conclusion

Lambs fed on Rhodes grass hay supplemented with 150g/h/d ground maize alone was found to lose body weight at Bako condition. In the current study, higher level of wilted *Leucaena pallida* leaf (410g/h/d) and 150g/h/d ground maize or maize-noug cake supplementation at a level of 300g/h/d resulted in an increased final body weight, total weight gain and average daily gain. From the results obtained it can be suggested that wilted *Leucaena pallida* leaf might be used as an alternative protein supplement to smallholder sheep producers in the rural areas which have little or no access to conventional protein supplements such as noug cake.

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Table 1. Analysis of variance and level of significance of fortnightly body weight, final body weight, total weight gain and daily weight gain as affected by treatment feed and initial body weight.

Sources	DF	Mean squares and significance levels for body weight:

		Wt1	Wt2	Wt3	Wt4	Wt5	Wt6	TG	ADG
Trt	3	2.04 *	13.55 ***	14.31 **	17.76 **	28.38 **	33.31 ***	33.31 ***	0.005 ***
Iwt	1	420.38 ***	379.55 ***	359.94 ***	436.96 ***	446.63 ***	373.50 ***	0.92	0.00013
R^2 (%)		95.00	87.00	81.60	80.60	77.40	75.00	41.30	41.30
CV (%)		5.10	8.20	9.77	10.37	11.19	11.46	80. 32	80.32
EMS		0.74	1.26	1.52	1.74	1.99	1.99	1.99	0.024

Trt= treatment; IWt= initial body weight; EMS=error mean squares; TG = total weight gain; ADG = average daily gain; *=p<0.05; **= p<0.01; ***=p<0.001.

Table 2. Least squares means (±SE) of fortnightly body weight, final body weight, total weight gain and daily weight gain of Horro lambs as affected by feeding treatments.

Source	Overall mean	Treatment 1	Treatment 2	Treatment 3	Treatment 4
N		8	12	10	11
IWt	14.88	15.50 (3.0)	15.25 (3.4)	14.25 (3.0)	14.59 (2.5)
Wt1 (Kg)	14.74	14. 20 ± 0.22a	14.70 ± 0. 22ab	15. 02 ± 0.22b	15.14 ± 0.22b
Wt2 (Kg)	15. 34	13. 81 ± 0.36a	15. 56 ± 0.37ab	16. 05 ± 0.40b	16.14 ± 0. 38b
Wt3 (Kg)	15. 53	14. 20 ± 0.46a	15. 05 ± 0.44ab	16. 35 ± 0.48bc	16. 66 ± 0.46c
Wt4 (Kg)	16. 81	15.13 ± 0.53a	16.57 ± 0. 51ab	17.74 ± 0.55b	17. 89 ± 0.53b
Wt5 (Kg)	17. 85	15. 91 ± 0.71a	16. 90 ± 0.58ab	18. 37 ± 0.64bc	19.83 ± 0.61c
Wt6 (Kg)	17. 35	14.66 ± 0.71a	16. 86 ± 0.58b	18.16 ± 0.63bc	19.12± 0.60c
Total gain (Kg)	2.48	-0.22 ± 0.71a	1.98 ± 0.58b	3.28 ± 0.63bc	4.24 ± 0.60c
Daily wt gain (Kg)	0.03	-0.003 ± 0.01a	0.024 ± 0.01b	0.04 ± 0.01bc	0.05 ± 0.01c

Different letters in rows denote significant differences between effects. N= no of animals, IWt, Wt1, Wt2, Wt3, Wt4, Wt5 and Wt6 were weight taken at beginning, 15 days, 1 month, 1and half month, 2 month, 2 and half month and 3 month beginning of the experiment, respectively.

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ANIMAL REPRODUCTION

Effect of addition of Phytase Enzyme on apparent nutrient digestibility and retention on maize based diets of Broilers

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Abstract

A study was conducted to evaluate the role of phytase-2500 enzyme on the digestibility and retentions of nutrients of broilers fed on maize based diets. Seventy-two New Hampshire broiler chicks were used and distributed randomly into four different treatment groups using Complete Randomize Design (CRD) with three replicates of six chicks each. Phytase enzyme at the levels of 0(T_1), 200 (T_2), 400 (T_3) and 600 (T_4) Units/kg diet were added. Results of the analysis of variance revealed that the supplementation of broiler diet with phytase enzyme significantly improved the body weight gain (905.87 to 1078.51 gm), reduced average feed intake (2656.99 to 2021.53 gm) and improved the feed conversion efficiency (2.94 to 1.87).In addition, the analysis of variance revealed that the supplementation of broiler diet with phytase enzyme improved both the apparent nutrient digestibility and retention on maize based diets. Hence, in this study it is possible to conclude that the addition of phytase-2500 enzyme up to 400 Unit/kg broiler ration could improve the availability of important nutrients to the broiler production in countries where phytase production is going on.

Key words: Digestibility, enzyme, nutrients, poultry, retention

Introduction

In poultry feed, there are anti-nutritional factors that hinder the availability, digestibility, absorption and utilization of nutrients. These are grouped as those having depressive effect on digestion of protein, carbohydrate, utilization of minerals and vitamins. Of these, phytic acid is ubiquitous in plant-derived feeds and is available in the form of in phytate (Lange *et al.,* 2000). It is estimated that 70-80% of the total cost in commercial poultry production is allotted for feed. The factors that adversely influence the utilization of feed would have a substantial effect on the total cost of broiler production. Pretreatment of poultry feeds with exogenous phytase enzyme increases the bioavailability of phytate phosphorus, improves the nutritional status of the feed and in addition, contributes to combat environmental pollution Bedford (2000). Addition of enzymes in poultry feeds improves nutrient utilization, feed intake, feed efficiency and provides flexibility in least cost feed formulation. Therefore, this study was proposed to examine the influence of phytase-2500 enzyme on the digestibility, retention and utilization of nutrients in broiler diets.

Material and Methods

Study site

The investigation was conducted at the Poultry Research Center (PRC) of G. B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal from 17 January 2002 to 11 March 2002.

Procurement of chicks and their management

A total of seventy-two, New Hampshire breed broiler chicks were obtained from the Poultry Research Center. The chicks were wing band numbered, individually weighed and distributed randomly into twelve pens of six chicks in each pen. The chicks were housed on raised wire mesh floors in the brooder house. The chicks had having free access to light for 24 hrs. Feed and water were given *ad libitum* throughout the experimental period. Individual body weight and feed consumption of chicks for each pen were recorded on weekly basis.

Preparation of experimental diets

The broiler starter feed (Table 1) was purchased from Uttar Pradesh Agro Industrial Corporation, Moradabad. Phytase-2500 enzyme, which was procured from Varsha multi tech, Bangalore, was added to the feed at the levels of 0 (T1), 200 (T2), 400 (T3) and 600 (T4) Units (U) per kg of the diet and uniformly mixed. A unit of phytase is defined as the quantity of enzyme which releases 1 µmol of inorganic orthophosphate per min. from 5.1 mM sodium phytate at pH 5.5 and 37 ^{O}C (Engelen *et al*., 1994).

Table 1.The composition of the experimental diet *****

Ingredients	Percent
Maize	42
Deoiled soybean meal	22
Deoiled rice bran	12
Rice polish	10
Jwala fish	7
Mineral mixture	1
Lime stone	3
Molasses	3
	100.00

Feed additives provided per 100kg diet: Vitamin AB_2D_3K, 10 gm; Vitamin B- complex, 20 g Neftin-200, 50 gm; other vitamins, 200 gm; Check 'O' Tox, 200 gm; Liveroline, 100 gm and Meridot, 50 gm.

Balance trial

A metabolic trial was conducted at the end of the growth experiment to find out the retention, digestibility and utilization of protein, phosphorus, calcium, and energy on maize based diets of broilers. Two birds from each dietary treatment were randomly picked up and transferred to cages having wire mesh floor.

A known quantity of the experimental diets was given to the chicks in the morning hour. Faecal trays along with polythene sheets were placed for the collection of excreta. Samples from poultry excreta after mixing well were collected in wide mouth glass stopper bottles for estimation of the dry matter and nitrogen contents and stored in a refrigerator. Samples for nitrogen estimation were preserved in 5% sulfuric acid (W/V). For dry matter estimation, 10ml of 2% acetic acid was added in the excreta (Gupta *et al*., 1992). Both Feed and excreta samples were dried at 80 ^{o}C to constant weight. Representative samples were taken for the determination of dry matter, nitrogen, phosphorus, calcium, gross energy and phytate-phosphorus contents.

Chemical analysis

The dry matter and crude protein contents of the experimental feeds and poultry excreta were analyzed according to AOAC (1990) procedures. Acid insoluble ash was determined after ashing the samples and treating the ash with hydrochloric acid (1:1, v/v). Phosphorus contents were analyzed calorimetrically after digestion of the sample with hydrochloric acid according to the methods of Gupta *et al*. (1992). Gross energy was determined using the chromic oxide method (O'

Shea and Maguir, 1962), Phytate-phosphorus using the method of Haugh and Lantzsch (1983) and calcium with the help of GBC Avanta 1.33 version Atomic Absorption Spectrophotometer.

Apparent nutrient digestibility

The apparent nutrient digestibility coefficients for calcium, phosphorus and crude protein were calculated using the following formula and acid insoluble ash as the indigestible marker (Ravindran *et al*., 2000).

$$\text{Apparent nutrient digestibility} = \frac{\left(\frac{\text{NT}}{\text{AIA}}\right)_d - \left(\frac{NT}{AIA}\right)_i}{\left(\frac{NT}{AIA}\right)_d}$$

Where,

$(NT/AIA)_d$ =Ratio of nutrient and acid insoluble ash in the diet

$(NT/AIA)_i$ = Ratio of nutrient and acid insoluble ash in faeces

Statistical analysis*:* The experiment was conducted in Complete Randomize Design (CRD) with four treatments comprising four phytase levels, each replicated three times The data obtained was statistically analyzed using MSTAT-C computer software (1989) and mean separation for those treatments for testing the significance of mean difference was done by using Duncan's multiple range tests (Duncan, 1955).

Results and Discussion

Body weight gain

The effects of various levels of supplementation of phytase enzyme on body weight gain of broilers at the end of seven weeks of the experimental period are presented in Table 2. The results of body weight gain revealed that there were significant differences between the treatment groups due to the addition of various levels of phytase enzyme. It is clear that T_3, which had 400 U of phytase/kg of the diet, had highest weight gain (1078.51 gm). These values were significantly ($P<0.01$) higher than all other treatments; T_2 showed the second highest value (1021.32 gm) followed by T_4 (959.66 gm) and least in T_1 (905.87 gm) where no phytase was added. It indicated that there was an increase in mobilization of nutrients due to phytase enzyme supplementation.

These results indicated that phytase-2500 enzyme exerted growth promoting effect on broiler chicks at 400 U of phytase added in the ration. In contrast Arun and Dewgoda (1997) reported non-significant differences in live weight gains in broiler chickens due to enzyme supplementation. These findings are in agreement with previous works done by Cabahug *et al.* (1999) who observed that there were little benefits in performance responses due to the addition of phytase enzyme beyond 400 FTU per kg diet. On the other hand, Kornegay *et al.* (1996) found that on maize soybean meal and semi purified soybean meal diets where responses to phytase enzyme reached a plateau were 600 to 700 FTU/kg diet.

Feed intake

The mean values with statistical analysis for feed consumption by the birds during the course of this investigation are presented in Table 2. The supplementation of phytase enzyme in showed a clear-cut effect on feed intake. At all age group birds in T_1 consumed highest amount of feed followed by T_2, T_4 and T_3. The values differed significantly (P<0.01) among each other. Feed intake was least for birds in T_3 (2021.53 gm) followed by those in T_4 (2076.61 gm), T_2 (2339.53 gm) and T_1 (2656.99 gm). However, Yi *et al.* (1996) indicated that the addition of supplemental phytase at the levels 350, 700, 1050 U/kg of soybean or corn meal increased feed intake from 6 to 25 %.

Feed efficiency

The calculated values of feed conversion efficiency (feed: gain) of broilers in this experiment are presented in Table 2. It is obvious that the best-feed conversion efficiency could be recorded in T_3 throughout the experiment. This treatment had 400 U of phytase/kg of diet. The values of feed efficiency also showed significant (P<0.01) differences among each other. The values of feed efficiency were noted as 2.94 (T_1), 2.30 (T_2), 1.87 (T_3) and 2.17 (T_4). Supplementing piglet diets with 1500 U phytase activity per kg feed significantly improved the feed conversion efficiency from 1.65 to 1.52 (Jongbloed et al., 1993).

Table 2. Effect of various levels of supplemental phytase enzyme on broiler performance at the end of the seventh week

Phytase level (U/kg diet)	Body weight gain (gm/bird)	Feed intake (gm/bird)	Feed conversion efficiency
0	905.87^{d}	2656.99^{a}	2.94^{a}
200	1021.32^{b}	2339.51^{b}	2.30^{b}
400	1078.51^{a}	2021.53^{d}	1.87^{d}
600	959.66^{c}	2076.61^{c}	2.17^{c}
Mean	991.34	2273.66	2.32
SE±	2.89	2.27	0.02
LSD	15.13^{**}	11.89^{**}	0.09^{**}

Values with different superscript within a column differ significantly at 1 %(**))

The apparent nutrient digestibility coefficients for some nutrients in broiler chicks fed on phytase-supplemented maize based basal diets are presented in Table 3.

Crude protein: The feeding of phytase supplemented diet for broiler chicks improved (P<0.05) the apparent digestibility of crude protein. However, increasing the levels of supplemental phytase in the diet did not show beneficial effect as compared with the control and the lower levels of phytase added in the ration. Addition of dietary phytase enzyme at the level of 600 U/kg diet rather resulted in a significant depression in crude protein digestibility (28.04%). Whereas, the addition of 200 U of phytase in the diet increased the average protein digestibility from 33.76% (T_1) to 53.44% (T_2) while increasing the level to 400U numerically reduced protein digestibility to 52.94 %.

These results suggested that the addition of supplemental phytase enzyme over 200 U /kg feed led to no further improvement as far as protein digestibility was concerned. Yi et al. (1996) indicated that the addition of 750 U of phytase/kg of corn-soybean meal increased nitrogen and amino acid digestibility in turkey poults. Similarly, it was reported by Kemme et al. (1995) using growing pigs fed on a corn-soybean meal with the addition of 900 U of phytase /kg diet. On the other hand, Ketaren et.al (1993) found that the addition of phytase to the diet of young pigs increased protein deposition and retention but had no effect on crude protein digestibility.

Calcium and phosphorus: The apparent calcium digestibility was increased numerically with increasing the supplemental phytase level up to 400 U in broilers diet, in which the response was increased little with further inclusion. The maximum improvement in calcium digestibility was in T_3 (80.77%) followed by T_4 (69.49%) and T_2 (68.34%) while the minimum calcium digestibility was in the control group (54.97%).

Although, the apparent phosphorus digestibility decreased numerically with increasing the addition of phytase enzyme above 400 U per kg of broiler chicks' diet, the difference in average phosphorus digestibility were not statistically significant ($P<0.05$) between all the three levels of inclusion. However, the supplementation of phytase enzyme significantly ($P<0.05$) improved P digestibility irrespective of the level of inclusion compared with the control diet. Mingan (1997) revealed that supplementing pig diets with 500 U of phytase activity/kg feed increased the digestibility of phosphorus from 44.2 to 52.4% and calcium 44.2 to 51.7%.

Table 3. Apparent nutrient digestibility coefficients (%) of crude protein, calcium and phosphorus in broilers fed on phytase-supplemented diet

Phytase level (U/kg diet)	Crude protein (%)	Ca (%)	P (%)
0	33.76ab	54.97^{b}	29.04^{b}
200	53.44^{a}	68.34^{ab}	52.07^{a}
400	52.94a	80.77^{a}	52.61^{a}
600	28.04^{b}	69.49^{ab}	48.63^{a}
Mean	42.05	68.40	45.59
SEM±	6.58	5.71	3.86
LSD	22.76^{*}	19.77^{*}	13.37^{*}

Values with different superscript within a column differ significantly at 5 %(*)

Gross energy: Significantly higher levels of energy retention was observed for birds in T_2 (34.99%), followed by T_3 (30.01%), T_4 (26.19%) and T_1 (19.99%) in that order. The statistical analysis showed no significant difference between T_3 and T_4 whereas the value of gross energy retention was the lowest in the control group.

Crude Protein: Results on retention of crude protein (Table 4) revealed that phytase levels positively influenced protein utilization when compared with the control. Protein retention increased with increase in phytase level up to 400 U and then decreased at 600 U, even though there were no significant differences between the values obtained at 200, 400 and 600 U. The lowest level of protein absorption was found in the control group. On the other hand, chicks fed diet without phytase enzyme showed a decrease in values of protein utilization. In summary, phytase supplementation increased protein intake, decreased the amount of protein in the excreta, reduced the moisture content of the excreta and as a result, improved the rate of utilization of nitrogen. Although, inclusion of phytase beyond 400 U resulted in little improvement in protein retention similar findings have been reported from studies on broilers (Sazzad et al., 1995) and laying hens (Van der Klis and Versteegh, 1991).

Calcium and phosphorus: The effect of phytase supplementation on the utilization of calcium and phosphorus by broiler chicks are shown in Table 4. Phytase supplementation increased the intake of Ca and P ($P< 0.05$). Dietary phytase improved the utilization of Ca and P and this must have resulted in the increased concentrations of Ca and P in the bones of the tibia and the toe. There was also notable reduction in Ca and P in the excreta. It was reported that supplemental phytase improved Ca availability and increased retention on turkey Poults (Qian et al., 1996) and broilers (Schoner et al., 1991).

Although, there was an increase in the retention of Ca with Phytase level, no significant differences were noted between T_2, T_3 and T_4. Similar trends were also observed in phosphorus retention except at 400 U of phytase, in which case the highest level of retention was recorded. The retention of Ca and P were poor when no phytase were added in the diet of chicks. This confirms the findings of Simon et al (1990) who showed that in 3-week old broilers, the dietary phosphorus availability was increased by 65% due to the supplementation of microbial enzyme and as a consequence, phosphorus excretion was reduced by 50 %. The values for retention of Ca and P recorded in this experiment generally indicated that the addition of phytase enzyme in the diet of broiler chicks improved of both Ca and P utilization.

Table 4. Effect of various levels of supplemental phytase enzyme on nutrient retention on broilers

Phytase level (U/kg diet)	Gross energy (%)	Crude protein %	Ca (%)	P (%)	Phytate-P (%)
0	19.99^{c}	50.16^{b}	27.58^{b}	30.88^{b}	0.38
200	34.99^{a}	71.45^{a}	56.74^{a}	53.10^{a}	0.19
400	30.01^{b}	73.00^{a}	61.96^{a}	64.80^{a}	0.14
600	26.19^{b}	66.76^{a}	61.96^{a}	53.17^{a}	0.25
Mean	27.80	65.35	52.06	50.49	0.29
SE±	0.84	2.36	6.65	4.68	-
LSD	4.38**	12.38**	23.01*	16.20*	-

Values with different superscript within a column differ significantly at 1%(**), 5%(*)

Summary and recommendation

The main ingredients of poultry diet are derived from plant origin, which contain significant amounts of phosphorus in the form of phytic acid. Phytic acid has a high chelating potential, combine with cations and protein in the digestive tract of monogastric animals such as chickens to form insoluble complexes. Simple stomached animals cannot utilize these complexes unless phytate is hydrolyzed by phytase, which is limited in monogastric animals. Phytase is an enzyme that hydrolyses phytate to inositol and inorganic phosphate. The present study was undertaken to evaluate the role of phytase-2500 enzyme on the digestibility and retentions of nutrients of broilers fed on maize based diets as affected by various levels (0, 200, 400, 600 Units/kg diet) of phytase enzyme. Hence, it is possible to summarize as follows:

- The biological studies showed that phytase supplementation to maize basal diet significantly improved the growth performance of broiler chickens as confirmed by increased body weight grain, reduced feed intake and improved feed conversion efficiency. For instance, at the end of the experimental period, the body weight gain of broiler chicks increased by 115.4 gm (T_2), 172.64 gm (T_3) and 53.79 gm (T_4). Moreover, the feed intake of broiler chicks was reduced by 317.48 gm (T_2), 615.46 gm (T_3), and 560.38 gm (T_4) as compared with phytase unsupplemented group. As a consequence, the feed conversion efficiency of broiler chicks fed phytase-supplemented diet improved from 2.94 in T_1 to 1.87 in T_3 at end of the experiment.
- The results of this investigation revealed that there were significant improvements in apparent crude protein, calcium and phosphorus digestibility. Beneficial effects of the inclusion of dietary phytase enzyme on apparent crude protein digestibility were noted at 400 U of phytase/kg broiler diet.
- The role of phytase enzyme on nutrient retention was also assessed. It can be summarized that little improvement in protein retention by broiler chicks was recorded due to the addition of phytase beyond 400 U/kg diet. In general, the results of the present study indicated that the addition of phytase in maize based ration improved the availability of nutrients such as crude protein, calcium and phosphorus and reduced the excretion of nutrients in poultry excreta.

Therefore, the results of the present study showed that phytic acid is a potent anti-nutritional factor that depressed the performance of broilers. It also demonstrated that the adverse effects of phytic acid could be partially overcome by supplemental phytase. Addition of phytase improved the growth, reduced feed intake and improved feed conversion efficiency of broiler chicks fed maize based diet. Moreover, there was little benefit from the addition of phytase beyond 400 U/kg diet. Further study should also be focused on the evaluation of the role of phytase enzyme on different strains, sex and age groups.

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Liveweight changes and serum progesterone concentration in post partum Horro cows in sub-humid environment in Ethiopia

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Abstract

An experiment was conducted on 20 cows (10 in the dry and 10 in wet seasons) between February 2001 and January 2002 at Bako Agricultural Research Center, Ethiopia, with the overall objectives of determining liveweight changes and serum progesterone profile of post-partum Horro cows. Data were analyzed using the General Linear Model (GLM) Procedures of SAS (SAS, 1994). Cows that calved during the dry season lost more weight compared to cows that calved during wet season (Figure 1). From the total number of cows that calved during the dry season only 20% of them became pregnant within 90 days post-partum, compared to 60% for cows that calved during the wet season. The mean serum progesterone (dry and wet season) concentration was 6.1ng/ml and it was significantly ($p<0.01$) affected by season of calving and the cows body weight at calving. The mean progesterone level obtained during the wet season (May to September) was higher (8.5±0.8ng/ml) as compared to that of the dry season (October to April)(2.8±0.92ng/ml).

Key words: Liveweight changes, serum progesterone, post partum, Ethiopia

Introduction

The economic efficiency of livestock production is mainly determined by the reproductive performance of the individual herds. The efficient production of meat and milk, therefore, depends first and for most upon successful reproduction. Maintaining a high reproductive rate is a major prerequisite for profitable livestock production. A high calving rate is thus the key to success. This determines the number of cattle born and raised and animals that must be retained to replace those animals lost from the breeding herd due to death or old age and those available for sale (Warweck and Legates, 1979). The reproductive efficiency of an individual can vary considerably from parturition to parturition, due to the hereditary predisposition and subjective influence of environmental conditions (Sane *et. al.*, 1982). Fertility in cattle is also affected by disease and managerial factors. The fertility of zebu in Ethiopia is generally low, particularly in animals raised under traditional less desirable management practices (Mukasa-Mugurwa, 1989). Loss in body weight in early lactation is often associated with a decline in the reproductive efficiency, primarily stemming from delay in the resumption of ovarian activity and lowered conception rate. Cows losing weight around the time of mating are less likely to conceive than cows gaining weight (Kaltenbateh and Dunn, 1980). Seasonality in the quality and quantity of fodder is closely related to the animals' performance and intake and digestibility of the feed.

Determination of serum progesterone concentration has been found to have practical application as a method of improving reproduction efficiency in farm animals. Serum progesterone levels have been measured for the purpose of pregnancy diagnosis in cattle (Heap *et. al.*, 1973). Normally, progesterone is a hormone produced in the ovary of the cow following ovulation and fertilization and can be detected in milk and blood serum samples. Maternal heat stress

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conditions could result in lower level of serum progesterone, abnormal pattern of progesterone secretion, a shorter corpus luteum life span (Bekana, 1997) higher oestrogen levels in the pre-ovulatory phase and a higher increase of ovulation without behavioral sign of oestrus (Berman, 1991). The objectives of this study were thus, to investigate seasonal fluctuation of live weight of post partum cows and subsequent fertility and seasonal patterns of progesterone profile.

Materials and Methods

Location of the study

This study was under taken in Ethiopia at the Bako Agricultural Research Center, located in the western part of the country, 250km from Addis Ababa at an altitude of 1650m, 73º 09′E longitude and 09º 6′N latitude. The center receives an average annual rainfall of 1300mm, more than 80 % of which falls between May and September (wet season). The average annual temperature ranges between 23.9˚c and 31.9˚c with a mean of 27.8˚c.The environment is hot and humid with a relative mean humidity of 60%.

Experimental animals

Twenty mature Horro (zebu) cows (average age of 5 years and body weight of 214kg) that had calved during the wet season (n=10) and the dry season (n=10) were used to study the post partum weight changes and serum progesterone concentrations.

Nutrition and management of experimental animals

The experimental cows that calved in the wet (n=10) and dry (n=10) seasons were maintained on natural pastures with out supplementation. These cows were housed in groups in a barn at night. The breeding system practiced at the center is continuous (year-round) mating. Both natural and artificial mating systems are used. Oestrous detection was done visually (06:00-08:00 and 17:00-18:00) by a trained inseminator and throughout the grazing time by the herd men.

Collection of blood sample and live weight measurement in post partum cows

Blood samples were collected from 20 cows, 10 of which calved during the wet season (May to September) and 10 during the dry season (October to April). The blood was collected weekly starting at 20 days post partum until 42 days, and thereafter every 14 days for a period of 120 days. The blood samples were taken by veni puncture (jugular vein) using an 18-gauge needle attached to a 7ml vacutainer blood collection tube with no anti clotting agent. Blood was allowed to clot in the vacutainer tubes for 30-45 minutes at room temperature. Serum was collected from each tube following centrifugation for 15 minutes at 2500 r.p.m. The serum was then separated and stored in vial at -20º C until assayed for serum progesterone concentration. The liveweight of the cows were recorded at calving and thereafter every 2 weeks for the entire observation period of 120 days.

The serum progesterone concentration assay

The serum progesterone concentration was assayed with the aid of an automated chemiluminescence's system (Chiron Diagnonistics ACS.180, USA). The system is based on competitive immunoassay technique using direct chemiluminescence's technology. Progesterone in the sample binds to an acridinium ester-labeled mouse monoclonal anti-progesterone antibody in the light reagent and the unbound antibody binds to a progesterone derivative covalently, coupled to paramagnetic particles in the solid phase. The amount of progesterone present in the sample is inversely related to the amount of relative light units detected by the system. The ACS: 180 progesterone assay measures progesterone concentrations up to 60ng/ml with the minimum detectable concentration of 0.11ng/ml. The analytical sensitivity is defined as the concentration of serum progesterone that corresponds to the relative light units (RLU's) of 20 replicate determination of the progesterone zero standards.

Statistical Analysis

General linear model (GLM) procedures of SAS (SAS, 1994) were used to analyze the data. To analyze post partum body weight changes and serum progesterone concentration in cows, the independent variable used in the model was the season of calving, which include the wet (May to September) and dry (October to April).

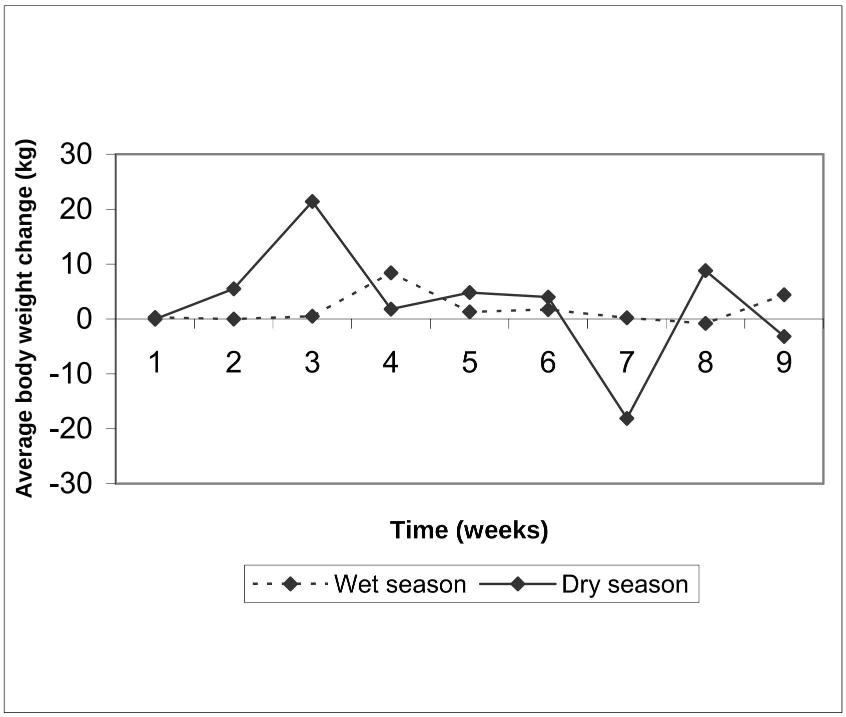

Figure 1. Liveweight changes of post-partum Horro cows in wet and dry seasons

Results and Discussion

Liveweight change

Live weight changes in post partum cows are set out in (Figure 1). Cows calved during the dry season lost more weight compared to those calved in the wet season. Cows calved during the wet season tended to better maintain their body weight through out the post partum period except week 7. Out of the total number of cows calved during the dry season, 50% did not show oestrus by 90 days post partum compared to 20% in the wet season. Of the total number of cows calved during the dry season, only 20% became pregnant with in 90 days post partum compared to 60% in the wet season. The season of parturition with its variable has been reported to significantly affect dam weight (Hetzel *et al.*, 1989; Dionisio, 1989). The reproductive performance in extensive tropical breeding systems as experienced in Ethiopia is often very low and usually associated with deficiencies in forage quality and availability. A practical method of monitoring the herds nutritional status is evaluated body weight changes of the animal (Schwalbach, 1997; Hetzel *et al*., 1989).

In this study cows calved during the dry (summer) season lost more weight compared to cows calved in the wet season. This was expected, as during the dry season the natural pastures are limited in quantitative and qualitative terms. Cows calved in the wet season (May to September in the cause of Bako Research Center) maintain their body weight constant except week 7. These findings could be explained by a higher nutritional content of the pasture during the rainy season. Cows calved during the dry season generally lost more weight and take longer time to recover and resume oestrus activity.

Post partum serum progesterone concentration in Horro cows

Determination of the serum progesterone concentration has been found to have practical application as a method of improving reproduction efficiency in farm animals so for example, serum progesterone levels have been measured for the purpose of pregnancy diagnosis in cattle (Heap *et al*., 1973). Kaul and Prakash (1994) reported the accuracy of pregnancy diagnosis in zebu and crossbred cattle by milk progesterone determination (day 20 to 24) in positive pregnancy diagnosis to be 91% and in negative pregnancy diagnosis to be 100%. Normally progesterone is a hormone produced in the cow following ovulation and fertilization and can be detected in milk or blood serum samples. As the serum progesterone profile follows a specific pattern it is possible to take blood /serum sample of a cow and predict when the next oestrus period is likely to occur and thus determine the best time to inseminate the cow. A low progesterone level on the day of insemination gives a good indication whether the cow was in oestrus and subsequent level should rise and remain high during pregnancy. Material heat stress condition could also result in lower level of serum progesterone abnormal patterns of progesterone secretions, a short corpus luteum life span, higher oestrogen levels in the pre-ovulatory phase and a higher increase of ovulation without behavioral signs of oestrus (Berma, 1991).

In this study, an overall serum progesterone concentration of 6.1ng/ml was recorded for the observation period and this was significantly ($p<0.01$) affected by the season when the blood was sampled. Serum progesterone level during the wet season was higher

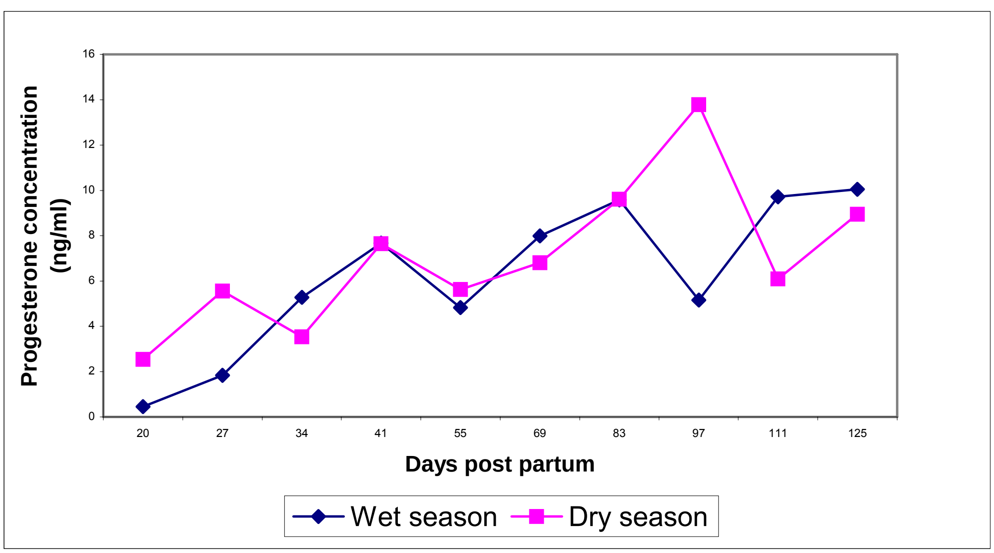

Figure 2. Serum progesterone profile of post partum Horro cows calving during wet and dry season

In this study, an overall serum progesterone concentration of 6.1ng/ml was recorded and it was significantly ($p < 0.01$) affected by season when the blood was sampled. Serum progesterone level was higher during the wet season (8.5±0.8ng/ml) than those collected during the dry season (2.8±0.92ng/ml). The low serum progesterone level recorded during the dry season was similar to those obtained by Berma (1991). These values are also in agreement with those reported by Dawuda *et al.* (1988) who also found that heat stress alters serum progesterone patterns in the post partum cows. Heat was also considered by Camothe-Zavaleta *et al.* (1991) to be responsible for increased secretion of adrenocortocotropin, which stimulates the secretion of progesterone from the adrenal glands.

Conclusion and recommendation

This study demonstrated that if higher reproductive performance is to be attained mating should be restricted to the dry season (October to April) and cows should give birth during the wet season when feed resources are readily available. Little information is available regarding the hormonal profile of Horro cows and heifers. Thus, detailed study of the hormonal profile is recommended.

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Effect of season and supplementation on libido of Horro (zebu) bulls in sub humid environment at Bako research center in Ethiopia

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Abstract

A total of 16 mature Horro (zebu) bulls average age of 6 years and body weight of 211kg were used in this study. Eight of the bulls were supplemented and eight were used as control. The bulls were tested every 14 days with the aid of teaser cows in which oestrus had been induced. Each bull to be tested was released in a pen of 10m by 20m for a period of 5 minutes with a cow in oestrus. Supplementation had no evident effect on libido recorded, but a seasonal trend was detected in both groups. Libido in this study was significantly (p<0.01) and positively correlated with scrotal circumference (r=0.1). A significant (p<0.01) correlation was recorded between bull libido score and bull body weight (r=0.27). The correlation between libido score and semen concentration was also significant (p<0.01) and positive (r=0.17).

Key words: Horro bulls, humid environment, libido, season, supplementation

Introduction

Libido can be defined as the sex drive or in other words, the eagerness of a bull to mate a cow. In male, testosterone is responsible for libido and for the development of the male secondary sex characteristics. Libido is largely under hormonal control of testosterone secreted by the cell of leyding in the testis. Libido can practically be measured by measuring the reaction time, the time interval between consecutive mating; in other words the duration of the recovery phase and the number of mating per unit time of the mating frequency. In practice libido is measured by the number of cows mated by a bull in a given period of time (Panwar and Nagpaul, 1989; Byerley *et al.*, 1990, Price and Wallach, 1990). Libido can be influenced by genetic factors, climate, season, level of nutrition, age and sexual experience, neural stimuli and physical factors (Osborne *et al.,* 1971; Crichton *et al.*, 1987). Chenoweth (1981) reviewed the use and value of libido tests and the influence of environmental and genetic factors on libido. The field studies of Farin *et al.* (1989) and others validate the predictive ability of the libido test for fertility. The test has also been used to demonstrate breed differences where *Bos indicus* bulls have been shown to have a lower libido than British or *Bos taurus* bulls (Chenoweth and Osborne, 1975). Differences in libido between *Bos indicus* and *Bos taurus* bulls are well documented. Crichton (1986), Jacobi (1989) and Maree *et al.* (1989) claimed zebu bulls to exhibit a marked sexual sluggishness or a tendency only to mount cows in a full oestrus. This suggest that zebu or *Bos indicus* bulls are more sensitive to the oestrus stimuli of teaser females compared to *Bos taurus* bulls. Bonsma (1980), however, claimed that under tropical heat stress, indigenous sanga bulls have a higher libido than *Bos taurus* bulls. In a study by Henney *et al.* (1990) it was reported that bulls with low libido tended to have a higher ratio of oestradiol to testosterone in the blood compared to those with high libido. Prolactin and cortisol concentrations in the blood increased during ejaculation. Pathak *et al.* (1990) recorded the reaction time to be longer in younger than in older bulls. Sharma *et al.* (1994) reported that in sexually mature bulls, libido score was significantly correlated to the progressive sperm motility, semen fructose and citric acid

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contents. Thus, this study was intended to see the libido of Horro (zebu) bulls in sub humid environmental conditions of Bako research center.

Material and method

Location of the study

This study was under taken in Ethiopia at the Bako Agricultural research center located in the western part of the country 250km from Addis Ababa at an altitude of 1650m, 37° 09'E longitude and 09° 6'N latitude. The center receives an average annual rainfall of 1300mm more than 80% of which falls between May and September (wet season). The average annual temperature ranges between 23.9°c and 31.9°c with a mean of 27.8°c. The environment is hot and humid with a relative mean humidity of 60%.

Animals

A total of 16 bulls, 8 supplemented and 8 control, were used in the libido test. Bulls were tested every 14 days with the aid of teaser cows. The teaser cows used to test bull libido were adult Horro cows in which oestrus had been induced by subcutaneous injection of 4mg estradiol clipionate ECP™ (Pharmacia and Upjohn®). Cows were administered at 2ml sterile solution 3 days prior to the test. Each bull to be tested was released in a pen of 10m by 20m for a period of 5 minutes with a cow in oestrus. Observers stayed at a distance and did not interfere while the animals were being tested. The behavior of each bull was observed and scored according to the system described by Osborne *et al*. (1971) and recommended by the Australian Veterinary Association for the examination of bulls.

The 16 bulls used for this study were randomly divided in to two groups of 8 animals each. One group was given a concentrate supplementation at a rate of 1.5kg/bull/day. The concentrate supplement composed of ground maize, oil cake meal (*Guizotia abssynica*), bone meal and blood meal and in order that it consisted about 20% crude protein.

The supplementation was given early in the morning (07.00) before the bulls went out to graze. The second group served as the control (no supplement). During the day the bulls were maintained on natural pasture, for approximately 8 hours per day (08:00 to 17:00). The bulls were housed in individual pens at night.

Experimental period

The experiment started in February 2001 and was terminated in January 2002 a total observation period 50 weeks.

Experimental diet

The experimental diet (concentrate) was made up of 49% ground maize 49% oil cake meal 1% common salt 1% bone meal and this contains about 20% crude protein.

The scoring system was:

0 = No sexual interest within 5 minutes

1 = Some interest but no attempt to mount within 5 minutes

2 = Mounted or attempted to mount within 5 minutes

3 = Mounted or attempted to mount more than once but did not complete a service within 5 minutes

4 = Mounted and completed one service within 5 minutes

Statistical analysis

Repeated measure analysis of variance procedure of SAS (SAS, 1994) was used to analyze the data.

Result and Discussion

The libido score are set out in Table 1. Supplementation had no evident effect on the libido recorded, but a seasonal trend was detected in both groups as is evident in Figure1. Bull libido in this study was significantly ($p<0.01$) and positively correlated with scrotal circumference ($r = 0.1$). A significant ($p<0.01$) correlation was also recorded between bull libido score and bull body weight ($r = 0.27$). The correlation between libido score and semen concentration was also significant ($p < 0.01$) and positive ($r = 0.17$). The time (week) when the libido tests were performed had a significant effect on bull libido. This is in agreement with the finding of Crichton *et al.* (1987) who reported season of the year to influence libido in bulls. Weekly variation in libido score was also recorded with no obvious effect of nutrition on libido being observed during the current study. This is in agreement with Mwansa and Makarechian (1991) who studied the effect of post weaning dietary energy level on sex drive of beef bulls and found that libido score was not affected by the feeding regime. Salisbary and Van Demark (1961) reported that libido is to be mainly under hormonal control of testosterone secreted by the cells of Leyding in the testis.

Table 1. Least squares means (±SE) libido score in Horro bulls over a 50-week period

Week	Mean (± SE) supplemented bulls	Mean (± SE) non-supplemented bulls
0	2.7 ± 0.3	2.0 ± 0.4
2	2.1 ± 0.5	2.2 ± 0.6
4	2.6 ± 0.5	2.4 ± 0.5
6	2.4 ± 0.5	1.42 ± 0.5
8	1.8 ± 0.4	1.7 ± 0.5
10	2.1 ± 0.4	1.8 ± 0.5
12	2.3 ± 0.3	2.9 ± 0.4
14	3.2 ± 0.3	3.6 ± 0.3
16	3.8 ± 0.2	3.6 ± 0.2
18	3.9 ± 0.1	3.8 ± 0.2
20	3.6 ± 0.2	3.7 ± 0.2
22	3.6 ± 0.2	3.9 ± 0.2
24	3.7 ± 0.2	3.7 ± 0.2
26	3.2 ± 0.2	2.7 ± 0.3
28	2.6 ± 0.2	1.6 ± 0.2
30	1.8 ± 0.2	1.4 ± 0.2
32	1.8 ± 0.2	1.7 ± 0.3
34	2.3 ± 0.3	2.1 ± 0.4
36	2.9 ± 0.2	2.5 ± 0.3
38	3.3 ± 0.2	2.9 ± 0.3
40	3.0 ± 0.3	2.9 ± 0.3
42	3.3 ± 0.3	3.3 ± 0.3
44	3.2 ± 0.3	3.0 ± 0.3
46	1.5 ± 0.3	2.0 ± 0.3
48	3.0 ± 0.3	2.2 ± 0.4
50	2.3 ± 0.3	1.7 ± 0.3

Chenoweth (1981) reviewed the use and value of libido tests and the environmental and genetic influences on libido. Other studies conducted by Farin *et.al.* (1989) also validated the predictive ability of libido test for fertility. The test has also been used to demonstrate breed difference where *Bos indicus* bulls showed to have a lower libido than British bulls (Chenoweth and

Osborne, 1975). A lack of significant differences in libido between the two groups (supplemented or control) is in agreement with the findings of Mwansa and Makarechian (1991), who reported that libido score was not affected by the feeding regime in young beef bulls. The libido score in the present study (scale = 0 to 5) in 5 minutes tests is comparable with the findings of Nwakalor and Ezinma (1989) (scale = 0 to 10) in Muturu and N'Dama beef bulls and who reported the libido score to average 3.6 ± 0.0 and 6.7 ± 0.4, respectively.

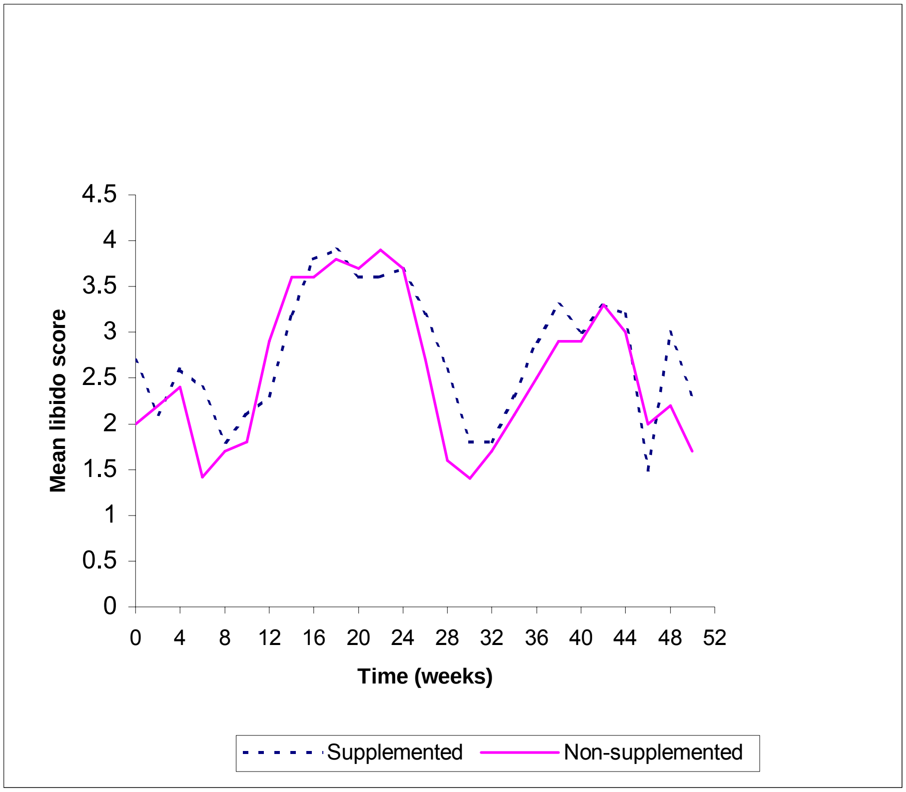

Figure 1. Mean libido score in supplemented and non-supplemented Horro bulls over a 50 week period

In this study, the low libido score recorded may be attributed to the hot and humid climatic conditions of the study site. Price and Wallach (1990) reported the method of housing to have an effect on bull libido in that individually housed bulls exhibited fewer mounts and spent less time with females than group housed bulls. In the current study, the bulls were housed individually and this could have contributed to the low libido score obtained in both the supplemented and non-supplemented groups.

Conclusion and recommendation

This study was conducted using older bulls (6 years of age). Pathak *et al.* (1990) recorded the reaction time to be longer in younger than in older bulls. Thus, further studies on libido using different age groups are recommended. It is also recommended that libido should be studied in relation to semen, testicular characteristics and testosterone level. A20 minute libido test is normally recommended for tropical bulls (zebu types). The short time used might have contributed for the lower libido score in this study (5 minutes test). Thus, allocation of appropriate time is warranted in the future study.

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Computer Assisted Semen Analyser Motion Characteristics of fresh and post thawed Spermatozoa in Sahiwal bulls

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Abstract

The study was conducted on 12 Sahiwal bulls, which is one of the best dairy breeds of Zebu cattle of Indian subcontinent, with the overall objective of evaluating the bulls using computer technology for the motion characteristics of spermatozoa. The bulls were grouped into two age groups (AGI, age<50 months and AGII, age>50 months) and two scrotal circumferences groups (SCGI, SC<33 cm and SCGII, SC>33 cm). Though there are many methods of evaluating bulls for fertility there is no single sure test for selection of the best performing and fertile bulls especially at an early age. In this study Computer Assisted Semen Analyser (CASA), the modern tool of evaluating motion characteristics of spermatozoa was used. Results of the study revealed that in most of the cases bulls with larger testicular size performed better than bulls with smaller testicular size indicating the possibility of selecting bulls at an early age based on testis size especially using that of SC and cull bulls with smaller testis and save the many labour and time which other wise spent on rearing such inferior bulls.

Key words: Sahiwal bulls, spermatozoa, evaluation, Computer Assisted Semen Analyser

Introduction

The Sahiwal, one of the best dairy breeds of Zebu cattle of Indian subcontinent, has its origin in Montgomery district of Pakistan and is distributed in farmer's herds in certain pockets of bordering districts of Punjab and Rajasthan in India. It is available at organized farms in North, North Western and Central India. The importance of this breed is evident from the fact that Sahiwal animals have been imported by countries, like Kenya, Tanzania, Australia, West Indies and Bangladesh either for crossbreeding with their local breeds or for incorporating some Zebu genes in crossbred animals for developing synthetic strains, like, Jamaica Hope, Australian milking zebu and Australian Friesian Sahiwal besides Mpwapwa and Pabna crosses (Joshi, 2001).

Hence, undertaking further evaluation, selection and propagation of superior germplasm as well as re-establishing the herds of Sahiwal cattle, being one of the most important indigenous milk breeds, is one of utmost importance. Attempts made to evolve an accurate and objective test for assessing the potential fertility of a bull on the basis of some specific characteristics of a given semen sample have not been successful (Raja and Rao, 1983). The consensus of opinion prevailed was that a combination of semen characteristics will serve the purpose of a single sure test to select bulls of high fertility from a mixed farm.

Computer Assisted Semen Analyser (CASA) is a recent tool for evaluating semen more precisely and objectively. It provides an opportunity to assess the sperm movements in terms of various velocities, and amplitudes quantitatively, more precisely, rapidly and accurately, and is the objective measurement of progressive sperm motility characteristic. So CASA allows investigators to objectively assess motility characteristics of semen cell from an individual male. Methodologies for application of this technique in clinical evaluation have been described for spermatozoa of human, bull and stallion (Mohaney et al., 1988). System for Computer Assisted

Semen Analysis of sperm motility can be utilized for analysis of various characteristics of sperm movement. Motility characteristics generated by CASA have been used to predict fertility. Further a significant correlation has been observed for sperm motility and velocity with non-return rates. The current study was initiated with the overall objective of evaluating breeding bulls based on different motion characteristics of spermatozoa under CASA.

Materials and methods

Location: The study was carried out at Artificial Breeding Complex, National Dairy Research Institute, Karnal during January to May 15, 2002. The farm is situated at an altitude of 250 m above the mean sea level on 29.42 ^{0} N latitude and 77.42^{0} E longitude. The climate of the farm is sub-tropical nature. The range of atmospheric temperature varies from near freezing point (0 ^{o}c) in winter months to about 45 ^{o}c in summer months. The average annual rainfall is approximately 760 mm to 960 mm, which is received mostly during months of July to August. Relative humidity varies from as low as 41 % to as high as 85 %.

Animals and Semen Collection: Semen samples (180) were collected, from 12 sahiwal bulls, in the morning hours between 8:00 -9:00 AM by using teaser bull. The bulls were thoroughly washed, cleaned and dried at least 15-30 minutes before collection. One collection a weak with two consecutive ejaculates were taken from those bulls currently donating semen, using Danish Model standard Artificial Vagina (AV) (14 inches). The temperature of AV was maintained between 45-47 ^{o}c with sufficient pressure and lubrication. The semen was kept in water bath maintained at 31 ^{o}c and was evaluated for physical attributes and fertility parameters within one hour after collection and the important seminal attributes for all the bulls were recorded. After the subjective assessment of sperm for progressive motility, the fresh semen samples were subjected to CASA. A drop of diluted semen was placed on the clean grease-free slide maintained at 37 ^{o}c with the help of warm stage and covered with a cover slip. The slide was observed at 20X magnification and phase 1 (P1) combination under Olympus phase contrast microscope attached to CASA system. For post-thaw examination of frozen semen, cryopreservation of semen was done using the semen samples having mass activity 3.5 and above which was frozen as per the procedure followed in the Artificial Breeding Complex of National Dairy Research Institute, Karnal. The method followed was as given below.

Glycerolisation: For the freezing purpose, the diluent was divided in to two parts (Part A and Part B). Both parts were kept at 30 ^{o}c. Part A was mixed with semen and part B was mixed with glycerol at the rate of 7 % of total diluent. Both the parts A and B were cooled from 30 ^{o}c to 5 ^{o}c by keeping it in cold cabinet. When both parts reached 5 ^{o}c, they were mixed together. The straws were sealed with polyvinyl alcohol powder.

Equilibration Time: The sealed straws were kept in water bath at 5 ^{o}c for 4 hours to avoid cold shock. After completion of equilibration time the straws were taken out of the water bath and dried with pre-cooled filter paper and were placed horizontally in freezing rack. The rack along with straws was kept in the liquid nitrogen vapor for 10 minutes.

Storage: The straws were transferred in the goblets with the help of pre-cooled forceps and the goblets were stored in separate canisters in the liquid nitrogen (LN_2) in cryovessel. Cryovessel were always kept 3/4th full by replenishing liquid nitrogen, under -196 ^{0}c.

Thawing And Examination of Frozen Semen: Post thaw motility of spermatozoa was examined using subjective judgment and CASA motion parameters, at interval of 0 h and 24 h after freezing. The straws immediately after removing from the liquid nitrogen were placed in water bath at 37 ^{o}c for 11 second. After picking-up the straws from water bath, outer surface was made dry and then lab seal of the straw was cut and then thawed semen was poured in to a test tube for examination.

A Computer Assisted Semen Analyser (CASA) ("Cell track/s", Automated Sperm Analysis, Santa Rosa, Ca., 1994) was used to determine various motility parameters; *viz* Percent Motility, Straight-line speed, Curvilinear velocity, Mean linearity, Amplitude of lateral head displacement, and Velocity of the Average path. A brief description of CASA motion parameters is given below.

Percent Motility (MOT %): The number of motile cells divided by the number of cells analyzed, expressed as a percent. Here, for every analysis, a total of 200 cells were analyzed. A cell was considered motile if its average straight-line speed (VSL) met or exceeded the minimum motile speed parameter.

Straight Line Speed (VSL): This has been adapted from the manual method of calculating the speed of a cell or group of cells. It is a measure of the cell's foreword progression and is computed by multiplying the curvilinear velocity (VCL) times the mean linearity (divided by 100). This measure is computed as the average for all motile cells.

Curvilinear Velocity (VCL): This is computed as the average scalar velocity (or speed) for all motile paths. It is calculated by computing the total distance traveled along each path and dividing by the time interval. The population VCL is computed only for motile cells (these with an average VSL > threshold speed), and is achieved by averaging the mean values from each individual cell.

Mean Linearity (LIN): The distance a cell travels along its normal (or un-smoothed) path is referred to as its gross displacement. The straight-line distance from its straight point to its current X-Y position (as the crow flies) is referred to as net displacement. The ratio of these two measures (time 100) is the linearity measure. It is evaluated at the end of each of the motile paths, and all of the motile path values are averaged to form the single number for the report. A cell that swam in a straight line has a value of 100; a cell that had just completed a circle had an instantaneous value of zero.

Lateral Head Displacement (ALH): For each cell, the distance between the actual curvilinear path and the smoothed (or average) path is computed. These values are sometimes referred to as RISERS. This measure computed twice the maximum value of the RISER for each motile path, and then computed as the average value of all of the individual maxima as the single value to include in the report.

Velocity of the Average Path (VAP): This measure is the mean value of the average or smoothed path. This parameter is used to characterise the overall trajectory of the sperm cell. It is concluded that VAP is less dependent on sampling rate.

Statistical Analysis

Data were analysed using the General Linear Model of SYSTAT 0.7 (1997). Scrotal circumference (SC) and age groups were fitted as fixed effect in the model. The bulls were classified based on the breed average for the characters under study. Accordingly, two SC group SCG I= SC< 33.00cm and SCG II=SC > 33 cm and two age group, AG I = age < 50 months and AG II = age > 50 months were used in the analysis.

Results and discussions

CASA Motion Parameters in Fresh Semen

Percent Motility (MOT %)

The average percent motility along with standard error estimated by Computer Assisted Semen Analyser (CASA) of fresh semen from bulls belonging to different age and scrotal circumference (SC) groups was 78.49± 17.27 %. The least square means ± SE of MOT % for age and SC groups are presented in Table 1. Percent motility was not significantly different either in age or SC groups. As evident from the table, the trend showed higher percent motility, MOT % in the matured bulls (AGII). Similar reports were available in literature (Gokcen et al. 1991). Lower average values than the current study (65.22%) was also reported in Sahiwal bulls (Keshava, 1996). Generally reports are available with in the range of 39.4 (Frieswal) to 86.2 % (HF) of motility in CASA.

Straight Line Speed (VSL μ/Sec)

Least square means ± SE of straight-line speed for age and SC groups are presented in Table 1. The average VSL for the breed was 28.54± 8.28 μ/sec. There was no significant variation in straight-line speed between age and SC groups. Keshava (1996) observed similar trends in KF bulls and slightly higher values for the same breed of bulls.

Curvilinear Velocity (VCL μ/sec)

The average curvilinear velocity was 106.32± 26.52 μ/sec in Sahiwal bulls. The least square means ± SE for age and SC group are presented in Table 1. Perusal of the results revealed non-significant variation in age and SC groups. The present results were in agreement with the report of Keshava (1996) on different breeds of dairy bulls.

Mean Linearity (LIN %)

The least squares mean ± SE for age and SC groups variation in mean linearity percent are depicted in Table 1. Age and SC group variation in mean linearity was found to be significant ($P<0.05$). The general trend was the improvement in linearity with advancement of age and increase in SC in the breed. Linearity of spermatozoa, which was reported to have strong correlation with non-return rate, is the main interest of this study.

Amplitude of Lateral Head Displacement (ALH μ)

The overall mean Amplitude of Lateral Head Displacement was 6.48±1.14 μ. The increase in ALH with increasing age and testis size does not reach statistically significant level (Table 1). Keshava (1996) reported higher values than the current study for Indian dairy bulls.

Velocity of Average Path (VAP μ/sec)

The average value of Velocity of Average Path was 61.62 ± 15.07μ/sec in Sahiwal bulls. Keshava (1996) reported similar result (62.28 μ/sec) for the same breed of bulls, but lower than the current value (50.22 μ/sec) in Karan Fries bulls.

CASA Motion Parameters in Frozen Semen

Percent Motility (MOT %)

The average post thaw percent motility was 69.62± 14.23 at 0 hr after freezing and 65.61± 11.13 at 24 hrs after freezing. Similar reports were available in literature (Keshava, 1996) on different breeds of cattle and buffaloes. Raina (1999) reported lower values (with in range 43.00±6.25 to 62.57±4.59) than the current results using different freezing rates in buffalo semen. The least square means ± SE for age and SC group are presented in Table 2 and 3. There was no significant difference in post thaw motility at 0 hr, either in age or SC groups. But after 24 hrs the post thaw motility showed significant ($P< 0.01$) differences in age group, indicating the importance of age in freezability of spermatozoa.

Straight Line Speed (VSL μ/sec.)

The overall mean of straight-line velocity (μ/sec) was 28.75±12.04 at 0 hr after freezing and 30.24±10.52 at 24 hr after freezing in Sahiwal bulls. Similarly, Keshava (1996) reported 25.95 ± 0.68 in Karan Fries bulls. The present results, for Sahiwal bulls, was in the range of values 26.76 ± 1.58 to 33.74± 2.10 reported for straight line velocity of post thaw buffalo spermatozoa frozen at various freezing rates using different nucleation in tris egg yolk (TEY) extender (Raina, 1999). The least square means ± SE of VSL for age and SC groups are presented in Tables 2 and 3. The differences in VSL either in AG or SCG of post thaw frozen semen did not reach statistically significant level.

Curvilinear Velocity (VCL μ/sec)

The average VCL (μ/sec) was 92.08±6.32 at 0 hr after freezing and 90.91±5.12 after 24 hrs of freezing in Sahiwal bulls. Raina (1999) reported a range of 92.90±8.59 to 126.67± 9.21 for VCL in post-thawed buffalo spermatozoa frozen at various freezing rates. Keshava (1996) reported also similar result (87.10 ±4.08) in Karan Fries bulls. The least squares means ± SE of VCL for age and SC group are presented in Tables 2 and 3. The least square analysis of variance could not reveal any significant differences in VCL.

Linearity (LIN %)

The overall mean linearity was 33.74±2.22 percent at 0 hr after freezing and 34.82±1.52 percent after 24 hrs of freezing in Sahiwal bulls. The current result was with in the range of (23.87±2.12 to 34.74± 3.31) linearity of post-thawed buffalo spermatozoa frozen at various freezing rates (Raina, 1999). Also Keshava (1996) reported similar result (34.48±2.48) in KF bulls. The least squares means ± SE for age and SC groups are presented in Tables 2 and 3. The difference in linearity of spermatozoa in post-thawed frozen semen was statistically significant in both Age and SC groups. It shows increases in linearity of spermatozoa with advancement of age and with increase in size of scrotal circumstance.

Amplitude of Lateral Head Displacement (ALH)

The mean averages of ALH μ for post-thawed frozen semen were 5.68 ± 0.40 at 0 hr after freezing and 5.88±0.92 at 24 hr after freezing in Sahiwal bulls. Higher values than in the current study have been reported (Keshava, 1996; Raina, 1999). The difference in ALH in either the age or SC groups of post thaw frozen semen did not reach statistically significant level.

Velocity of Average Path (VAPμ/sec)

Overall average values of VAP (μ/sec) for post-thawed frozen semen were 58.29±13.85 at 0 hr after freezing and 56.58± 9.26 at 24 hr after freezing in Sahiwal bulls. Similarly, Keshava (1996) reported 52.03± 1.93 in Karan Fries bulls. However, the current results were in the lower margins of the range of (58.82±3.03 to 73.32 ± 5.12) VAP values of post-thawed buffalo spermatozoa frozen at various freezing rates using different nucleation in tris egg yolk (TEY) extender (Raina, 1999).

Conclusions

Seminal attributes were evaluated in two age groups and two SC groups using CASA. Motion characteristics of CASA, especially, linearity of spermatozoa that was reported to have strong correlation with non-return rate, showed significant improvement with larger SC group and with advancement of age, indicating the need of inclusion of this parameter in routine evaluation of bulls, and the probability of culling bulls based on testicular size, especially at an early age with out spending money, labor and time on rearing of such inferior bulls.

Table 1. Least squares means ± SE of CASA parameters in fresh semen of Sahiwal bulls by age and SC group

Parameters	Age group		Scrotal circumference group	
	AG I	AG II	SC I	SC II
MOT (%)	77.12±2.85	79.49±2.83	77.12±2.85	82.10±2.10
VSL (μ/sec)	29.40±3.68	27.85±3.66	28.31±1.70	28.73±1.54
VCL(μ/sec)	107.94±4.92	104.88±4.89	112.26±6.86	101.01±2.96
LIN (%)	27.78±1.68 [a]	37.04±3.27 [b]	27.76±1.67 [a]	37.04±3.22[b]
ALH (μ)	6.36±0.37	6.56±0.37	6.34±0.37	6.58±0.35
VAP (μ/sec)	60.59±2.80	62.76±2.76	62.91±2.79	60.44±2.68

Table 2. Least squares means ± SE of CASA parameters in Frozen-thawed Sahiwal bulls semen

	Time interval			
Parameters	After freezing at 0 h		After freezing at 24 h	
	AG I	AG II	AG I	AG II
MOT (%)	70.83±3.36	66.70±3.94	76.40±3.07[a]	65.00±3.50 [b]
VSL (μ/sec)	24.60±3.68	30.41±3.34	25.20±4.36	32.18±2.91
VCL(μ/sec)	94.45±5.66	90.72±3.07	74.90±15.31	97.06±2.74
LIN (%)	26.98±6.41[a]	40.64±5.40[b]	28.86±6.38[a]	41.20±4.67[b]
ALH (μ)	5.28±0.47	5.83±0.38	4.94±0.70	6.24±0.33
VAP (μ/sec)	58.26±6.00	58.30±3.64	53.22±6.67	54.86±1.75

Table 3. Least squares means ± SE of CASA parameters in Frozen thawed Sahiwal bulls semen

	Time interval			
Parameters	After freezing at 0 h		After freezing at 24 h	
	SC I	SC II	SC I	SC II
MOT (%)	66.56±4.04	67.56±3.78	63.30±3.07	65.12±3.50
VSL (μ/sec)	24.18±4.48	30.18±3.13	2 5.20±4.36	31.17±2.91
VCL(μ/sec)	94.48±6.86	91.32±2.94	73.90±15.31	95.02±2.73
LIN (%)	28.40±7.65 [a]	39.34±5.22 [b]	28.86±6.38 [a]	40.20±4.65[b]
ALH (μ)	5.22±0.57	5.81±0.36	4.85±0.71	6.24±0.33
VAP (μ/sec)	54.72±5.93	59.40±3.56	53.22±6.67	57.86±1.77

*Within age or SC group row values bearing different superscripts are statistically significant

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Animal Nutrition and Feed Resources

Economics of different supplement options to teff straw for fattening arsi oxen

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Abstract

Economic analysis of used oxen fattening on different teff straw based supplements was undertaken at Adami Tulu Agricultural Research Center. The rations were 1) teff straw alone (R1), 2) teff straw supplemented with 2 kg noug cake (R2), 3) teff straw supplemented with 1.5 kg maize grain and 73 g urea and 4) teff straw supplemented with 1 kg noug cake and 1 kg molasses (R4). From the analysis, the group of animals fed on R2 gave the highest average net return (344 ETB/animal) and the highest Annual Financial Rate of Return (AFRR) (200 %) followed by the group of animals fed on R4 that had given an average net return of 309 ETB/animal and AFRR of 166 %. Nearly, 70 % of the gross return was due to the change in price of the animal over the fattening period and 20 % was due to the weight change because of nutrition. The rest 10 % of the gross return was due the interaction effect of the price change and the live weight change of the animals.

Key words: Teff straw, supplement, used oxen, economic analysis.

Introduction

Ethiopia is an agrarian country with 7-10 million hectares of land under cultivation (Alemu, 1997). The tilling of more than 90 % of this land is undertaken by the aid of animal power, of which oxen power plays the major role. In the central rift valley of Ethiopia, the only animal used for plowing is ox. Because of poor feeding, medication, and other management problems, an ox can serve for limited number of years. After an ox gets tired, farmers replace it with young ones mostly from the stock owned (Semion et al., 1997) or by purchasing from the local market.

In Ethiopia, there are about 7-8 million oxen (Alemu, 1997). These animals after their plowing life expire due to several reasons they will be sold or slaughtered as they are or after fattened. The ox, when a farmer decides to change it, is emaciated and can fetch very small amount of money, if marketed directly or very poor quality and quantity meat, if slaughtered. To get better income and/or meat yield from a poor conditioned ox, farmers feed it on different crop residues and by-products of agro-industry and home made beverages, and household wastes. Crop residues such as teff, barley and wheat straws, and maize stover, and supplements like atela, noug cake, molasses, linseed cake, cottonseed cake, maize grain and wheat bran are among the most important sources of feeds in Ethiopia. The price of these feed resources are dependent on the availability.

In Ethiopia, many feeding trials were undertaken to improve the body condition and marketability of livestock. The drawbacks of these studies were the exclusion of the economic analyses in the majority of the works. This has very much affected the adoption of the technologies. Now days it is well understood that the increment in biological yield alone cannot improve the prevailing economic situation of the end users. Thus, this study was undertaken to examine the economics of supplement option to teff straw for fattening used Arsi oxen.

Methodology

The data for this study were collected from a fattening experiment undertaken using 24 used Arsi oxen purchased from the local market around Adami Tulu Agricultural Research Center. The animals were drenched and dipped against endo and ecto parasites. Then after the animals were grouped into four and the groups were randomly assigned to feed on one of the four diets. The diets were: (1) teff straw alone (R1), (2) teff straw supplemented with 2 kg noug cake (R2), (3) teff straw supplemented with 1.5 kg maize grain and 73 g urea (R3) and (4) teff straw supplemented with 1 kg noug cake and 1 kg molasses (R4). The fattening was undertaken for 90 days from May to July. Data on labour, feed intake and change in live weight were recorded. Inputs used for fattening and items used for the estimation of the value of the by-product (dung) and their prevailing price are given in Appendix 1. Body condition was scored at the beginning and end of experimental period. For this purpose a guide prepared by **Nicholson** *et al.,* (1986) was employed.

A group of people was formed to estimate the prices of the finished animals. The estimation was done after surveying the surrounding livestock market. The value of the by-product (dung) was estimated based on the estimates obtained from literatures. According to Senait (1997), an ox gives 10 kg of dung per day and one tone of dung contain about 8 kg N, 4 kg P_2O_5 and 16 kg K_2O (Simeon *et*, *al*, 1997). One tropical livestock unit (TLU) can produce 100 to 140g N per day depending on feed intake, feed type and season (Smith *et al.,* 1997 quoting Schlecht *et al.,* 1995). Depending on the estimates given above, the yield of N from the dung was assumed to be 140 g per day per TLU. The prevailing market prices of chemical fertilizers (Urea and DAP) during the experimental period were used to estimate the value of N obtained from dung. The cost of depreciation of barn and utensils were not included in this study because of the unavailability of the data required for the estimation.

Financial analysis was done to determine profitability of fattening of poor conditioned used Arsi oxen on teff straw based diets. Gross margin was calculated to examine the profitability of fattening of the animals on different rations. To examine the rate of return to fattening on annual basis, the Annual Finance Rate of Return (AFRR) to fattening was calculated using formulae:

AFRR = [(R-C)/C)*(365/t)]*100, (Baur *et, al.,* 1989) Where, R = revenue from selling of the animal, C = purchase and other variable costs; and t = number of days the animals fed.

The AFRR to feeding is thus revenue less purchase cost of the animal and other variable costs, multiplied by the number of days in the year the animal was fed.

The gross margin was further decomposed into its different components (price, weight and their interaction) in order to examine the relative contribution of the components in the gross return. To disaggregate the gross margin into its components the following formulae used was

M = R-C,

Where, M = gross margin

C = cost of animal purchase

R as above

By definition,

$C = p_i \times w_i$

$R = p_f \times w_f$,

Where p = price per kg of live weight,

w = live weight in kg,

i = the beginning of the fattening period and

f = the end of the fattening period

$p_f = p_i + d(p)$ and $w_f = w_i + d(w)$

Where, d = change in p or w over the feeding period

Then, $M = d(P) \times w_i + d(w) \times p_i + d(p) \times d(w)$ dividing this equation by M and multiplying by 100 % gives:

$100\ \% = \{\%(d(p)*w_i) + \%(d(w)*p_i) + \%(d(p)*d(w))\}/M.$

Result

Financial analysis

The average net return, the difference between the average sale price of animals and all variable costs including the animal purchase cost, was ETB 129 for animals fed on R3 and ETB 344 for animals fed on R2. The animals fed on R4 gave average net return of ETB 309 whereas the animals kept on R1 incurred loss of about ETB 68. When the cost of animal purchase is excluded, the cost of feed comprised 70-85% of the sub total cost. The maximum feed cost (ETB 237) was incurred on R3 and minimum was (ETB 105) on R1. Among the supplemented groups, the animals fed on R2, the ration with medium cost (ETB 137), attained the highest total body weight gain (46.50 kg). However, the animals fed on R3, ration of the highest cost, attained lower total body weight gain (36 kg). The body weight gain was lowest for the group of animals fed on the cheapest feed (R1). The return to person-day labor used was lowest (ETB 20.75) from animals fed on R3 and highest (ETB 49) from the group of animals fed on R2. The same was negative from un-supplemented group and 45 from the group of animals fed on R4.

The price per kg of live weight had changed considerably for all supplemented groups. The percent change in price per kg live weight and change in body condition score were highest for group supplemented with noug cake (R2). The percent change in kg of live weight and the change in body condition score were 57.2 and 1.96, 41.2 and 1.5 and 56.7 and 1 for group of animals fed on R2, R3 and R4, respectively. For group of animals fed on R1 the percent change in price per kg live weight was 4.3 and the change in body condition score was zero.
For the calculation of AFRR the value of dung was not included for it could not be directly received by the fattener. From the supplemented groups the AFRR was highest (200.2 %) from the group of animals fed on R2 and lowest (63 %) for R3. Animals fed on R4 also gave AFRR of about 166 %.

Table 1. Result of financial analysis of fattening Arsi oxen with different rations

S. No.	I t e m s	Ration			
		R1	R2	R3	R4
1	Average purchase price (ETB)	596.67±36	516.67±25	556.67±25	576.67±28
2	Average live weight (kg) at purchase	228.50±7	210.17±7	212.67±11	235.17±12
3	Purchase price per kg of live weight	2.611	2.458	2.617	2.452
4	Operating costs				
	a. Feed	105.00	136.80	236.70	135.00
	b. Labor				
	c. Medicine	26.25	26.25	26.25	26.25
	Sub total	17.71	17.71	17.71	17.71
		148.96	180.76	280.66	178.96
5	Average Total cost	745.63	697.43	837.33	755.63
6	Average return				
	Average sale price	627.50±43	991.67±111	916.67±70	1014.67±84
	Value of dung	50.00	50.00	50.00	50.00
	Sub total	677.50	1041.67	966.67	1064.67
7	Average live weight (kg) at sale	230.50±6	256.67±10	248.67±12	264.00±13
8	Body weight gain (kg)	2.00	46.50	36.00	29.17
9	Sale price per kg of live weight	2.722	3.863	3.686	3.843
10	Average net return	-68.13	344.24	129.34	309.04
11	Return per person-day labor	-5.58	49.40	20.74	44.70

S. No.	I t e m s	Ration			
		R1	R2	R3	R4
12	Annual economic rate of return to fattening (AFRR, %)	-37.06	200.18	62.65	165.87
13	Change in price per kg of live weight (%)	4.25	57.15	41.23	56.72
14	Change in body condition score	0.00	1.96	1.5	1.00

Different components of the gross margin

The largest portion of the gross margin was obtained due the change in price of the animals in the course of the fattening period (Table 2). The portion of gross margin obtained due to weight gain was 24 % from the group of animals fed on R2. The contributions of price component to the total gross margin were more than 4.5, 2.5 and 2.4 folds of the amount contributed by weight gain of animals fed on R4, R2 and R3, respectively. From all supplemented groups, the gross margin contributed by the interaction of price change and weight gain was below 15 %. For un-supplemented group the same was very small (0.72 %).

Table 2. Different components of gross margin from fattened Arsi oxen

S. No.	Ration	Components of return (%)		
		Price	Weight	Interaction
1	R1	82.3	17	0.7
2	R2	62.2	24.1	13.8
3	R3	63.1	26.2	10.7
4	R4	74.7	16.1	9.2
5	Average	70.6	20.8	8.6

Discussion

The average net financial margin depended on feed cost, weight gain, and purchase and sale prices per kg live weight. From the supplemented group, average net return per animal was lowest for the group of animals fed on R3. This was due to highest feed cost, lowest sale price per kg live weight and relatively higher average purchase cost per kg live weight. Contrary to this the animals fed on R2 gave the highest average net return (344 ETB) per animal. The average weight gain attained by the group of animals fed on R4 was the lowest (324.1 g/day) of all supplemented groups but the average net return obtained was higher than the group of animals gained 400 g/day (the group of animals fed on R3). This was because of the higher sale price per kg of live weight and low purchase cost per kg of live weight. The group of animals fed on R1 exhibited loss of about ETB 68.1 for the return obtained from the small gain (22.22 g/day) could not cover operation cost. There was also small increment in sale price per kg live weight.

For the same amount of person-day labor was utilized across all groups, the groups of animals fed on cheaper ration gave more return per person-day labor. The minimum return per person-day labor was ETB 20.7, which is more than six folds of the prevailing wage rate (ETB 3.50) in the area. This showed that even the lowest gross return is paying than going for labor work. However, this activity will not give full time employment and should be taken as a sideline work. Thus, a small-scale fattener while doing fattening can do other works. The highest return per person-day labor (ETB 49.4) was obtained from the group of animals fed on R2 due to the highest net margin (ETB 344.2). The AFRR from the group of animals fed on R2 was 200.2 %. This means for one ETB investment on fattening a farmer will get about a return of ETB 2 if the farmer exercises fattening for the whole year provided the input and output prices and fattening period are the same as that of the experiment.

The prices of the animals were determined by personal judgment based on the prevailing local market prices. Between the purchase and sell of the animals, there was great improvement in price per kg live weight. From this result, one can observe that three things contributed for the increase in the gross margin of the fattener. These are the increase in price per kg of live weight of the animal during sale, the gain in the animal's body weight and interaction of the two (Table 2).

Conclusions and recommendations

Fattening of old oxen can help the farmers as a financial source to purchase young oxen for replacement. Most of the time, the finance secured from the sale of old ox is not enough for the purchase of the young. This forces farmers to seek another alternative of securing the money for making the balance. One of the alternatives to get the money required is selling small ruminant or calves, which leads to the de-capitalization of the scarce resources at hand. To avoid or reduce de-capitalization farmer can fatten old ox and fetch better price.

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Appendix 1.

Inputs used for fattening and their respective prices.

S. No	Inputs	Unit	Unit price (EBR)
1	Teff straw	Kg	0.22
2	Noug cake	Kg	0.31
3	Maize grain	Kg	1.10
4	Urea	Kg	2.50
5	DAP	Kg	2.65
6	Molasses	Liter	0.05
7	Albendazole Boli	Bollus	1.60
8	Diazinol spray	Liter	1.25
9	Anthrax vaccine	Dose	0.20
10	Black Leg vaccine	Dose	0.20
11	Pasturellosis	Dose	0.30
12	CBPP	Dose	0.20
13	Lumpy skin disease	Dose	0.30

Maize Grain Yield, Yield Components and Laboratory Evaluation of the Nutritional Value of Maize Residue Succeeding a Fallow of Panicum and Stylosanthes Binary Mixture

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Abstract

The experiment was conducted at Bako Research Center during 2001 and 2002 cropping seasons with the objective of evaluating the grain yield, yield component and nutritive value of maize residue succeeding Panicum (P) and Stylosanthes (S) mixed stand grown at variable seed proportions of the component species. The treatments were: Pure Stylosanthes (T1), 25P+75S (T2), 50P+50S (T3), 75P+25S (T4), Pure Panicum (T5), 100P+100S (T6) and fallow land which was under natural pasture for at least 6 years adjoining the experimental blocks (T7). The base seed rate used was 10 kg/ha for the grass and 14 kg/ha for Stylosanthes. Higher grain yield (8.05t/ha) was recorded during 2001 as compared to 2002 (7.62t/ha) season. When averaged over years, significantly highest (8.52t/ha) grain yield was recorded for the plots that were under 25P+75S mixture and lowest for natural pasture fallow (5.93t/ha). The crude protein (CP) content ranged from 2.08% for natural fallow plots to 3.16 % for the plots that were under sole Stylosanthes. The neutral detergent fiber (NDF) values were generally very high ranging from 82.69 % for pure Stylosanthes plots to 86.94 % for the natural pasture fallow. On the other hand, the in vitro DM digestibility (IVDMD) values varied from 53.85 % for 25P+75S plots to 74.60 % for 100P+100S plots. It is apparent that maize grain yield and yield of most of the other components was higher for the plots that had previously been planted with improved pasture (sole or mixed) as compared to the adjoining natural pasture fallow. This may be attributed to improvement in total soil N fixed by the legume in the legume or grass-legume mixture plots and improved soil physical and chemical properties. Based on the beneficial aspect on grain yield and residue quality attributes, the study generally demonstrated an important benefit of the improved fallow as compared to the natural pasture fallow.

Key words: Maize; Mixed pasture; Residual effect; Stylosanthes; Fallow

Introduction

The use of N fixing legumes in crop rotations for soil fertility and crop yield improvement is one of the oldest agricultural practices (Hargrove and Frye, 1987). Research reports elsewhere have indicated that maize grown following crimson clover or hairy vetch was reported to yield as much as that grown following rye or oats with 112 kg N/ha (Mitchell and Teel, 1977). Hargrove (1986), in a study that included four legumes and one non-legume cover crop treatment, found that the calculated fertilizer N replaced by four legumes averaged 72 kg N/ha. Tarawali (1991) has also stated that legume pastures improve the soil N budget that could also be exploited for crop production. Several authors (Tarawali, 1991 and references cited therein and Buresh et al, 1993) have extensively documented the use of this concept to increase the yield of subsequent crops.

According to Mohammed-Saleem and Otsyina (1986), maize grown on land previously under fodder banks of *Stylosanthes* species gave higher yields than that of natural fallow or continuously cultivated land. These findings have demonstrated an important benefit of the forage legume in addition to its value as supplementary feed for ruminants subsisting on low quality diets (Kouame et al, 1992). Indeed, the majority of the available evidences are based on sole grown legumes to evaluate the potential residual contribution to succeeding cereal crop. The role of forage legumes for improving the soil N budget and performance of the subsequent crop could be influenced by several factors. Tarawali and Mohammed-Saleem (1995) have indicated that age-induced invasion of the legume field by nitrophilous grass species could reduce the N available to subsequent crop production and implied that delayed cropping may be disadvantageous (Mohammed-Saleem and Otsyina, 1986). This is because of the uptake of the fixed N by grass. For grass and legume mixed system, Mallarino *et. al.* (1990) have reported that legume dominant swards are required to maximize fixed N yields for red clover-tall fescue and birds foot trefoil-tall fescue mixtures. Butler and Ladd (1985) have also indicated that legumes grown in mixture with grasses have larger percentage N derived from air as a result of competition for soil N by associated grass.

There is little research in Ethiopia examining the use of planted legume/grass leys for animal production and the restoration of soil fertility for increased crop production. Elsewhere in Africa, MacColl (1990) has reported that three to four–year-old pure pastures of eleven legumes were compared with grasses and non-legumes for their contribution of nitrogen to subsequent maize crops in experiments where the grasses and legumes were cut three times a year, but the residues were not removed. Superior rice yield was reported after a grass-legume pasture compared with the grass-only pasture when no nitrogen fertilizer was applied (Thomas and Lascano, 1995) and soil organic matter levels were reported to be greater under a long term improved grass-legume pasture compared with the grazed native savannah (Thomas and Lascano, 1995). The present study was conducted with the objective of evaluating the grain yield and yield components, and the chemical composition and digestibility *in vitro* of maize residue succeeding Panicum-Stylosanthes mixed stand grown at variable seed proportions of the component species.

Materials and methods

Location

The experiment was conducted at Bako Research Center during 2001 and 2002 cropping season. The Center is located about 250 Km west of Addis Ababa some 4 Km away from the main road to Nekemte at an altitude of 1650 m.a.s.l. It lies at 09^{o}6'N and 37^{o}09'E. The area experiences a hot and humid climate and receives a mean annual rainfall of about 1219 mm of which more than 80% falls in the months of May to September. Mean monthly minimum and maximum temperatures are about 14^{o}c and 28^{o}c, respectively, with an average monthly temperature of 21^{o}c. The daily mean minimum and maximum temperatures are 9.4 ^{o}c and 31.3 ^{o}c, respectively. Potential evapotranspiration averages 60 mm per month.

Treatments

This study was conducted with the intention to evaluate maize grain yield, yield components and residue quality following Panicum (P) and Stylosanthes (S) mixed pasture grown at different relative seed proportions for 3 years (1999-2001). Initially, the study was designed to determine performance of the component species and assess the biological yield advantages of mixed cropping. The grass and legume mixture study was completed in mid-December 2001 and Diriba (2003) has reported the results of the three years study. Following the completion of the grass-legume mixture study in December 2001, the plots were manually cultivated using a hoe three times before the onset of rain and all the plant parts, roots and stubbles, of about 10 cm height remaining from the previous study were properly worked in to the soil.

At the onset of rain, additional cultivation was made for the fourth time to prepare a fine seedbed. Each plot with different cropping history was divided in to two; one of the plots receiving fertilizer rate recommended for maize production in the study area (75/75 N/P_2O_5) and the other with out any additional chemical fertilizer source. The experiment also included fallow land adjoining the experimental blocks totally consisting of seven treatments: the soil that had been cropped for three years with pure Stylosanthes (T1), 25 P : 75 S mixture (T2), 50 P:50 S mixture (T3), 75P:25S mixture (T4), Pure Panicum (T5), 100P : 100 S (T6) and fallow land which was under natural pasture for at least 6 years adjoining the experimental blocks (T7). The treatments were arranged in split-plot design; the main plots being the plot history and the subplots being the fertilized (75/75 N/P_2O_5) and unfertilized (0/0 N/ P_2O_5) treatments.

Field operations and data collection

Open pollinated maize variety, Kulani, released by Bako Research Center was used for this study. The crop was planted using an intra- and inter-row spacing of 25 and 75 cm, respectively. Weeding and other cultural practices were done as required. At harvest, which took place at 197 and 176 days after planting for 2001 and 2002 cropping seasons, respectively, the cobs from all plants of each subplot treatment ($6m^2$) were plucked, dehusked, dried and threshed to determine the grain yield at 12.5 percent moisture content. The stover was then harvested and partitioned in to all plant components to determine their DM yield. Finally, all stover components including husk and cob were reassembled and a composite sample was retained for laboratory analysis to determine the stover nutritional value.

Chemical analysis and *in vitro* DM digestibility

The chemical analysis of the feed samples was done at the International Livestock Research Institute Nutrition Laboratory, Addis Ababa. Nitrogen was analyzed using the Kjeldhal procedure and crude protein (CP) was calculated as N * 6.25. The fiber components, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were determined by the procedures of Goering and Van Soest (1970). The *in vitro* DM digestibility (IVDMD) was determined using the Tilley and Terry (1963) *in vitro* technique. All the data collected were subjected to the analysis of variance using MSTATC computer software and significant mean differences were separated using least significant difference (LSD) procedure.

Results and discussion

Grain yield and yield components

Mean squares and levels of significance from the analysis of variance for maize grain and other yield components are given in Table 1. The effect of the interaction of year and plot history treatments was not significant (P>0.05) for grain, cob, stalk and total annual residual yield indicating that the two factors were independent. Thus, average effect of year pooled over plot background treatments is compared independently as the simple effects are homogenous. For leaf and husk components, the significant interaction between year and plot history treatment is largely due to the highly significant effect of the latter on the measured traits. For all parameters studied, highly significant main effects of fertilizer was observed (P<0.01) and the year by fertilizer; and plot history by fertilizer interaction effects were not significant (P>0.05) for cob, leaf and husk components. The three way interaction effects were significant for stalk (P<0.01), mainly due to the highly significant (P<0.01) treatment by fertilizer interaction. The cob fraction was also significantly influenced by the three way interactions of year, treatment and fertilizer mainly due to the differential response of the interaction of land history by fertilizer interaction across years.

Mean yield for grain, cob, stalk and total residue as influenced by year and plot history treatments are shown in Table 2. Higher grain yield (8.05t/ha) was recorded for 2001 as compared to 2002 (7.62 t/ha) season and little differences were observed between the two years for cob. Significantly higher DM yield of stalk was obtained during the 2001(3.09 t/ha) season as compared to that of 2002 (1.94 t/ha). For total residue DM yield the difference between the two years was not significant but a slightly higher total residue was obtained during 2001 season (8.79 t/ha) as compared to that of 2002 (8.46 t/ha). The lower grain yield observed in the present study during the second year as compared to the first year is in agreement with the findings of Tarawali (1991) who reported lower overall maize grain yield during the second year as compared to the first year in an experiment in which residual contribution of Stylosanthes fodder banks was studied.

When averaged over years and fertilizer treatment levels, significantly ($P<0.01$) highest grain yield was recorded for the plots that were under 75 Stylosanthes and 25 Panicum mixed pasture and the lowest mean grain, cob, stalk and total forage yields were observed for the plots that were under the natural pasture. Generally, narrow range of differences was observed for cob, stalk and total forage yields. It is apparent that maize grain yield and yield of most of the other components was higher for the plots that had previously been planted with improved pasture (sole or mixed) as compared to the adjoining natural pasture fallow. This may be attributed to improvement in total soil N fixed by the legume in the legume or grass-legume mixture plots and improved soil physical and chemical propertied such as bulk density, infiltration rates, and field moisture capacity as reported by other workers (Mohamed-Saleem and Otsyina, 1986; Mohamed-Saleem *et. al.,* 1986; Tarawali, 1991). Significant increases in available soil N and total soil N in soils in which legume have been grown was also reported (Vallis, 1972; Myers, 1976; Wetselaar, 1967 and Tarawali *et. al.,* 1987) and this could be attributed to the better performance of maize under those improved pasture plots as compared to the natural grassland fallow.

The effects of year and plot background treatments for leaf and husk components are given in Table 3. During the 2001cropping season, significantly highest leaf biomass was recorded from the pure Stylosanthes plots. During the 2002 season, plots which were under 75 S: 25 P gave the highest mean leaf yield. For the husk component, highest mean DM yield was recorded from the plots in which the two forage species were grown at 100:100 proportions. In 2002, the highest husk component yield was recorded from the 75 S: 25 P plots. Generally ranking of treatments was not consistent between the two years. When averaged over the two years, significantly highest husk DM yield was recorded for the pure Stylosanthes plots suggesting the improvement of soil fertility as a result of N fixation. The effect of fertilizer application on grain yield and other yield components is given in Table 4. Fertilizer application significantly affected all the measured traits and averaged over years and fallow treatments, for all traits, the fertilized plots gave superior yield when compared with the unfertilized plots indicating the importance of N to increase grain and other yield components of maize.

Chemical composition and *in vitro* DM digestibility

Chemical composition and *in vitro* DMD concentrations of the residue samples collected from different fallow treatments during 2001 are given in Table 5. As residue samples were collected for the fertilized and unfertilized subplots within the fallow treatments during the 2001 only, the total variance was partitioned in to the effects of fertilizer and that of the fallow treatments. No statistically significant ($P>0.05$) difference was observed between the fertilized and unfertilized plots for all measured traits. It is generally evident that the crude protein content is very low, far below 8 percent and the total cell wall component, as measured by the NDF concentration is high and the values for IVDMD were moderate under both fertilized and unfertilized conditions.

The effect of plot history was found to be significant for CP, ADL and IVDMD of whole maize residue. The values of CP ranged between 2.08 for the plots which were under natural pasture to 3.16 for the one under pure Stylosanthes and are generally far below the critical dietary levels required for optimal rumen function and positive nitrogen balance (Van Soest, 1982). The percentage NDF values were high, ranging between 82.6 for the plots that were under pure Stylosanthes to 86.94 for those that were under the natural pasture fallow. The ADF was high for 25 S : 75 P and was lowest for the natural pasture fallow plots. On the other hand, IVDMD values were significantly lower for the 100 S: 100 P plots and highest for 25 S : 75 P fallow plots.

Conclusion

Generally, the mean yield for grain was higher for 2001 as compared to 2002 season and little differences were observed between the two years for cob. Significantly higher DM yield of stalk was obtained during the 2001 season as compared to that of 2002. For total residue DM yield, the difference between the two years was not significant but a slightly higher total residue was obtained during 2001 season as compared to that of 2002. When averaged over years and fertilizer treatments, highest grain yield was recorded for 75 Stylosanthes and 25 Panicum mixture and lowest mean grain, cob, stalk and total forage yields were recorded for the plots that were under the natural pasture. It was observed that grain yield and other yield components were higher for the plots that had previously been planted with improved pasture, pure stands of both species or mixed, as compared to the adjoining natural pasture fallow suggesting improvement of chemical and physical soil properties under the improved fallow system as compared to the natural fallow. The percentage values for CP ranged between 2.08 for the plots that were under natural pasture to 3.16 for the one under pure Stylosanthes. These CP contents are generally far below the critical dietary levels required for optimal rumen function. On the other hand, IVDMD values were significantly higher for the 100 S: 100 P plots and lowest for 25 S:75 P fallow plots. The study generally demonstrated an important benefit of the improved fallow system based on the beneficial aspect on grain yield and residue quality.

Table 1. Mean squares and levels of significance for grain and other yield components of maize

Source	DF	Grain		Cob		Stalk		Leaf		Husk		Total fodder	
		MS	P	MS	P	MS	P	MS	P	MS	P	MS	P
Year (A)	1	503.08	NS	0.20	NS	37.28	**	2.38	NS	2.07	**	3.07	NS
Treatment (B)	6	1249.69	**	0.33	NS	1.14	**	1.02	**	0.53	**	9.06	**
A x B	6	128.44	NS	0.18	NS	0.54	NS	0.37	*	0.40	**	1.95	NS
Fertilizer (C)	1	4497.98	**	2.29	**	9.91	**	9.87	**	4.26	**	95.66	**
AC	1	422.49	NS	0.01	NS	1.42	*	0.55	NS	0.08	NS	2.21	NS
BC	6	52.55	NS	0.05	NS	1.07	**	0.42	NS	0.13	NS	3.79	**
ABC	6	61.86	NS	0.14	*	1.44	**	0.21	NS	0.16	NS	3.25	NS

* Significant at P<0.05; ** significant at P<0.01; NS= not significant

Table 2. The effect of year and mixture treatments on maize grain, cob, stalk and total residue yield

Year	Grain	Cob	Stalk	Total residue
2001	8.05	1.42	3.09	8.79
2002	7.62	1.50	1.94	8.46
SE	1.52	0.07	0.09	0.19
P level	NS	NS	**	NS
1	8.00	1.49	2.49	9.13
2	8.52	1.52	2.32	8.76
3	7.63	1.28	2.46	8.51
4	8.17	1.62	2.76	8.63
5	8.04	1.49	2.86	9.05
6	8.25	1.56	2.65	9.28
7	5.93	1.24	2.08	7.04
SE	3.05	0.08	0.14	0.32
P level	**	NS	**	NS

Pure Stylosanthes (T1) 25 P : 75 S mixture (T2), 50 P:50 S mixture (T3), 75P:25S mixture (T4), Pure Panicum (T5), 100P : 100 S (T6) and fallow land which was under natural pasture for at least 6 years adjoining the experimental blocks (T7)

Table 3. The effect of year and land history treatments on leaf and husk components of maize

Treatment	Leaf			Husk		
	2001	2002	Mean	2001	2002	Mean
1	3.32	3.45	3.39	1.43	1.55	1.49
2	3.02	3.92	3.47	0.89	1.79	1.34
3	3.10	3.35	3.22	1.39	1.45	1.42
4	2.96	2.91	2.94	1.28	1.52	1.39
5	3.01	3.24	3.13	1.13	1.57	1.35
6	3.25	3.39	3.32	1.59	1.62	1.60
7	2.55	2.98	2.77	0.97	1.07	1.02
SE	0.14	0.14	0.09	0.09	0.09	0.06
P level	*	*	**	**	**	**

Pure Stylosanthes (T1), 25 P: 75 S mixture (T2), 50 P: 50 S mixture (T3), 75P:25S mixture (T4), Pure Panicum (T5), 100P : 100 S (T6) and fallow land which was under natural pasture for at least 6 years adjoining the experimental blocks (T7)

Table 4. Effect of fertilizer application on yield and other yield components of maize

Traits	Unfertilized	75/75 N/P_2O_5	SE	P level
Grain	7.20	8.47	1.55	**
Cob	1.31	1.60	0.03	**
Stalk	2.22	2.81	0.07	**
Leaf	1.18	3.47	0.06	**
Husk	1.18	1.57	0.04	**
Total residue	7.70	9.55	0.14	**

** = significant at $P<0.01$; SE = standard error of treatment means

Table 5. Effect of fertilizer application and grass-legume mixed fallow on crude protein, fiber components and *in vitro* DM digestibility (%) of maize residue

Fertilizer	CP	NDF	ADF	ADL	IVDMD
Unfertilized	2.48	84.42	43.93	4.31	53.04
75/75N/P_2O_5	2.38	86.11	45.02	4.61	53.13
SE	0.128	9.0214	5.6005	0.8197	2.1638
P level	NS	NS	NS	NS	NS
1	3.16	82.69	45.37	5.66	57.55
2	2.35	83.72	45.21	5.58	53.85
3	2.41	85.77	44.77	4.46	55.06
4	2.14	85.73	43.03	3.74	59.42
5	2.56	86.28	43.98	3.79	55.61
6	2.31	85.72	45.02	4.48	74.60
7	2.08	86.94	43.96	5.53	55.51
SE	0.2394	16.8775	10.4776	1.5336	4.0481
P level	*	NS	NS	**	*

Pure Stylosanthes (T1), 25 P: 75 S mixture (T2), 50 P: 50 S mixture (T3), 75P: 25S mixture (T4), Pure Panicum (T5), 100P: 100 S (T6) and fallow land which was under natural pasture for at least 6 years adjoining the experimental blocks (T7)

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Forage Productivity and Compatibility of Mixtures of *Chloris gayana* and *Panicum Coloratum* with *Desmodium unicenatum* at Bako, Western Ethiopia

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Abstract

Two experiments were conducted using mixtures of Panicum coloratum, cv. coloratum and Desmodium unicenatum, cv. silver leaf; and that of Choris gayana cv. massaba (Rhodes) and Desmodium unicenatum during 2001 and 2002 cropping seasons to evaluate the forage productivity and compatibility of the component species under Bako condition. The treatments were: Puree legume (T_1), 75% legume: 25% grass (T_2), 50% legume: 50% grass (T_3), 25 %legume: 75%grass (T_4) and Pure grass (T_5). The base seed rate used for both grass and legume component was 10 kg/ha. In Panicum and Desmodium mixture of the first experiment, significantly (P<0.01) highest Desmodium DM yield (2.43 t/ha) was recorded for sole legume plots followed by the second treatment (0.46 t/ha) where the legume component consisted of 75% of the total mixture seed mass. The effect of seed proportion was not significant (P>0.05) for the DM yield of the grass component but a slight yield improvement was observed when grown in mixtures as compared to the pure grass plots. The partial land equivalent ratio (LER) of the legume component was lower than unity indicating the aggressivity of the grass against the legume. Except for the 50: 50 proportions, the total LER values were observed to be greater than one indicating the presence of biological yield advantage through intercropping. In Rhodes - Desmodium mixture of the second experiment, the effect of seed proportion was not significant for Desmodium DM yield (P<0.01). Higher mean yield values for the legume (1.99 t/ha) and the grass (6.11 t/ha) were recorded for the sole plots. Similar to the first experiment, the grass component was observed to be aggressive as the partial LER values for the legume were all lower than one. The total LER values of the mixture revealed the existence of biological yield advantages from mixed cropping (LER>1). For both experiments, the DM yield of the pure legume plots was inferior compared to the total mixture or sole grass yields. For the Panicum-Desmodium mixture, significantly (P<0.05) highest total DM yield was recorded for the 25 Desmodium: 75 Panicum mixture, which gave 58.69 % Dm over the sole legume and 20.33 % over the sole grass. Similarly, for Rhodes and Desmodium mixture, highest (P<0.05) DM yield was obtained from the 25 Desmodium: 75 Rhodes proportion, giving 65.26 and 15.01 % higher DM yield values compared to the sole Desmodium and sole Rhodes, respectively. In both studies, the botanical composition of the legume component was far below what was considered desirable in grass-legume mixture (30-50%) suggesting the aggressivity of the grass component.

Key words: Forage productivity; Compatibility; Mixed pasture; *Chloris gayana; Panicum coloratum; Desmodium intortum*

Introduction

Inadequate nutrition in terms of quality and quantity is a major constraint to realizing increased ruminant production in Ethiopia. Grass-legume mixtures have long been recognized as a means of providing adequate forage for ruminant livestock (Ezenwa and Akenova, 1998). It was also reported that mixtures provide higher forage dry matter (DM) yields than pure grass or legume stands and there is a saving in inorganic nitrogen needed to obtain similar levels from pure grass stands (Evans, 1970; Akinyemi and Onayinka, 1976). Higher live weight gains of animals are also obtained from grass-legume mixtures than from pure grass stands (Akinyemi and Onayinka, 1982) because of better forage quality.

Forage improvement efforts in the Animal Feeds and Nutrition Division of Bako have resulted in the identification of productive grass and legume species with superior forage DM yields in pure stands. There is little information on the forage productivity of the different grasses and legumes when used in a mixture in Western Ethiopia. Few studies conducted so far on the mixture of Oat and Vetch (Lemma and Alemu, 1989) and Panicum and Stylosanthes mixture (Diriba, 2000) can be cited as examples. In the present study, DM yields and percentage composition of the component species to total forage DM yields were determined for Rhodes-Desmodium and Panicum-Desmodium mixtures grown at varying relative seed proportion of the component species. Biological yield advantages and complementarity aspects of the mixed stands were also assessed using land equivalent ratio values based on mixture and sole crop yields of the species in mixture.

Materials and methods

Location

The study was conducted at Bako Agricultural Research Center, which is located at 9° 6’ N latitude and 37° 9’ E longitude and at an altitude of 1650 m.a.s.l and receives a mean annual rain fall of 1200 mm and, a respective mean maximum and minimum temperatures of 28 and 13 °c. The soil is a reddish brown, clay to sandy clay loam Nitosol with P^H of 5.3-6.

Field operations

Seedbed preparation was done using tractor drawn implements. The land was cultivated two times before the onset of rain and at planting additional cultivation was done to prepare a fine seed bed. Seeds of *Chloris gayana* cv.massaba and *Panicum coloratum* cv.coloratum were mixed with *Desmodium unicenatum* cv. silverleaf in a replacement series (Pure legume; 75% legume: 25% grass; 50% legume: 50% grass; 25% legume: 75% grass; and Pure grass). The pure stands of each species were also included for comparison and the base seed rate used for both grass species and the legume was 10 kg/ha. The mixed seeds of the two species were row planted on plots of 12m^2 (4m x 3m) area at 30 cm inter-row spacing in a randomized complete block design with four replications in two experiments, the first experiment dealt with the mixture of Panicum and Desmodium and the second set with that of Rhodes and Desmodium.

Treatments

Experiment 1. Panicum coloratum and Desmodium unicenatum

1. Pure Desmodium
2. 25% P. coloratum + 75 % D. unicenatum
3. 50% P. coloratum + 50 % D. unicenatum
4. 75% P. coloratum + 25 % D. unicenatum
5. Pure Panicum

Experiment 2. Rhodes and *D. unicenatum*

1. Pure Desmodium
2. 25% Rhodes + 75 % D. unicenatum
3. 50% Rhodes + 50 % D. unicenatum
4. 75% Rhodes + 25 % D. unicenatum
5. Pure Rhodes

Data collection

For DM yield determination, two middle rows were harvested when the grass component reached 50 percent flowering stage and the harvested biomass was then separated in to grass and legume components. The fresh weight of each was recorded just after partitioning and the sub samples of each component species were dried in a forced draught oven at 65 ^{o}c for 72 hrs to determine the DM content. This percentage DM was used to determine herbage yield on per hectare basis. Biological yield advantages and species compatibility of the different binary mixtures were assessed using the Land Equivalent Ratio (LER) calculated by the equation:

LER = LG + LL;
LG = YG/SG and LL = YL/SL (Mead and Willey, 1980),

Where LG and LL are the partial LER values of grass and legume, YG and YL are their yields in mixtures, and SG and SL are their respective yields in the pure stands. The data collected were analyzed using the MSTATC computer software and significant differences were separated using LSD procedure.

Results and discussion

Experiment 1

The summary of the analysis of variance for the effect of year, seed proportion treatment and their interaction is given in Table 1. The effects of year ($P<0.01$), seed proportion ($P<0.01$) and the interaction of year and seed proportion ($P<0.05$) were significant for DM yield of the legume component and its land equivalent ratio ($P<0.05$). The botanical composition of the grass component in total forage DM was significantly influenced by seed proportion ($P<0.01$) but not by year ($P>0.05$) and the interaction of year and seed proportion ($P>0.05$). On the other hand, the DM yield of the grass was affected significantly by year ($P<0.01$) but not by seed proportion and its interaction with year ($P>0.05$). Seed proportion treatment significantly affected percentage contribution of the grass component to total DM yield ($P<0.01$) but that of year and its interaction with seed proportion did not ($P>0.05$). Both the main and interaction effects of the two factors did not significantly ($P>0.05$) affect the LER values of the grass component but significantly affected ($P<0.05$) that of the legume component.

The mean forage DM yield, botanical composition and LER of the two components for Experiment 1 are shown in Table 2. Sole grown legume gave the highest yield (2.34t/ha) and least (0.15t/ha) in 25:75 legume: grass proportions. Mean yield for the 2nd (0.46t/ha) and the 3rd (0.25t/ha) treatments did not differ statistically. The DM yield of the grass component ranged between 4.59t/ha for 75 legume: 25 grass proportion to 5.02t/ha for 25 legume: 75 grass proportion. The superior DM yield when averaged over years of the grass component particularly for 50: 50 and 25: 75 legume and grass proportion, respectively compared to that grown sole in the current study could be associated with the benefit from the legume component through nitrogen transfer or less competition of the legume for growth resources with the grass, particularly N. An increasing trend of the percentage proportion of both grass and legume in total DM was observed with increasing seed proportion in the mixture of the two species (Table 2) and this is in agreement with previous observation reported by Dirriba (2000) for Panicum and Stylosanthes mixture. The partial LER and total LER for the mixture of Panicum and Desmodium is also given in Table 2. Total LER was greater than unity for 75 legume: 25 grass (1.40) and 25 legume and 75 grass proportions (1.23) when averaged over years and the total land equivalent ratio for the 50:50 proportion was exactly equal to unity indicating the absence of biological yield advantage in mixed cropping. The total LER values above unity in the present study imply that the two species were not strictly competing for the same limiting factors, being dependent on different sources of nutrients or utilizing moisture from different soil depths.

Diriba (2000) has reported similar results for Panicum and Stylosanthes mixed stand and Daniel (1990) for Rhodes grass and Lucerne mixtures.

Experiment 2

Mean squares and levels of significance from the analysis of variance for Rhodes-Desmodium mixture is shown in Table 3. The DM yield of Desmodium and its percentage contribution to total mixture yield were significantly affected by year (P<0.05) and seed proportion treatment (P<0.01). For partial LER, only the effect of year (P<0.05) was observed to be significant for the legume. On the other hand, significant interaction effect of year and seed proportion was observed for DM yield, percentage composition and partial LER of both species. For Rhodes (Table 3), year effect was significant (P<0.05) for DM yield. Similarly, the effect of year and seed proportion was significant for percent composition of the grass component. Year, seed proportion and the interaction of the two did not significantly (P>0.05) influence the partial LER values of Rhodes grass.

The mean DM yield, botanical composition, and partial LER of the two components and total LER values are given in Table 4. Significantly higher DM yield of the legume component (1.99 t/ha) was obtained from pure stand. It also varied between 0.08t/ha for 25 L: 75 G proportions to 0.12 t/ha for 75 L: 25 G proportion. Similarly, the DM yield of the grass was superior (6.11 t/ha) for the pure stand plots, though there was no statistically significant difference between the pure stand and the rest treatments. The contribution of the legume proportion to total forage DM exhibited an increasing trend with its increasing seed proportion but was generally very low. The grass component was found to be dominant and its percentage contribution to total forage DM yield of the mixture ranged from 97.68 % to 98.67 % for 75 Desmodium: 25 Rhodes and 25 Desmodium: 75 Rhodes, respectively. The LER for the legume was less than unity and that of the grass was greater, indicating the dominance of the grass component in the mixed sward. The total LER value of the mixture was greater than unity suggesting the existence of biological yield advantage of mixed cropping as compared to the monostands.

The total DM yield of the two mixture types at different seed proportion of the component species is given in Table 5. In both experiments, the DM yield from the pure legume plots was inferior compared to the rest treatments. For the Panicum-Desmodium mixture, significantly (P<0.05) highest DM yield was recorded for the 25 Desmodium: 75 Panicum mixture, which gave 58.69 % DM over the sole legume and 20.33 % over the sole grass. Similarly, for Rhodes – Desmodium mixture, significantly highest (P<0.05) DM yield was obtained from the 25 Legume: 75 Grass proportion, giving 15.01% higher DM yield as compared to sole Desmodium and sole Rhodes, respectively.

Conclusion

For both experiments, the grass component was observed to be highly aggressive and its percentage contribution to total forage DM was superior. This is explained by the higher partial LER values of the grass component in both experiments as compared to the legume. Except for 50:50 proportion of the legume and grass mixture in the first experiment, the total LER values of the other mixtures were slightly greater than unity suggesting that mixed cropping is biologically advantageous. The percentage proportion of the legume component as compared to the grass component, in all cases was far below 30–50 percent that is considered desirable in grass and legume mixtures (Crowder and Chheda, 1982) and is indicative of the aggressivity of the grass component. Future research should focus on development of management techniques that improve the compatibility of the two species.

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Table 1. Mean squares (MS) and levels of significance from the analysis of variance for the effect of year and seed proportions on DM yield, botanical composition and partial LER in Panicum –Desmodium mixture

Sources of variation	DF	Legume		Grass	
DM yield					
		MS	P level	MS	P-level
Year (A)	1	1.14	**	39.40	**
Seed proportions (B)	4	7.46	**	2.65	NS
A*B interaction	4	0.10	*	0.57	NS
Composition					
Year (A)	1	70.66	NS	65.70	NS
Seed proportions (B)	3	17578.50	**	145.44	**
A*B interaction	3	43.66	NS	45.10	NS
Partial LER					
Year (A)	1	0.04	*	0.12	NS
Seed proportions (B)	2	0.02	*	0.22	NS
A*B interaction	2	0.03	*	0.01	NS

* = Significant at $P<0.05$; ** = significant at $P<0.01$; NS = non significant; DF = degrees of freedom

Table 2. Effect of seed proportion on DM yield (t/ha), botanical composition (%) and, partial and total LER values of the mixture in Panicum-Desmodium mixture

Seed proportions		Yield		Composition		LER		
Legume	Grass	Legume	Grass	Legume	Grass	LER (D)	LER (P)	Total LER
100	0	2.43a	-	100a	-	-	-	-
75	25	0.46b	4.59	10b	89.92c	0.18a	0.87	1.40
50	50	0.25bc	5.84	6bc	93.90bc	0.10ab	0.90	1.00
25	75	0.15c	5.02	3c	96.62ab	0.08b	1.17	1.23
0	100	-	4.86	-	100a	-	-	-
SE		0.07	0.41	1.51	1.49	0.03	0.10	0.09

LER (D) and LER (P) were used to denote the land equivalent ratio for Desmodium and Panicum, respectively; SE stands for standard error of treatment means; NS stands for non-significant treatment effects; within column means having common letters do not vary significantly

Table 3. Mean squares (MS) and levels of significance from the analysis of variance for the effect of seed proportions of the component species on DM yield (t/ha), botanical composition (%) and partial LER of the component species in Rhodes-Desmodium mixture

Sources of variation	DF	Legume	P-level	Rhodes DM	P-level
Year (A)	1	0.51	*	14.93	*
Seed proportions (B)	4	5.71	**	1.72	NS
A*B interaction	4	0.04	NS	0.25	NS
		Composition		Composition	
Year (A)	1	22.80	*	22.80	*
Seed proportions (B)	3	19294.54	**	7.702	**
A*B interaction	3	2.99	NS	2.99	NS
		Partial LER		Partial LER	
Year (A)	1	0.023	*	0.24	NS
Seed proportions (B)	2	0.001	NS	0.25	NS
A*B interaction	2	0.000	NS	0.07	NS

**= Significant at P<0.01; *= significant at P<0.05; NS = Not significant; DF stands for degrees of freedom

Table 4. Effect of seed proportion of the component species on mean DM yield (t/ha0, botanical composition (%) and, partial and total LER values in Rhodes–Desmodium mixture

Seed Proportions		DM yield		Botanical composition		LER		
		Desmodium	Rhodes	Desmodium	Rhodes	LER (D)	LER (R)	Total
100	0	1.99a	-	100a	-	-	-	-
75	25	0.12b	5.09	2.32b	97.68b	0.06a	1.02	1.08
50	50	0.09b	5.78	1.70b	98.30b	0.04b	1.02	1.06
25	75	0.08b	5.12	1.33b	98.67b	0.04c	1.32	1.37
0	100	-	6.11	-	100a	-	-	-
SE		0.06	0.62	0.37	0.37	0.01	0.19	0.21

LER (D) and LER (R) were used to denote the land equivalent ratio for Desmodium and Rhodes, respectively; SE stands for Standard Error of treatment means; NS stands for non-significant treatment effects; within column means having common letters do not vary significantly

Table 5. Effect of seed proportion on total forage DM yield of Panicum-Desmodium and Rhodes-Desmodium Mixture

Seed Proportion		Mixture Type	
Legume	Grass	Panicum-Desmodium	Rhodes-Desmodium
100	0	5.94	4.95
75	25	11.53	12.75
50	50	11.63	12.69
25	75	14.38	14.25
0	100	11.95	12.39
SE	7.36	17.12	
P-level	*	*	

SE = standard error of treatment means; * = significant at p<0.05

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Effect of Variety on Maize Grain Yield, Plant Fractions and Nutritional Value of the Stover

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Abstract

The study was conducted in 2001 with the objective of evaluating two maize hybrids (BH-660 and BH-540) and one open pollinated variety (Kulani) all released by Bako Research Center for grain yield, yield components, digestible crop residue yield and nutritive value of the stover. Differences between varieties were significant (P<0.01) for all measured parameters except for the husk fraction (P>0.05). Grain and leaf yields were significantly highest for BH-660. The cob and total residue yields were lowest for BH-540. The values for harvest index were highest for BH-540 (52.74%), intermediate for BH-660 (51.96 %) and lowest for Kulani (45.66 %). Significant varietal differences were observed for ash (P<0.01), NDF (P<0.01), ADF (P<0.05), ADL (P<0.05) and IVDMD (P<0.01) values. The present study revealed that the two hybrids had higher grain yield compared to the open pollinated variety, Kulani. Ranking of the genotypes was consistent for harvest index, potential utility index and digestible crop residue yield, the order being BH-540 > BH-660 > Kulani. Consistently similar ranking order was observed for stalk, total residue, CP and CP yield; the ranking being Kulani > BH- 660 > BH-540. BH-660 ranked first in grain yield and consistently ranked second for most of the important quality traits. In the present study, genotypes with higher grain yield were also observed to have higher digestible crop residue yields suggesting the possibility of selecting maize varieties that combine grain yield with desirable residue quality attributes.

Key words: Variety; Maize; Nutritive value; Grain yield; plant fractions

Introduction

Maize ranks first in production and yield among main cereals in Ethiopia (Benti *et. al.,* 1992). The improvement efforts made so far focused on grain yield and no attention has been given to yield and quality of stover (Adugna *et. al.*, 1999). In maize dominated farming system of Western Ethiopia, farmers traditionally use maize stover as important source of feed, firewood and construction of grain storage structures. Due to rapidly increasing human population and a subsequent need for cultivable land, more grazing land is being put under cereal production. It is, therefore, desirable to have a high grain and stover yielding genotypes to improve animal feed budget in the intensified maize based systems.

Literature evidences reveal the existence of genetic differences in yield and quality of cereal residues. Pearce *et al* (1988) for example have reported wide genotypic differences for leaf to stem ratio, chemical components, *in vitro* DM digestibility and intake for rice. Saini *et. al.*, (1977) reported that digestibility, neutral detergent fiber and tannin contents are under genetic control in sorghum, and consequently improvements through breeding should be possible. Moreover, Rattunde (1998) detected large genetic variation for grain and stover yields in sorghum, with these attributes not negatively correlated.

Studies conducted by Adugna *et. al.*, (1999) have also revealed evidence of varietal differences in grain and stover yields; and stover quality in maize and suggested that there are possibilities of selecting for maize varieties that combine high grain yield and desirable stover quality parameters. This suggests that there are considerable opportunities for selection favoring both traits provided that plant breeders, agronomists and animal nutritionists make joint efforts. The objective of the present study was to evaluate three commonly grown maize genotypes for grain, digestible crop residue yield and nutritive value of the stover.

Materials and methods

Location

The study was carried out at Bako Research Center located at $09^{0}6'$ latitude, $37^{0}09'$ E longitude and 1650 m.a.s.l. The mean annual rainfall is 1200mm, of which more than 80 percent is received between May and September. The mean minimum and maximum temperatures of the area were 13.7 and 27.9^{0}C, respectively. The soil is reddish-brown clay to sandy-clay loam Nitosols with a P^{H} ranging 5.3-6.

Maize varieties

Two hybrids (BH-660 and BH-540) and one open pollinated variety (Kulani) developed by Bako Research Center were used for the study. BH-660 and BH-540 are hybrid varieties released in 1993 and 1995, respectively. BH-660 adapts well in areas having an altitude ranging 1600-2400 and BH-540 was released for areas having an altitude varying from 1000-2000 m.a.s.l. Kulani was the third variety used in this study and it is an open pollinated maize variety released in 1995 by the same center. It adapts to areas with an altitude range of 1700-2400 m.a.s.l.

Planting, data collection and sampling

BH-660, BH-540 and Kulani were grown on neighboring plots at the Animal Feeds and Nutrition Division Research Farm of Bako Agricultural Research Center on 1,298, 930 and $525m^2$ area, respectively in 2001. An intra-and inter-row spacing of 50 and 80cm, respectively with 2 plants per hill and Recommended fertilizer rate of 92/69 N/P_2O_5 was used for BH-660. For BH-540 and Kulani, the within and between row spacing was 25 and 75cm, respectively, and the fertilizer rate used was 75/75 N/P_2O_5. All field operations were done as per the available recommendations for maize production. At grain maturity 10 samples of 8, 6 and 6-m^2 area for BH-660, BH-540 and Kulani, respectively were harvested by cutting the stalk at about 10 cm above ground level. The harvested stover was partitioned in to grain and different stover components. Sub samples of each stover component were dried in an oven at 65 ^{0}C for 72 hrs to determine the dry matter yield for each component. Harvest index (HI) was calculated as the ratio of grain to total above ground biomass yield multiplied by 100. The potential utility index (PUI) of the different maize varieties was calculated according to Fleischer *et. al.*, (1989). Digestible crop residue yield (DCRY) was calculated through multiplying the IVDMD values by the whole residue DM yields and crude protein yield was also estimated through multiplying crude protein concentration of the whole stover by the total crop residue DM yield.

Chemical analysis and *in vitro* DM digestibility

DM and ash contents were determined according to the procedure of AOAC (1980). The concentration of N was determined by micro Kjeldhal procedure and crude protein (CP) content was calculated as N x 6.25. The fiber components viz. neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest (1970). A modified *in vitro* Tilley and Terry technique (1963) was used to determine *in vitro* DM digestibility (IVDMD).

Design and data analysis

The data were arranged in completely randomized block design considering the 10 randomly collected samples of each variety as replicates for both yield and stover quality attributes. The analysis of variance was conducted using MSTATC computer software and significant mean differences were detected using the least significant difference (LSD) procedure.

Results and discussion

Grain yield, yield components and indices

The mean grain yield and other components, harvest and potential utility indices, digestible crop residue and crude protein yields of the three maize varieties are given in Table 1. Varietal differences were significant (P<0.01) for all measured parameters except for the husk fractions (P>0.05). Grain and leaf yields were significantly highest for BH-660. The cob and total residue yields were lowest for BH-540 and in most cases values with a narrow range of differences were observed for BH-660 and Kulani. The values for harvest index were highest for BH-540 (52.74%), intermediate for BH-660 (51.96 %) and lowest for Kulani (45.66 %). Harvest index for the open pollinated maize variety, Kulani, in the present study is similar to indices reported for open pollinated varieties by Adugna *et. al.*, (1999). Narrow inter-varietal differences for harvest index were observed in the current study for the hybrid varieties, BH-660 and BH-540, and the values are generally higher when compared with the open pollinated variety. Digestible crop residue yield was higher for BH-540 followed by Kulani and BH-660 in a decreasing order. On the other hand, crude protein yield was significantly lower for BH-540, higher for Kulani, and intermediate for BH-660. The significant differences in potential utility index (PUI) in the present study is also in agreement with results reported elsewhere (Adugna *et. el.*, 1999) where maize varieties differed significantly in their harvest index values. The mean percentage values of potential utility indices for all varieties were also higher than those of the harvest indices indicating the higher potential benefit of maize if residues are effectively utilized for feeding of farm animals.

Chemical composition and *in vitro* DM digestibility

The effect of variety on chemical composition and *in vitro* DM digestibility of three maize varieties is shown in Table 2. Significant varietal effects were observed for ash (P<0.01), NDF (P<0.01), ADF (P<0.05), ADL (P<0.05) and IVDMD (P<0.01) values. For N and ADF-ash, the effect of variety was not significant (P>0.05). The significant varietal difference for ash and other fiber components in the current study is in agreement with the reports of Adugna *et. al*, (1999) who found significant (P<0.05) varietal differences for these components in maize. The overall mean in ash concentration obtained in the present study (4.334g/kg), however, is much lower than the mean values reported previously (74g/kg) by Adugna *et. al.*, (1999). The significant difference for *in vitro* DM digestibility among varieties observed in this study is contrary to the reports made by Fleischer *et. al*, (1987) for maize. Adugna *et. al*, (1999) also reported a significant difference for i*n sacco* DM digestibility for maize under Awassa condition of Southern Ethiopia. In general, the CP values of all varieties in the present study were lower than the reported critical level of 8 percent suggested by Milford and Minson (1966) and it can thus be implied that intake and utilization of these residues would be low unless supplemented with a protein–rich diet. Adugna *et. al.*, (1999) in evaluating different maize varieties have, based on their result suggested that due to low CP and high lignocellulosic cell wall contents, it is justifiable to evaluate alternative sources of protein if nutritional constraints to animal production is to be alleviated.

Conclusion

The present study revealed that the hybrids, BH-660 and BH-540, had higher grain yield compared to the open pollinated variety, Kulani. Ranking of varieties was consistent for harvest index, potential utility index and digestible crop residue yield, the order being BH-540 > BH-660 > Kulani. The same was also true for ranking varieties using NDF, ADF and IVDMD. Consistently, similar ranking order of the varieties was observed for stalk, total residue, CP and CP yield; the ranking order being Kulani > BH- 660 > BH-540. The hybrid, BH-660 ranked first in grain yield and consistently ranked second for most of the important quality traits suggesting the possibility of selecting for varieties that combine higher grain yield with desirable quality parameters.

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Table 1. Effect of variety on maize grain yield, yield components, harvest and potential utility indices, crude protein and digestible crop residue yields of three maize varieties (n = 10)

Yield components	Maize varieties			SE	P level
	Kulani	BH-660	BH-540		
Grain (t/ha)	7.86b	9.93a	8.00b	0.19	**
Cob (t/ha)	1.66a	1.59a	1.28b	0.07	**
Stalk (t/ha)	4.05a	3.62a	2.56b	0.24	**
Leaf (t/ha)	2.36b	2.93a	2.09b	0.13	**
Husk (t/ha)	1.32	1.09	1.19	0.06	NS
Total residue (t/ha)	9.37a	9.24a	7.17b	0.36	**
Harvest index (%)	45.66b	51.96a	52.74a	0.97	**
Potential utility index (%)	67.51b	71.61b	78.18a	1.43	**
Digestible crop residue yield (t/ha)	3.77ab	3.75b	3.86a	0.29	*
Crude protein yield (kg/ha)	261.00a	254.00a	195.00b	15.33	**

*= Significant at P<0.01; * = significant at P<0.05; NS = non significant; SE = standard error of treatment means; means within row followed by different letters vary significantly

Table 2. Effect of variety on Crude protein (%), ash and fiber components (g/kg) and *in vitro* DMD of three maize (n=10) Varieties

Variables	Varieties			SE	P level
	Kulani	BH-660	BH-540		
DM	90.03	89.78	89.80	0.31	NS
Ash	4.33b	4.43b	5.55a	0.26	**
CP	2.79	2.78	2.71	0.23	NS
NDF	741.30b	772.45b	867.20a	8.46	**
ADF	442.27b	458.41ab	463.91a	6.35	*
ADL	44.69b	52.57a	47.86ab	2.21	*
ADF-Ash	16.49	17.18	17.00	2.27	NS
IVDMD	40.20b	44.78b	53.86a	1.35	**

** = Significant at P<0.01; * = significant at P<0.05; NS = non significant; SE = standard error of treatment means; means within row followed by different letters vary significantly

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Determination of rangeland condition using the benchmark method: A study in part of the Middle Awash

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Abstract

A study with the objective of comparing the condition of communal grazing lands with that of the benchmark sites was undertaken in part of the middle Awash Valley of Ethiopia. The communal grazing lands and the benchmark sites were compared in terms of herbaceous species composition, basal cover, grass DM yield, grazing capacity and soil compaction. The benchmarks had higher basal cover (p<0.01) and grass DM yields (P<0.001) than the communal grazing lands. In both the benchmark and the sample sites, Chrysopogon plumulosus was the dominant grass species. Therefore, future studies should focus on the ability of this grass species to resist heavy grazing pressure. The result of this study demonstrates that, given proper management like resting of the grazing land the rangeland will bounce back remarkably well.

Keywords: rangeland, benchmark, communal grazing lands, Awash Valley, grazing capacity, herbaceous species composition

Introduction

A benchmark can be defined as a rangeland site (native pasture) with the best possible botanical composition and cover (excellent condition) in relation to prevailing climatic condition (Tainton 1999). Benchmarks are needed for rangeland managers to determine the condition and trend of the vegetation, which can provide pastoralists with information on the kind and amount of species that can be expected when vegetation is protected from grazing. It is also important for rangeland managers to be able to separate the impacts of grazing (or other consumptive uses) on the species composition and productivity of vegetation from those caused by climatic variations, explosions of insect populations or pollution (Taylor & Whalley 1976).

Danckwerts (1982) suggested that a benchmark should be an example of vegetation that is considered to provide the highest possible sustainable animal production for the rangeland type under consideration. This implies that it would have been well managed in the past. Unfortunately, under the prevailing condition in Ethiopia, there are few areas that can be classified as being in excellent condition. To overcome this problem, in relative terms, the best sites irrespect of vegetation condition were identified in the study area, which could serve as a benchmark for this study. Accordingly, protected grazing reserves locally known as 'kalo' and the little used junction site between the Afar and Oromo ethnic groups were used for the study. The use of multiple benchmarks has been recommended by Wilson (1984) to minimize the bias arising from area selection. This study was, therefore, undertaken to compare the communal rangelands with the protected plots and therefore get an insight into the condition of grazing areas in relation to protected plots (Benchmarks).

Materials and methods

Description of the study area

The study districts, Awash-Fantale (Afar) and Kereyu-Fantale (Oromo) are located adjacent to each other in the southern part of north-eastern rift valley of Ethiopia, in the middle Awash valley that has taken its name from one of the biggest river (Awash) in Ethiopia. They fall at the junction between the Afar and Oromia Regional States and are situated along the main transport system in Ethiopia. The total land area of Kereyu-Fantale district is 1,169.85 km^2 (CSA 2000), while that of Awash-Fantale district is 1,080.0 km^2 (Wolde Gabriel 2001). The main rainy season is from July to September, while the short rainy period is from February to April. The rainfall is highly irregular, weakly bimodal with a mean annual rainfall of 550.9 mm. The mean minimum and maximum temperatures are 17.4°C and 32.7°C, respectively.

Identification of benchmark sites

Three benchmarks sites were identified in the study area based upon similarity in altitude, soil, and nature of the vegetation in the rangelands to which they will be compared. The Oromo pastoralists protected two of the benchmark sites during the dry season, to use either by harvesting or allowing the animals to graze. The third one is known as the `land of fear` locally called "Lafa soda"**.** This area is located at the junction between the Oromo and Afar boundaries and has a very good vegetation cover for the mere reason that both pastoral groups do not graze their animals freely and continuously in these areas in fear of prosecution by the other group. As a result, the intensity of the grazing was low. Six sampling sites (four from the Oromo and two from the Afar) were compared with the benchmark sites.

The rainfall both at the benchmarks and the sampling sites ranged from 550 to 620 mm and the altitude from 950 to 1040 m.a.s.l. The major focus in this study was the composition of grass layer based on the rationale that the cattle and sheep are more affected by the change in the vegetation compared to the camels and the goats, which are also browsers. Comparisons were made between benchmarks (Dhebeti and D/Galcha = Benchmark 1) and the sample sites (Madala1, Kachachilo and Harole1= First group). The second group contained one benchmark (Dakaakae= Benchmark II) and four sampling sites (Top of bud, Aleka, Harole 2 and Madala 2 = second group).

Data collection and analysis

In each of the benchmark and sampling site the species composition of herbaceous layer was determined based on the frequency of occurrence using a wheel point apparatus (Tidmarsh & Havenga 1955) where the nearest plants were recorded. At each point observation, the nearest herbaceous plant, within a radius of 300 mm was recorded by species for grasses, which included both annuals and perennials. Non-grass herbaceous species were combined as forbs. If no herbaceous species of the given criteria occurred within the given radius of the point, it was recorded as “bare ground”. Bare ground was treated as if it was a plant species and gave an indication of plant density (Mentis 1984), which is also an important additional parameter for recording real changes in rangeland condition (Danckwerts & Teague 1989). Plants that can be identified easily in the field were identified using field guides (CADU 1974; Ibrahim & Kabuye 1987; Reinhard & Admasu 1994) and experienced technical personnel. For those plant species not identified in the field, a herbarium sample of each species was pressed, labelled and sent to the National Herbarium of Addis Ababa University for identification. Sampling was done from mid August to mid September 2001, at a time when most pasture plants were fully-grown and flowering (important for identification).

The identified grass species were classified into four groups based upon desirability. The desirability ratings were based on their long-term reaction to grazing (ecological groups) and palatability. The ecological status (decreaser and increaser species) as defined by Foran *et al.* (1978) was also taken into consideration. Accordingly, they were divided into highly desirable, desirable, less desirable and undesirable grass species. Highly desirable grass species include species that are decreasers and perennials with a high palatability, while the desirable grass species are those that increase in abundance with moderate over-utilisation (Increaser IIa), perennials and which were average or high in terms of their palatability as perceived by the pastoralists. The less desirable species include those species of grasses that increase in abundance with severe or extremely severe over utilisation (Increaser IIb and IIc). This group includes both perennial and annual species that are less palatable. Forbs and bare ground were considered as undesirable plants. The classification of the grass species into decreaser, IIa, IIb and IIc followed the method described by Vorster (1982) with some modification to suit the local conditions.

Basal cover

The same apparatus (wheel point) used in determining species composition was used for basal cover assessment and was determined from the proportion of strikes as described by Tidmarsh & Havenga (1955) and Foran *et al.* (1978).

Grass dry matter yield

At each sample site the herbaceous vegetation (grasses & forbs) was harvested at ground level at 50% flowering stage. Clipping the vegetation in 5 randomly placed quadrates by (1 m x 1 m) were done per identified sampling site. Separation was made between grasses and forbs, but the scale of the sampling, did not permit separation into the different grass species. At the end of the fieldwork, the samples were oven-dried at 105 °C for 24 hours and weighed.

Soil compaction

Soil compaction was measured using a rod penetrometer (ELE pocket penetrometer). At each sampling site three representative plots of 1 m x 1 m were identified and watered artificially to a depth of approximately 10 mm. Two to three hours after wetting, an estimation of the soil compaction was obtained by penetrating to a depth of 6 mm of the topsoil surface (Friedel 1987).

The benchmarks and the sampling sites were compared for vegetation attributes according to Danckwerts (1982). The relevant weighting score of 10, 7, 4 and 1 for highly desirable, desirable, less desirable and undesirable (bare ground and forbs), respectively, was multiplied with the percentage species composition of each species to give the individual species score and these were added up for each sample site to give the total score for the site. The total score of the site, expressed as a percentage of the total score of the comparable benchmark, gave the percentage score of the site.

Estimation of the grazing capacity was made from the yield of grass layer, using the formula proposed by Moore *et al*. (1985) and again described by Moore & Odendaal (1987) and Moore (1989) as follows:

$$Y = d \div \underline{[DM \times f]}/r$$

Where, y = grazing capacity (ha LSU^{-1})

d = number of days in a year (365)

DM = total grass DM yield (kg ha^{-1})

f = utilization factor

r = daily grass DM required per LSU (2.2% of body mass = 10 kg day^{1})

The grazing capacity was expressed using both hectare per Large Stock Unit (ha LSU^{-1}) and hectare per Tropical Livestock Unit (ha TLU^{-1}). An LSU is an animal with a mass of 450 kg and which gains 0.5 kg day^{-1} on forage with a digestible energy percentage of 55%. The animal will consume 10 kg of forage dry matter daily. In the calculation of grazing capacity based upon TLU, the assumption taken was that, an animal will consume 2.5 % of its body weight (Boudet & Riviere 1968; Minson & McDonald 1987), thus each TLU will consume 6.25 kg of forage dry matter daily. In both LSU and TLU, the utilization factor used was 0.35. The grass DM yield and basal cover data were analysed using GLM (SAS, 1987).

Results

Rangeland condition assessment

The condition of the sample sites (Harole1, Madala1 and Kachachilo= group 1), when calculated as a percentage of the average of the benchmarks (Benchmark = 1), was lower than the benchmarks and it ranged from 65.58% (Madaa1) to 90.08% (Harole 1). The condition of the second group of sample sites in relation to the respective benchmark was 97.19% (Aleka), 90.96% (Harole2), 94.27% (Madala2) and 99.09% (Top of bud). In terms of rangeland condition, the small-scattered grassland areas interspacing woodlands along the top of bud were comparable to the benchmark (**Tables 1 and 2**).

Grass dry matter yield and basal cover

The DM yields of the grass (kg ha^{-1}) of the three sample sites, compared with the average of Dire galcha and Dhebeti (Benchmark 1) was 37.73% (Kachachilo), 48.20% (Madala1) and 40.79% (Harole 1). This implies that the benchmarks had a higher yield than that of the sample sites ($P<0.001$) (Figure 1). Similarly, the yield of the grasses, for the second group of sample sites, was 44.31% (Harole 2), 52.36% (Madala 2), 50.54% (Top of bud) and 53.11% (Aleka) of that of the benchmark (Dakaakae). Similar to the yield, the basal cover of the benchmark was higher than that of the sample sites in both cases ($P<0.01$).

Table 1. Rangeland condition scores in the first group of sample sites

Species category	Species	Factor	BM1 (Dhebeti)		BM1 (Dire galcha)		Kachachilo		Madala 1		Harole1	
			%	score	%	Score	%	Score	%	Score	%	Score
Highly desirable	Chrysopogon plumulosus	10	71	710	86.6	866	36.79	367.90	54.7	547	62.40	624.0
Undesirable	Bare ground	1	1	1	0.6	0.6	7.31	7.31	5.18	5.18	5.6	5.60
Less desirable	Coelachyrus Poiflorum	4	1	4			1.38	5.52	3.59	14.36	6.6	26.40
Less desirable	Sporobolus natalensis	4	2.8	15.2	8	32	48.61	194.44	0.4	1.6	20.6	82.40
Less desirable	Panicum snowdenii	4					1.58	6.32	0	0	3.6	14.40
Undesirable	Forb	1			1.6	1.6	2.96	2.92	0.8	0.8	0.8	0.80
Less desirable	Eleusine indica	4							0	0	0.2	2
Highly desirable	Cenchrus setigerus	10	0.4	4			0.98	9.8	1.6	16	0.2	2
Highly desirable	Cenchrus ciliaris	10							0	0	0	0
Desirable	Heteropogon contortus	7	20.4	142.8					0	0	0	0
Less desirable	Setaria verticellata	4			0.2	0.80	0.19	0.76	0	0	0	0
Desirable	Cymbopogon commutatus	7	3.4	23.80	1	7			0.8	3.2		0
Less desirable	Cynodon dactylon	4			2	8			0	0	0	0
Highly desirable	Tetrapogon cenchriformis	10							0	0	0	0
Highly desirable	Panicum coloratum	10							0	0	0	0
Desirable	Chloris roxburghiana	7							0	0	0	0
Desirable	Paspalm glumaceum	7							0	0	0	0
Highly desirable	Chloris gayana	10							1.4	5.6	0	0
Less desirable	Aristida Adscenionsis	4							0.2	0.8		0
Less desirable	Dactyloctenium aegypticum	4							0	0	0	0
Highly Desirable	Cymbopogon excavatus	10							0	0	0	0
Less desirable	Sorghum purpureo cericeum	4							0	0	0	0
Less desirable	Enneapogon schimperanus	4							0	0	0	0
Desirable	Eragrostis racemosa	7							0	0	0	0
Less desirable	Tragus berteronianus	4					0.2	0.80	0.8	3.2	0	0
Desirable	Pennisetum stramineum	7							30.53	213.71	0	0
Less desirable	Eragrostis cilianensis	4							0	0	0	0
Total score			100	900.80	100	916.0	100	595.77	100	811.45	100	757.6
Percentage score relative to the benchmarks								65.58		90.08		83.40

Table 2. Calculation of rangeland condition in the study districts

Species category	Species	Factor	Dekaakae		Harole 2		Aleka		Madala 2		Top of bud	
			%	Score	%	Score	%	Score	%	Score	%	Score
Highly desirable	Chrysopogon plumulosus	10	43.6	436	73.1	731	84.3	843	71.23	712	85.32	853.2
Undesirable	Bare ground	1	0.2	0.2	7.1	7.1	5	5	0.6	0.6	3.07	3.07
Less desirable	Coelachyrus Poiflorum	4	2.6	10.4	6.4	25.6	2	8	0.09	0.36	1.06	4.24
Less desirable	Sporobolus natalensis	4	2.8	11.2	4.60	18.4	5.12	20.48	9.05	36.2	8.28	33.12
Less desirable	Panicum snowdenii	4	0		4.4	17.60	1.4	5.6	0	0		
Undesirable	Forb	1	1.2	1.2	0.80	0.80	1.58	1.58	0.8	0.8	0.66	0.66
Less desirable	Eleusine indica	4	0	0	0	0	0.4	1.6	0	0		
Highly desirable	Cenchrus setigerus	10	1.8	18	0.8	8	0.2	0.80	0	0	0.2	2
Highly desirable	Cenchrus ciliaris	10	6.2	62	1	10			0.2	2	0.25	2.50
Desirable	Heteropogon contortus	7	0	0					0	0		
Less desirable	Setaria verticellata	4	0	0					0	0		
Desirable	Cymbopogon commutatus	7	0	0					0	0		
Less desirable	Cynodon dactylon	4	0.4	1.6					0.6	2.4		
Highly desirable	Tetrapogon cenchriformis	10	15	150					0	0		
Highly desirable	Panicum coloratum	10	9.8	98					0	0		
Desirable	Chloris roxburghiana	7	4.2	29.4					0	0		
Desirable	Paspalm glumaceum	7	1.6	11.2	0.2	1.4			0	0		
Highly desirable	Chloris gayana	10	2	20					1.01	7.07		
Less desirable	Aristida adscenionsis	4	0.2	0.8					0.8	3.2		
Less desirable	Dactyloctenium Aegypticum	4	0.2	0.8	0.6	2.4			0	0	1.16	4.64
Desirable	Cymbopogon commutatus	7	5	35					0	0		
Highly desirable	Cymbopogon excavatus	10	2.2	22								
Less desirable	Sorghum purpureo cericeum	4	0.6	2.4					0	0		
Less desirable	Enneapogon schimperanus	4	0.4	1.6					0	0		
Desirable	Eragrostis racemosa	7			1	7			0	0		
Less desirable	Tragus berteronianus	4							2.82	11.3		
Desirable	Pennisetum stramineum	7							10.79	75.5		
Less desirable	Eragrostis cilianensis	4							2.01	8.04		

Species category	Species	Factor	Dekaakae		Harole 2		Aleka		Madala 2		Top of bud	
			%	Score	%	Score	%	Score	%	Score	%	Score
Total score			100	911.8	100	829.3	100	886.06	100	859.5	100	903.43
Percentage score relative to the benchmark						90.96		97.19		94.27		99.09

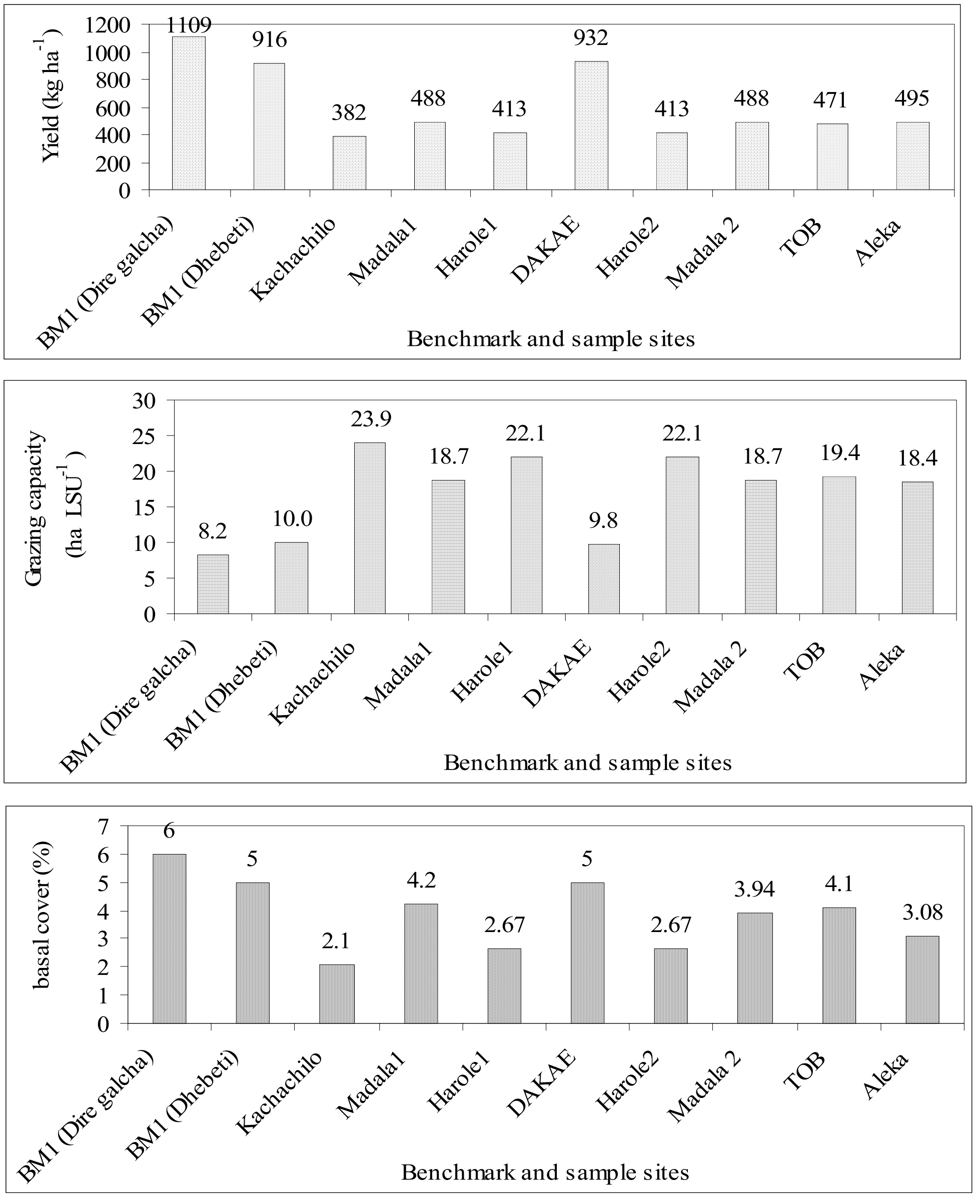

Figure 1. Grass dry matter yield, grazing capacity and basal cover of sample sites and the respective benchmark sites.

Grazing capacity

In both benchmark sites and across the sample sites (**Figure 1**), the grazing capacity improved from as low as 23.9 ha LSU^{-1} (Kachachilo) to 8.2 ha LSU^{-1} (BM1) and when the same figure is expressed using TLU^{-1} it ranged from 5.88 to 17.06 (**Figure 2**). This result indicated that, given proper management of the rangelands, there could be a considerable improvement in the grazing capacity of the rangelands.

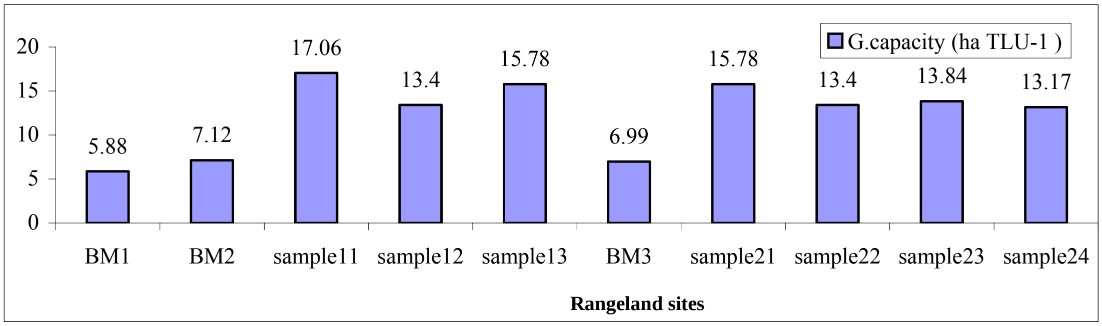

Figure 2. Grazing capacity (ha TLU-1)

Soil compaction

The compaction of the topsoil surface was lower at benchmark 1 than the corresponding sample sites, namely, Kachachilo, Madala1 and Harole1. Compared to the average of the protected plots, the compaction at the sample sites was higher by 25.58% (Kachachilo), 26.58% (Madala1) and 4.98% (Harole 1). In the second group, two of the sample sites had slightly higher soil compaction than the benchmark site and two of the sample sites had slightly lower soil compaction than the corresponding benchmark site (Figure 3).

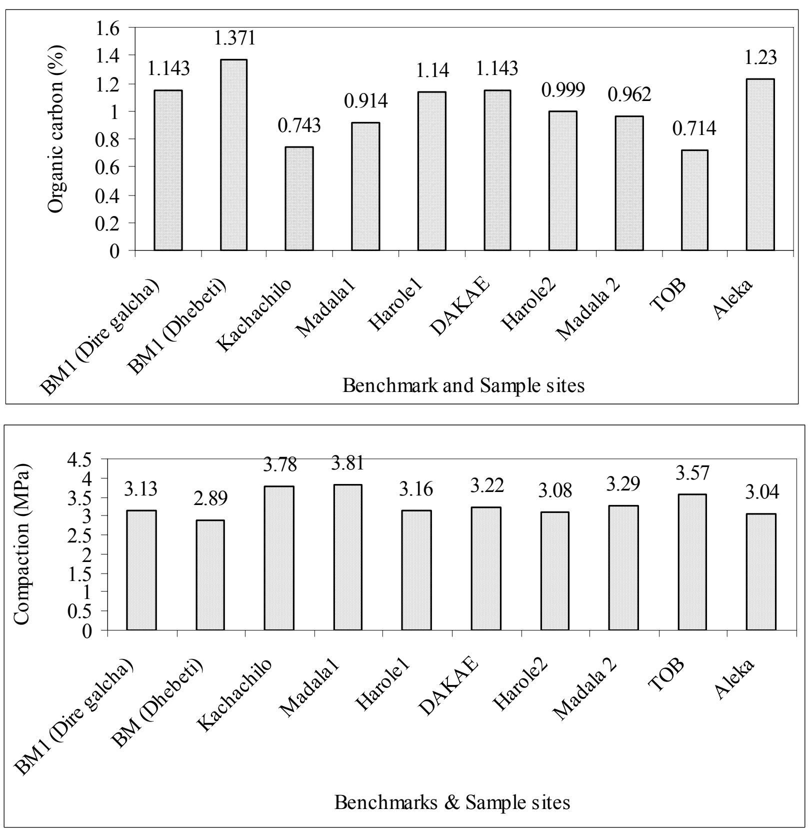

Figure 3. Soil organic carbon and compaction values in the sample and benchmark sites.

Discussion

Rangeland condition

With an objective of developing better and faster methods of rangeland evaluation, numerous researchers have contributed to the refinement of the available techniques as well as the variables that need to be measured. Accordingly, the benchmark method was developed as one method of rangeland evaluation technique. However, limitations to the benchmark method have been suggested by Mentis (1983); Barnes *et al.* (1984) and Martens *et al.* (1996). One of the drawbacks of the rangeland evaluation techniques is that they usually lack universal applicability. Thus, the choice of which method to use usually depends on the local condition. Accordingly, an assessment of vegetation was undertaken using the benchmark method. Except at Kacachilo, where the rangeland condition was low relative to the benchmark sites, the rest of the sample sites had a comparable condition with the benchmark sites. This could be due to the relatively short period of years that the benchmarks have been protected. Therefore, the grass species are more or less similar at the benchmark and the sample sites. It can also be concluded that the current benchmark sites are not a good indication of the true potential of the area.

Grass dry matter yield, basal cover and grazing capacity

Compared to the benchmark sites, the sample sites had a substantially lower grass DM yield, basal cover and grazing capacity, which implies that there had been a deterioration in condition of the rangelands. The specific reasons for the degradation are many and varied. However, the most likely reason for the deterioration in rangeland condition manifested in lower yield, basal cover and consequently reduced grazing capacity, is associated with overgrazing. The sample and the benchmark sites are found in the same ecological unit, where one can assume that the influence of climate is the same for both. Overgrazing and the associated decrease in basal cover and lowered grazing capacity were well documented (e.g. O`Connor 1985; O` Connor 1991). Lazenby & Swain (1969), and Snyman (1999a) argued that overgrazing lead to a decline in the quality and productivity of the rangelands. Though it is very difficult to determine grazing capacity of rangelands under the pastoral production system where communal ownership of the land predominate the management, it is essential to estimate grazing capacity. This can serve as a guide for sustainable rangeland utilisation. The improvement in the grazing capacity from the protected plot is a clear indication that, given proper management of the rangeland, there is room for improving the condition of the rangeland.

Soil compaction

Compaction is the most complex soil feature having significant interrelationships with most of the recognized physical, chemical and biological properties of soils as well as with environmental factors such as climate (McKibben 1971). Both internal and external factors affect the compaction of a given soil (Bennie & Krynauw 1985), and organic matter is one of the internal factors affecting soil compaction. In general terms, the findings of this study indicated that those sites with a low OC content had a higher compaction. Woodward (1996) argued that negative effects on seedling establishment and growth are often attributed to changes associated with soil compaction, including reduced water infiltration rates, decreased diffusive and mass flow of nutrients and solutes through the soil, anoxia and increased resistance to root penetration (Greacen & Sands 1980). The loss of vegetative and litter cover with degradation (Warren *et al.* 1986) allows direct impact of raindrops on soil (Russel *et al.* 2001) and may also produce hydrophobic substances that can reduce infiltration (Snyman 1999 a,b).

Conclusions

The most noteworthy differences between the benchmark and sample sites were found to be in basal cover and grass yield, which indicated the possibility to improve the grazing capacity of the study area with proper management. Two of the benchmarks used in this study are plots protected by the community and such efforts need to be encouraged and supported technically. In both the benchmark and the sample sites, *Chrysopogon plumulosus* was the dominant grass species. Therefore, future studies should focus on the ability of this grass species to resist heavy grazing pressure. The result of this study demonstrated that given proper management like resting of the grazing land the rangeland would bounce back remarkably well

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Evaluation of different oat/vetch mixtures for forage yield performance and compatibility in the highland of Bale

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Abstract

*Three oat varieties (*Avena sativa*) and three vetch species (*vicia sativa*) were sown in mixture at three seed rate proportion and at four locations (Sinana on station, Sinana on farm, Goba &Agarfa) in 2002 and 2003 ' Meher (August- December) season. The yield performance and compatibility of different oat- vetch mixture were evaluated in split- split plot design. Result indicated that DM yield and agronomic performances were significantly (P<0.05) varied across years and locations. Relatively, 37% higher DM yield was obtained in 2003 with that of 2002. Total DM yield and DM proportion of oat and vetch in mixture were not significantly (P>0.05) affected by the interaction of seed rate of oat varieties and vetch species. Though highest DM yield was recorded from* Oat CI8237 *mixture with* Vicia sativa *(7.78t/ha) at 60:22.5 kg/ha seed rate, this combination was not compatible due to early maturing nature of* V.sativa. *Generally, from all oat-vetch combinations, in terms of DM yield, mixture of* Oat-CI8251 + V. atropurpurea *and in terms of DM yield proportion of vetch in mixture,* Gray algiers + V. atropurpurea *at seed rates of 60:22.5 and 40:15 kg/ha were relatively compatible and performed well. The highest DM yield (6.83 and 6.76 t/ha) and other agronomic parameters were obtained at the seed rates of 80:30 and 60:22.5 kg /ha. There was an increasing trend of DM yield and agronomic parameters with increasing seed rate. Further study is required to evaluate the effect of fertilizer on quantity, compatibility and quality of oat -vetch mixture.*

Introduction

In high lands of Bale livestock mainly depend on natural pasture, crop residue, and crop aftermath. The quality and quantify of these feed resources, however, are very poor to meet the feed requirements of livestock. As a result, the productivity of livestock became low. The draught out put from oxen is minimal and this inturn affected crop production negatively (Tekleyohanis & Worku, 1999). To alleviate these problems cultivation of oat/vetch mixture is important.

Oat /vetch mixture improve the crude protein content of the product (Getent and Ledin 1999; Astatike, 1977) and it increases the quantity of the livestock feeds (Getent and Ledin 1999; Mesifin and Samuel 2000). It has a good potential when integrated with food crops (Daniel 1993) as it maintains soil fertility. Many oats varieties and vetch species have been selected and identified for Bale high lands by Tekleyohanis & Worku, (1997).

Oat/ vetch mixture study at Sinana indicated that cultivating oat and vetch in mixture in integration with barley-increased forage and barley grain yield (Tekleyohannes, 2003). However forage yields, quality, compatibility and proportion of oats and vetch in mixture is affected by several factors among which soil fertility, proportions of seed rate and variety difference of the companion crop are important. Oat Variety and vetch species have difference agronomic characteristics. As a result, their performance could vary when sown in mixtures of different varieties oat and vetch species combinations, on different soil type and fertilizer level (Getent and Ledin, 1999).

However, information on yield performance and compatibility of oat/vetch mixture under different seed rate proportion is scanty in the high lands of Bale. Hence identifying compatible combination of oat/vetch varieties in the existing farming system is important to improve livestock feed quantity & quality. The objectives of the experiment, therefor, to evaluate the yield performance of different oat- vetch mixture under different seed rate proportion and to identify the best compatible combination from different mixtures of oats varieties & vetch species.

Materials and methods

The experiment was conducted for two years (2002-2003) in high lands of Bale at four locations, Sinana on station (2400m.a.sl), Sinana on farm (2400m.a.sl), and Agarfa (2530) and Goba (2700m.a.sl). A ten-year data obtained from Agarfa training college indicates that Agarfa receives about 760mm of rainfall per annum. The monthly average temperature ranges from 5.8^{0}C (February) to 10.4^{0}C (April) and the maximum temperature ranges 21.2^{o}C (April) to 24.5^{0}C (March). Sinana district received 850 mm of rainfall per annum (Alemayehu & Franzel, 1987). The areas are characterized by bimodal rainfall. The first or Belg rain lasts from March to July while the second or 'Meher' rain is from August- December. The study was undertaken in 'Meher' season (August to December). The soil type in Sinana area is generally classified as pellic vertisol (Alemayehu & Franzel, 1987), while most of that of Agarfa and Goba was vertisol type (Chintalapati et al., 2001).

The design used for the experiment was split- split plot with three replications. Seed rate was laid as main plot treatment at three levels (80:30, 60:22, 40:15 kg/ha) of oat /vetch mixture). The Sub plots treatments were three Oat varieties (*Oat CI8251, Oat CI8237, & Gray algiers*). The three vetch species (*V.villosa. V.atropurpurea & V.sativa*) were used as sub – sub plot treatment. Totally, twenty-seven treatments were used for the experiment. Main plots, Sub-plot, Sub-sub plot size were 11mx14m, 3mx14m, and 3mx4m, respectively.

The mixtures were sown in broadcast method on well-prepared seedbed. No fertilizer was applied to all plots. Hand weeding was done once after 30 days in all locations. Plot cover, vigor, and compatibility were measured on plot basis using 0-5 rate scale. Dry matter yield estimate was made when oat reach full heading and the vetch attained (15-50) flowering stage. Plant height of oat and vetch were measured at harvest. The total biomass of oat and vetch in mixture was weighed and separated in to oat and vetch to estimate their proportion. DM was determined in sun-dried after constant weight had obtained.

All data were subjected to analysis of variance using MSTAT software and means were separated using LSD test

Result and Discussion

Yield and agronomic data were presented in Table (2, 3, 4, 5 & 6). Based on visual appraisal, all oat varieties were fast growing and dominated over the associated vetch species in terms of plot cover and vigor from establishment time up to anthesis. However, at latter stage, the growth of vetch species was found to be compatible with oats. This might be due to the supporting structure of oats to vetch species since the vetch is climbing annual legume. Mean DM yield and all considered agronomic parameters were significantly ($P<0.05$) varied over the trial periods (Table 2). Relatively 37% higher DM yield was obtained in 2003 with that of 2002. This variation might be due to climatic factor, particularly the rainfall in 2003 (Table 1). Significantly ($P<0.05$) higher total DM yield, DM proportion of oat in mixture and height at harvest of both oat and vetch were observed at Agarfa followed by Goba, Sinana on station and

Sinana on farm. This is probably due to climatic variation among the four locations, particularly, moisture stress at Sinana on farm and high stem rust severity at Sinana on station during late growing period might have retard the growth and the performance of the mixture.

DM yield and DM proportion of oat and vetch in mixture were not significantly (P>0.05) affected by the interaction of seed rate of oat varieties and vetch species (Table 3&4). Though highest DM yield was recorded from Oat CI8237 mixture with *Vicia sativa* (7.78t/ha) at 60:22.5 kg/ha seed. This combination was not compatible due to early maturing nature of *V.sativa*. In terms of DM yield proportion of vetch in the mixture, *Gray algiers* + *V. atropurpurea* (0.81t/ha) mixture performed better than other combination (Table 4). This could be due to short in height, less vigor growth nature of *Gray algiers* and relatively did not suppress and reduce the growth rate of vetch**.** Lemma and Alemu (1991) found that the late oat variety, *Gray algiers*, had better compatibility with the medium maturing, wooly pod vetch.

Generally, from all oat- vetch combinations, mixture of Oat-CI8237 with *V. atropurpurea* and *V. villosa* at seed rate of 60:22.5 and 40:15 kg/ha and Oat -CI8251 mixture with *V. atropurpurea* and *V. villosa* at seed rate of 60:22.5 and 40:15 kg/ha and *Gray algeris* in mixture with *V.atropurpurea* at seed rate of 60:22.5 and 40:15 kg/ha were compatible and performed well.

As Lemma and Alemu (1991) and Mesifin and Samuel (2000) reported the oat CI8237 mixture with *V.atropurpurea* had better compatibility. Mesifin and Samuel (2000) also indicated Oat CI 8237 mixture with *V. villosa* gave better forage yield. Oat varieties and vetch Species had significant effect (P<0.05) on total DM yields, DM proportion of oat and vetch in mixture, plant height, tillering and seedling accounts for both oat and vetch (Table 5).

Oat CI 8251(7.15 t/ha) & Oat CI 8237(7.11 t/ha) gave significantly higher DM yield compared with *Gray algeris* (5.52t/ha). This attributed to higher DM proportion, plant height and seedling count of the respective oat varieties. Oat CI8251 (25.03), Oat CI 8237(24.06), *V. villosa* (6.55) and *V. atropurpurea* (6.71) had significantly higher seedling count at emergency compared with other oat variety and vetch specie. This result agrees with the result reported by Getnet and Ledin (1999), Gray algiers and vicia sativa showed lower seedling count at emergency (21.98&5.29). At latter growth stage, significantly (P<0.05) more tillers were developed among other oat varities and vetch species (Table 5). Over all means also indicated that oat CI 8251 (106.41 cm)& V. *villosa* (90 cm) were the tallest among oat varieties and vetch species and gray algeris (84.04 cm)& *V. sativa* (66.03 cm) was shortest among oat and vetch species. *Vicia atropurpurea* was constantly compatible with the oat varieties and significantly (P<0.05) produced higher DM proportion in the mixture (0.62t/ha)

Seed rate had significant (p<0.05) effect on total DM yields, DM proportion of oat, plant height, tillering and seedling accounts for both oat and vetch (Table 6).
Significantly highest DM yield (6.83 & 6.76 t/ha) and better agronomic performance were obtained at 80:30& 60:22.5 kg /ha seeding rate. However, tillering ability of oat and vetch performed best at lower seeding rate (40:15kg/ha).
Generally, there was an increasing trend of DM yield and agronomic parameters with respect to increasing seed rate. This result agree with the result reported by Tekleyohanes et al., (2003) that DM yield increased with increasing oat seed rate in oat vetch mixture and sowing at 80: 30 kg/ha seeding rate of oat vetch mixture gave highest DM Yield (7t/ha).

Conclusion

According to the result obtained mixture of Oat-CI8237 with *V. atropurpurea* and *V. villosa* at seed rates of 60:22.5 and 40:15 kg/ha, and Oat -CI8251 mixture with *V. atropurpurea* and *V. villosa* at seed rates of 60:22.5 and 40:15 kg/ha and *Gray algeris* in mixture with *V.atropurpurea* at seed rate of 60:22.5 and 40:15 kg/ha were compatible and performed well. Further study is required to evaluate the effect of fertilizer on quantity, compatibility and quality of oat-vetch mixture

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Table 1. Rainfall and temperature of Sinana on station and on farm, 2002-2003.

	Month	Rainfall (mm)	Temperature Minimum (0^C)	Temperature Maximum (0^C)
2002	August	33.8	9.9	22.3
	September	89.5	9.6	22.2
	October	81.6	10.3	20.4
	November	10.6	8.3	22.4
	December	36.4	10.2	22
	Total	251.9	Mean 9.66	21.89
	August	52.2	10.2	20.4
2003	September	129.3	9.4	20.5
	October	41.7	9.3	19.9
	November	38	9.3	21
	December	47.4	8.05	20.1
	Total	308.6	Mean 9.25	20.38

Table 2 .The effect of location and year on Yield and agronomic parameters of oat-vetch mixture.

	Year		Location					
Parameters	2002	2003	On station	On farm	Goba	Agarfa	LSD (P<0.05)	CV (%)
Total DM Yield (t/ha)	4.92	8.26	4.61c*	4.1d	8.23b	9.45a	0.2821	19.61
Proportion of oat in mixture (t/ha)	4.38	7.81	4.33c	3.73d	7.44b	8.89a	0.05028	20.88
Proportion of vetch in mixture (t/ha)	0.53	0.45	0.27d	0.33c	0.79a	0.56b	0.05028	47.01
Height at harvest of oat (cm)	82.56	114.56	68.64d	81.16c	119.49b	125a	2.161	10.04
Height at harvest of vetch (cm)	70.83	90.31	62.07b	53.63c	102.53a	104.1a	2.686	15.26
Seedling count of oat (no/0.25m^2)	20.87	26.51	24.59b	31.07a	15.53d	21.57c	1.167	22.56
Seedling count of vetch(no/0.25m^2)	6.54	5.83	6.31b	7.2a	5.6c	5.6c	0.4304	31.26
Tillering of oat per plant (No.)	4.27	4.7	5.17a	3.66d	4.37c	4.74b	0.2022	20.64
Tillring of vetch per plant (No.)	3.33	3.2	2.45d	3.1c	4.0a	3.52b	0.1679	23.57

Means within a row with different letters are significantly different (P< 0.05).

Table 3. The interaction effects of seed rate, oat varieties and vetch species on mean dry matter yield of mixture.

Treatment	Seed rate (kg/ha)			
	80:30	60:22.5	40:15	Mean(t/ha)
Oat CI8251-*V. villosa*	7.21	7.31	6.75	7.09
Oat CI8251-V. atropurpurea	7.49	7.37	6.54	7.13
Oat CI8251-*V. sativa*	7.32	7.49	6.82	7.21
Oat CI8237-*V. villosa*	7.29	7.13	6.68	7.03
Oat CI8237-V. atropurprea	7.34	7.04	6.93	7.10
Oat CI8237-*V. sativa*	7.37	7.78	6.44	7.20
Grey algeris-V. villosa	5.84	5.59	5.01	5.48
Grey algeris-V. atropupurea	5.62	5.39	4.93	5.31
Grey algeris- V. sativa	5.97	5.75	5.45	5.72
Mean (t/ha)	6.8	6.76	6.17	
CV (%)	19.21			
LSD (P<0.05)	NS			

Table 4. Two years mean dry matter yield proportion of vetch and oat sown in mixture (2002-2003).

Treatment	Vetch				Oat		
	Seed rate(kg/ha)				Seed rate (kg/ha)		
	80:30	60:22.5	40:15	Mean	80:30	60:22.5	40:15
Oat CI8251-*V. villosa*	0.38(5.2)*	0.36(4.9)	0.29(4.3)	0.34	6.83	6.95	6.46
Oat CI8251-V. atropurpurea	0.55(7.3)	0.49(6.6)	0.42(6.4)	0.49	6.94	6.88	6.12
Oat CI8251-*V. sativa*	0.30(4.1)	0.28(3.7)	0.25(3.4)	0.28	7.02	7.21	6.57
Oat CI8237-*V. villosa*	0.47(6.4)	0.39(5.5)	0.45(6.7)	0.44	6.82	6.74	6.23
Oat CI8237-V. atropurprea	0.52(7.1)	0.54(7.7)	0.61(8.8)	0.56	6.83	6.5	6.32
Oat CI8237-*V. sativa*	0.40(6.8)	0.33(4.2)	0.36(5.6)	0.36	6.97	7.43	6.09
Grey algeris-V. villosa	0.62(10.6)	0.65(11.6)	0.59(11.7)	0.62	5.22	4.94	4.42
Grey algeris-V. atropupurea	0.87(15.5)	0.77(14.3)	0.80(16.2)	0.81	4.75	4.62	4.13
Grey algeris- V. sativa	0.49(8.2)	0.5(8.6)	0.48(8.8)	0.49	5.48	5.25	4.97
Mean (t/ha)	0.51	0.48	0.47		6.32	6.28	5.7
CV (%)	47.01				20.88		
LSD (P<0.05)	NS				NS		

* Numbers in the brackets indicate the vetch proportion in percentage.

Table 5. The effect of oat varieties and vetch species on dry matter yield and other agronomic parameter (2002-2003).

Varieties/Species	DM (t/ha)	POM (t/ha)	PH (cm)	SC (0.25m^2)	T/P (No.)
Oat varieties					
Oat CI 8251	7.15a	6.78a	106.41a	25.03a	4.14c
Oat CI 8237	7.11a	6.67b	102.23b	24.06a	4.53b
Gray algiers	5.52b	4.86c	84.04c	21.98b	4.78a
Mean	6.59	6.10	97.57	23.36	4.48
LSD (P<0.05)	0.2443	0.04355	1.871	1.011	0.1751
CV (%)	19.61	20.88	10.04	22.56	20.64
Vetch Species		PVM (t/ha)			
V. villosa		0.47b	90.01a	6.55a	3.55a
V. atropurpurea		0.62a	85.67b	6.71a	3.06b
V. sativa		0.38c	66.03c	5.29b	3.17b
Mean		0.49	80.57	6.18	3.26
CV (%)	19.61	47.01	10.01	0.3727	0.3727
LSD(P<0.05)	0.2268	0.04355	2.326	31.26	31.26

DM: Dry matter, POM: proportion of oat in mixture, PVM: proportion of vetch in mixture, PH: plant height SC: Seedling count at emergency, T/P; tiller per plant; Mean in a column with different letters are significantly different (P <0.05).

Table 6. The effects of seed rate on dry matter yield and other agronomic parameters of oat-vetch mixture (2002-2003).

Parameters	Seed rate kg/ha			
	80:30	60:22.5	40:15	LSD (0.05)
Total DM Yield (t/ha)	6.83a*	6.76a	6.17b	0.2443
Proportion of oat in mixture (t/ha)	6.32a	6.28a	5.7b	0.04355
Proportion of vetch in mixture (t/ha)	0.51	0.48	0.47	NS
Height at harvest of oat (cm)	99.92a	99.02a	96.56b	1.8771
Height at harvest of vetch (cm)	82.57a	80.63ab	78.52b	2.2326
Seedling count of oat (no/0.25m2)	28.35	24.69	18.03	0.7283
Seedling count of vetch (no/0.25m2)	7.46a	6.37b	4.72c	0.3727
Tillering of oat per plant	4.21b	4.56a	4.68a	0.1769
Tillering of vetch per plant	3.06c	3.25b	3.47a	0.1454

* Means within a row followed by different letters are significantly different (P< 0.05).

Effect of feeding green sorghum cut at two maturity stages on the intake and nutrient utilization in crossbred heifers supplementing with different levels of concentrate

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Abstract

Sixteen crossbred heifers (Sahiwal x Jersey) ranging from 11.3 to 12.6 months of age and 86.04 to 102.79 kg body weights were randomly divided in to four uniform groups of 4 each to study the effects of ad lib feeding of green sorghum (Rio) cut at two maturity stages on nutrient utilization supplementing with different levels of concentrate (0, 0.75, 1.5 and 2.0 kg/d/animal). Results revealed that two stages of sorghum fodder had differences in chemical composition, DMI and digestibility. The mean DM, OM, NDF, ADF, Hemicellulose, cellulose, ADL and AIA contents of the fodder increased while CP, EE, total ash, Ca and P contents decreased as the fodder matures from stage I (75-82 DAS) to stage II (105-112 DAS). Significant (P<0.01) variation was observed among the treatment groups in total (fodder plus concentrate) DMI in terms of kg/100 kg BW. The higher DMI value was 4.062 which was observed in sorghum stage I adlib plus 2.0 kg concentrate mixture groups. The increased concentrate level led to a significant (P<0.01) increase in total ration DMI. For the whole ration, DMI (kg/100 kg BW) increased with the level of supplementation up to 0.75 kg/d, however, there was a tendency for its stabilization at levels over 0.75 kg/d. The increased in concentrate level of the ration led to a significant (P<0.01) decrease in fodder DMI (kg/ 100 kg BW). Substitution rates (SR) of sorghum by concentrate was increased with increasing level of concentrate in the ration and it was higher in stage-II (0.4132) than stage-I (0.2473). The cutting stage also significantly (P<0.01) affected fodder DMI (kg/100kgBW), which was lower for stage-II (1.89) than stage-I (2.83).DM, OM, CP and energy digestibilities of the ration increased with increasing level of concentrate. However, digestibility of the fibre fractions (NDF, ADF and cellulose) increased slightly with the low level of supplementation (0.75 kg/d), but decreased with higher levels (1.5 and 2.0 kg/d). Hemicellulose digestibility increased up to the level of 1.5 kg/d compared to the level of 0kg/d. Harvesting the fodder in stage I had significantly (P<0.01) higher digestibility of nutrients than stage II.

Key words: Sorghum fodder, DMI, concentrate level, digestibility, crossbred heifers, Substitution rates

Introduction

Sorghum (*Sorghum bicolor (L) Moench*) is one of the important graminaceous fodder crop, grown extensively during *kharif* (*Meher)* season (Gill and Patil, 1983; Desale *et al.,* 1999), which is palatable to cattle and buffaloes in green and dry stages (Panwar *et al.,* 2000). Fodder scarcity, which is often experienced, has given impetus to the cultivation of sorghum fodder varieties. During the last three decades, various varieties of sorghum such as RIO, PC-6, PC-1, S-136, IS-4776 etc. have been developed which can be extensively used as nutritional fodder for ruminants

(Kumar and Singh, 1985). Among the various factors, the stage of harvesting has a great bearing on the nutritive value, digestibility and voluntary intake of fodder (Panwar *et al.,* 1999).

Quality of forages in terms of protein is inadequate in most of the *kharif* fodders (Prasad and Agrawal, 1996) including sorghum fodder to fulfill the requirements of ruminants. Providing supplemental protein to cattle consuming low quality forage can improve forage use and performance of the animal (McCollum and Horn, 1990). If nitrogen supply is inadequate, then digestion of starch and fibre is likely to be depressed (Ørskov *et al.,* 1972) and voluntary intake may also be affected (Ram *et al.,* 1985). It is necessary to supply adequate nitrogen to microbes to achieve maximum efficiency (Raut *et al.,* 1980; Ram *et al.,* 1985). Addition of restricted amounts of concentrates to the diet of ruminants, offered roughage *adlib,* often alters the voluntary intake of roughage. The type and extent of the change in voluntary intake of roughage seems to depend largely on the quality of the roughage given (Campling, 1966). Increasing the amount of concentrates generally depresses the voluntary intake of roughages, the depression being greater for roughages of high than of low digestibility (Campling and Murdoch, 1966). When roughages of very low digestibility are offered, small amounts of concentrates may increase the voluntary intake of roughage (Campling and Murdoch, 1966; Campling, *et al.,* 1962)

Although the comparative feeding value of sorghum fodder (RIO) for cattle and buffaloes (Kumar and Singh, 1985), chemical composition and *in vitro* digestibility of nutrients (Kumar *et al.,* 1994) and evaluation of its nutritive at two stages of growth (Teka *et al.,* 2001) have been assessed so far, however, data on voluntary dry matter intake and nutrient utilization as affected by concentrate supplementation and cutting stage in crossbred heifers is lacking. The present study was therefore, undertaken to assess the effect of feeding green sorghum (Rio) of two stages voluntary intake of sorghum fodder and nutrient utilization in crossbred heifers supplementing with different levels of concentrate.

Materials and Methods

Location

The experiment was conducted at Livestock Research Center (LRC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, district Udham Singh Nagar, Uttaranchal, India. The center is situated at 29^0N latitude, 79.3^0E longitude and 243.8m above sea level in the foothills of Himalayas, annual rainfall (mm) 1658.

Experimental animals

Sixteen growing crossbred (*Sahiwal x Jersey*) heifers ranging from 11.3 to 12.6 months of age and 86.04 to 102.79 kg body weights were selected from the herd maintained at LRC of the university and they were divided into four uniform groups of four each according to their age and body weight to study the effect of level of concentrate supplementation (0, 0.75, 1.5 and 2.0 kg/d/animal) in addition to *ad libitum* access to sorghum fodder variety (RIO) at two stages of growth on nutrient utilization in cross bred heifers. One animal from each group was randomly allotted to one of the four treatments.

Experimental ration and Period

Two separate digestion/ feeding trials were conducted using two stages of green sorghum(75-82 DAS-stage I and 105-112 DAS-Stage II). During period I, the animals were offered green sorghum *adlib* of stage I (75-82 DAS) and during period II, the same animals were fed green sorghum *adlib* of stage II (105-112 DAS) in addition to one of the four level of concentrate supplementation in each group. To each type of the two stages of fodder, the four concentrate levels were associated, resulting in the following 8 experimental diets:

0 kg conc. Mix. + sorghum *adlib* of stage I (T_1)

0 kg conc. Mix. + sorghum *adlib* of stage II (T_2)

0.75 kg conc. Mix. + sorghum *adlib* of stage I (T_3)

0.75 kg conc. Mix. + sorghum *adlib* of stage II (T_4)

1.5 kg conc. Mix. + sorghum *adlib* of stage I (T_5)

1.5 kg conc. Mix. + sorghum *adlib* of stage II (T_6)

2.0 kg conc. Mix. + sorghum *adlib* of stage I (T_7)

2.0 kg conc. Mix. + sorghum *adlib* of stage II (T_8)

During the last 7 days of each experimental period, a digestion trial was conducted to assess intake, the availability of nutrients and their digestibility.

Feeding and Management of Animals

All the heifers were fed *ad libitum* a normal basal diet of sorghum fodder (RIO) with four levels (0, 0.75, 1.5 and 2.0 kg/d/animal) of concentrate supplementation. The concentrate mixture was fed first to individually penned heifers in the forenoon daily according to the treatments and after cleaning this mixture, a measured quantity of chaffed (2-3 cm) green fodder (RIO) was offered individually once a day. The quantity of concentrate given to each animal was determined on the basis of their body weight and the ingested quantity of the previous day. Water was offered *ad libitum* twice daily. The crossbred heifers were drenched against internal parasites before the start of the study. The animals were dipped before the experiment commenced and at weeks interval during the study.

Digestibility trial

During the final seven days of each period (I and II) digestibility trials was conducted. For the first 18 and 30 days of period I and II respectively, the animals were allowed to adapt to the new diet.

Data collection and Analytical procedures

Daily feed offered and refusals were measured for each animal, and representative samples were taken after thorough mixing of the feed or refusal. The first 24 hours faeces were discarded after weighing. The collection of faeces was started 48 hours after the first feed sample was taken. Feaces voided by individual animal during the preceding 24 hours was quantitatively collected and weighed. Representative samples were taken to laboratory for dry matter and nitrogen estimation. All the collected samples were kept in an oven for drying at 70 - 80^{o}C till a constant weight was recorded for dry matter determination. After drying, the daily samples were weighed and collected in the form of a period of bulk for individual animals. The dried samples were ground through a laboratory mill using 2 mm and 1 mm sieve size and stored in clean labeled polythene bags pending for chemical analysis.

The chemical analysis of feeds and faeces was performed for proximate composition as per the procedure of AOAC (1975), cell wall constituents were determined by Goering and Van Soest (1970), energy by chromic oxide method of O' shea and Magurie (1962), phosphorus by Gupta (1992) and calcium by using Atomic Absorption Spectrophotometer.

Statistical analysis

The data were analyzed in randomized block design (two factors RBD) considering sorghum fodder (variety RIO) of two stages and four levels of concentrate supplementation as treatments and animals as replication by using MSTATC statistical package (1989). Duncan's multiple range tests was applied for testing the significance of mean differences (Duncan 1955).

Results and Discussion

Feed Chemical composition

Table 1 summarizes the feed chemicals composition results. The chemical composition of the fodder varies between the two stages of growth. The DM, OM, NDF, ADF, Hemicellulose, cellulose, ADL and AIA contents of the fodder increased by 39%, 1.64%, 10.8%, 13.1%, 8.1%, 9.8%, 26.5% and 18%, respectively while CP, EE, total ash, Ca and P contents decreased by 22.63%, 21.74%, 20.94%, 13.3 % and 30% respectively as the fodder matures from stage I to stage II. The gross energy (GE) content of the fodder (kcal/g DM) has shown a slight increase (3.946 to 4.051) from stage I to stage II. These results show that the synthesis of more of the structural carbohydrates (NDF, ADF, cellulose, Hemicellulose) and lignin in the cell wall as the plant matures from stage I to stage II. Siegal (1968) also reported that more structural carbohydrates and lignin are synthesized and deposited in the cell wall during latter stage of growth. The results obtained in the present study are in agreement with earlier findings (Kumar *et al.,* 1974; Nandra *et al.,* 1983; Kumar *et al.,* 1994; Joshi *et al.,* 1998; Panwar *et al.,* 1999; Teka *et al.,* 2001).

Ration dry matter intake (DMI)

The differences in total DMI (concentrate + fodder) (ration intake) in kg/100 kg BW were highly significant ($P<0.01$) among the different treatment groups. It ranged from 2.318 in stage II fodder with no concentrate to 4.062 in stage I fodder with 2 kg concentrate supplementation (Table 2). Concentrate level affected significantly ($P<0.01$) DM intakes of the ration. When the concentrate level went from 0 to 0.75 kg, DMI went from 2.684 to 3.186 kg/100 kg BW. However, at higher concentrate levels in the ration (0.75 to 1.5 kg, then 2.0 kg) there was no further significance increase in DMI (kg/100 kg BW). The increase in DMI with increasing concentrate level up to 0.75 kg could be due to the improved digestibility of the whole ration (Table 4), which could be attributed to the increased CP content of the ration which might be contributed by the concentrate mixture in addition to the CP content of the fodder alone (Table 1), enhancing better cellulolytic activity with in the rumen. This agrees with Kraiem *et al.,* (1997). The cutting stage also significantly ($P<0.01$) affected total ration DM intake kg/100 kg BW, which was higher for stage I (3.652) than stage II (2.805) fodder, which was in agreement with Teka *et al.,* (2001). However, the interaction between concentrate levels and stages was not significant ($P>0.05$).

Fodder dry matter intake

When fodder was fed alone, the DMI of stage I fodder (3.05) was significantly ($P<0.01$) higher than the DMI of stage II fodder (2.32) in kg/100kgBW. The differences in fodder DMI of both stages of growth in each concentrate level also statistically significant ($P<0.01$). Accordingly, the increased in concentrate level of the ration led to a significant (P<0.01) decrease in fodder DMI (kg/100 kg BW) in both stages of growth (Table 2). When forage is given *ad libitum,* supplementation with concentrates, although increasing total DMI, results in a reduction in forage intake (Thomas, 1980). The effect also demonstrated in the present study. As the concentrate level went from 0 to 2.0 kg, fodder DMI decreased from 2.68 to 1.92 kg/100 kg BW, which could be explained by the higher substitution rates of the forage by the concentrate (Vinet *et al.,* 1980; Malossini *et al.,* 1995; Kraiem *et al.,* 1997), as the level of concentrate supplementation increased to sorghum fodder based diet. The cutting stage also significantly (P<0.01) affected fodder DMI (kg/100 kg BW), which was lower for stage II (1.891) than stage I (2.83) (Table 2), which was in agreement with Teka *et al.,* (2001) who reported a significant decrease in DMI of the fodder from 2.54 to 2.15 kg/100 kg BW as the plant matures form flowering to dough stage. The interaction among the concentrate levels and stage of growth also statistically significant (P<0.05).

Substitution rates (SR)

The SR of the sorghum fodder by the concentrate can be calculated when animals are fed fodder alone and then concentrate is added at increasing levels. The SR among the different treatment groups was statistically significantly (P<0.01). The SR of the stage I fodder by concentrate at the 0.75kg concentrate level was very low (0.189), indicating that a low concentrate supplementation did not depress fodder DMI and caused an increase in total ration DMI might be due to the upgrading of forage digestibility. The SR interaction among the treatment groups was significant (P<0.05). The SR increased (from 0.201 to 0.462) with increasing levels of concentrate (from 0.75 to 2.0kg) in the ration, respectively and the difference was statistically significant (P<0.01) (Table 3), which confirm the results presented by (Vinet *et al.,*1980; faverdin *et al.,*1991) for dairy cows and (kraiem *et al.,*1997) for rams, but disagree with those reported by (Gordon, 1984) who indicated that the SR does not vary in a function of added amounts of concentrate to the ration. The stage II mean SR (0.413) was higher (P<0.01) than the mean SR of stage I (0.247) (Table 3). The higher SR of the stage II fodder shows that the SR increases with increasing levels of fodder ADF content (Table 1). This result agrees with the findings of (kraiem *et al.,* 1997; Donker and Mac Clure, 1982).

Digestibility of nutrients

The digestibilities of DM, OM, CP and Hemicellulose (HC) were significantly (P<0.01) higher in stage I fodder with 2 kg concentrate supplementation (T_7) compared to stage I fodder with no concentrate (T_1) and also their mean digestibilities at 2 kg concentrate level were significantly higher than 0 kg concentrate level. However, HC digestibility at 1.5kg concentrate level was significantly higher than 0kg concentrate level (Table 4). The increased DM, OM, CP and Hemicellulose digestibilities with the increased in concentrate level could be attributed to good digestibilities of the nutrients in the concentrate mixture. Similar findings have also been reported for the oats hay cut at three maturity stages (Kraiem *et al.,* 1997).

The mean digestibility coefficients of structural carbohydrates (NDF, ADF and cellulose) were significantly (P<0.01) higher in 0.75kg concentrate level treatment groups compared to 0 concentrate level group. The differences among the other concentrate levels were not statistically significant (P>0.01) (Table 4). The increased digestibilities of the fibre fractions with 0.75 kg concentrate level could be attributed to the increased of the ration CP content which might be contributed by the concentrate in addition to the CP content of the fodder alone (Table 1), enhancing better cellulolytic activity with in the rumen. These findings agree with the values reported by Kraiem *et al.,* (1997) who reported a slight increase in the digestibility of the fibre fractions of oat hay up to 20% concentrate level in the ration. However, the decreased in digestibilities of the fibre fractions when rations contained more than 0.75 kg concentrate level could be explained by the development of the amylolytic bacteria with in the rumen, leading to a decrease in pH values (Kraiem *et al.,* 1997). The associative effects are usually negative and greatest when low quality roughage is supplemented with a starchy concentrate. In these circumstances rapid fermentation of starch to volatile fatty acids (VFA) depresses the rumen pH 6 or less, which inhibits celluloytic microorganisms and fibre digestibility is depressed (McDonald *et al.,* 1995).

The digestible energy (DE) coefficient (69.75%) was also significantly ($P<0.01$) higher in stage I fodder with 2 kg concentrate supplementation (T_7) compared to the other groups except in stage II fodder with 2kg concentrate (T_8). The mean energy digestibility in 2.0 kg concentrate level (69.012 %) was significantly ($P<0.01$) higher than the other concentrate level groups (Table 4). The increased energy digestibility with the increased in concentrate level could be attributed to good digestibility of energy in the concentrate.

The over all mean digestibilities of all nutrients of the ration in stage I was significantly ($P<0.01$) higher than stage II (Table 4). This may be explained by the lower digestibility of the fodder in the latter stage of growth than in the first cutting stage due to the synthesis of more structural carbohydrates and lignin during latter stage of growth (Table 1). Mc Donald *et al.,* (1995) indicated that the fibre fraction of a food has the greatest influence on its digestibility and both the amount and chemical composition of the fibre are important.

Conclusions and recommendations

The mean DM, OM, NDF, ADF, Hemicellulose, cellulose, ADL and AIA contents of the fodder increased while CP, EE, total ash, Ca and P contents decreased as the fodder matures from stage I (75-82 DAS) to stage II (105-112 DAS).

Concentrate supplementation beyond 0.75kg/d in sorghum fodder based diet did not have effect on total ration DMI (kg/100kgBW) by crossbred heifers. Hence, whole ration DMI was improved with increasing level of concentrate up to the level (0.75kg/d) where energy density and CP content of the ration seem to become limiting factors. However, the increased in concentrate level to sorghum fodder based diet led to a decrease in fodder DMI in both stages of growth. The Latter stage (Stage II) had a lower fodder DMI (kg/100kgBW) and a higher SR than stage I. The SR was increased with increasing level of concentrate supplementation to sorghum fodder based diet.

When sorghum fodder is given *ad libitum*, supplementation with concentrates up to the level of 2.0 kg/d, although increasing the digestibilities of DM, OM, CP and energy results in a reduction of the digestibilities of the fibre fractions (NDF, ADF and cellulose) beyond the level of 0.75 kg/d concentrate supplementation in sorghum fodder (Rio) based diet. Dry matter intake and digestibilities of all nutrients were higher in stage I than stage II fodder. It is therefore, concluded that the addition of a low level of concentrate to sorghum fodder based diet improved the digestibility of the cell wall components of the ration. However, with high concentrate level, forage digestibility drops while digestibility of the whole ration increases. The nutritive value of RIO was superior in stage I than in stage II for crossbred heifers and it is necessary to harvest RIO in stage I (75-82 DAS) than in stage II (105-112 DAS) to get maximum nutrient availability per unit body size of the animals. Finally, we recommend that in future due consideration should be given in evaluating the effect of level of concentrate supplementation on sorghum fodder (Rio) based diet on growth rate of crossbred heifers depending up on the availability of fodder along with its economics of feeding so as to give complete recommendation.

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Table 1. Chemical composition of the feeds on DM basis (%)

Ingredient	Concentrate	Stage of harvest of sorghum fodder	
		Stage–I (75-82DAS)	Stage–II (105-112DAS)
Dry matter (DM)	91.50	22.00	30.65
Organic matter (OM)	87.89	92.74	94.26
Crude protein (CP)	20.35	7.69	5.95
Neutral detergent fiber (NDF)	29.00	60.10	66.60
Acid detergent fiber (ADF)	20.20	32.90	37.20
Hemicellulose	8.80	27.20	29.40
Cellulose	16.00	25.50	28.00
Acid detergent lignin (ADL)	2.90	4.90	6.20
Ether extract (EE)	4.20	2.30	1.80
Total ash (TA)	12.11	7.26	5.74
Acid insoluble ash (AIA)	3.20	2.50	2.95
Calcium	0.35	0.30	0.26
Phosphorus	0.41	0.20	0.14
Gross energy (GE) in kcal/g on DM basis	4.404	3.946	4.051

Each is an average of four observations.

Table 2. Average dry matter intake (DMI)

Treatments		DMI (Kg /100Kg BW)		
		Concentrate	Sorghum fodder	Total
0 kg conc. mix. + Sorghum (RIO) – stage I (75-82 DAS) (T_1)		-	3.050^{a*}± 0.09	3.050^{c}± 0.09
0 kg conc. mix. + Sorghum (RIO) – stage II (105-112 DAS) (T_2)		-	2.318^{c}± 0.09	2.318^{d}± 0.09
0.75 kg conc. mix. + RIO – stage I (T_3)		0.604	2.936^{a}± 0.09	3.540^{b}± 0.09
0.75 kg conc. mix. + RIO – stage II (T_4)		0.652	2.179^{c} ± 0.09	2.831^{c}± 0.09
1.5 kg conc. mix. + RIO – stage I (T_5)		1.142	2.815^{ab}± 0.09	3.957^{a} ± 0.09
1.5 kg conc. mix. + RIO – stage II (T_6)		1.286	1.739^{d} ± 0.09	3.025^{c} ± 0.09
2.0 kg conc. mix. + RIO – stage I (T_7)		1.551	2.511^{bc}± 0.09	4.062^{a}± 0.09
2.0 kg conc. mix. + RIO – stage II (T_8)		1.718	1.328^{e}± 0.09	3.046^{c}± 0.09
Concentrate levels in the ration	0 kg (mean)		2.684^{a}± 0.09	2.684^{b}± 0.09
	0.75 kg (mean)		2.557^{ab}± 0.09	3.186^{a}± 0.09
	1.5 kg (mean)		2.277^{bc}± 0.09	3.491^{a}± 0.09
	2.0 kg (mean)		1.920^{c}± 0.09	3.554^{a}± 0.09
Stage of sorghum	Stage – I (T_1 +T_3 +T_5+ T_7) (mean)		2.828^{a}± 0.09	3.652^{a}± 0.09
	Stage –II T_2 +T_4 +T_6+ T_8) (mean)		1.891^{b}± 0.09	2.805^{b}± 0.09

*Values bearing different superscripts in the same column are significant ($P<0.01$) and ($P<0.05$)

Table 3. Substitution rates[1] of sorghum fodder by the concentrate mixture.

Concentrate level in the ration (kg/d)	Stage of maturity of sorghum fodder		Means
	Stage I (75-82DAS)	Stage II (105-112DAS)	
0.75	0.1887±0.039	0.2132±0.039	0.201^{b*}±0.039
1.5	0.2057±0.039	0.4502±0.039	0.328^{ab}±0.039
2.0	0.3475±0.039	0.5763±0.039	0.462^{a}±0.039
Means	0.2473^{b*}±0.039	0.4132^{a}±0.039	

* Values bearing different superscripts in the same column (row) are significant ($P<0.01$)

1 calculated as (DM in take of fodder fed alone – DM intake of the fodder when associated with concentrate)/DM intake of the concentrate.

Table 4. Average percent digestibilities of nutrients.

Treatments		DM	OM	CP	NDF	ADF	Hemi-cellulose	Cellulose	GE
T_1		62.063^{bc*}	61.180^{bc}	56.17^{bcd}	54.458^{bcd}	47.530^{abc}	63.503^{bc}	51.123^{bcd}	62.625^{cd}
T_2		52.485^{d}	55.304^{c}	49.57^{d}	48.98^{d}	36.448^{d}	55.678^{d}	45.410^{d}	61.100^{d}
T_3		62.123^{bc}	65.928^{ab}	59.95^{abc}	63.910^{a}	54.432^{a}	67.697^{ab}	61.793^{a}	64.175^{c}
T_4		54.367^{d}	56.282^{c}	53.66^{cd}	60.040^{ab}	45.615^{bc}	59.552^{cd}	55.690^{abc}	62.350^{d}
T_5		65.296^{ab}	66.70^{ab}	62.89^{ab}	60.323^{ab}	51.320^{ab}	68.915^{ab}	57.483^{ab}	66.500^{b}
T_6		56.546^{cd}	58.67^{c}	56.28^{bcd}	54.278^{bcd}	41.920^{cd}	61.320^{c}	51.480^{bcd}	64.200^{c}
T_7		71.395^{a}	70.90^{a}	66.97^{a}	58.940^{abc}	50.781^{ab}	72.580^{a}	55.503^{abc}	69.75^{a}
T_8		57.033^{cd}	59.866^{bc}	61.00^{abc}	52.960^{cd}	39.545^{cd}	64.960^{bc}	49.580^{cd}	68.275^{a}
Concentrate levels in the ration	0 kg	57.274^{b}	58.242^{b}	52.87^{b}	51.719^{b}	41.989^{b}	59.590^{b}	48.266^{b}	61.863^{c}
	0.75 kg	58.245^{b}	61.105^{ab}	56.805^{ab}	61.975^{a}	50.024^{a}	63.625^{ab}	58.741^{a}	63.263^{c}
	1.5 kg	60.921^{ab}	62.685^{ab}	59.585^{ab}	57.300^{ab}	46.620^{ab}	65.117^{a}	54.481^{ab}	65.350^{b}
	2.0 kg	64.214^{a}	65.383^{a}	63.985^{a}	55.950^{ab}	45.163^{ab}	68.770^{a}	52.541^{ab}	69.012^{a}
Stage of sorghum	Stage– I	65.219^{a}	66.177^{a}	61.495^{a}	59.408^{a}	51.016^{a}	68.174^{a}	56.475^{a}	65.763^{a}
	Stage–II	55.108^{b}	57.531^{b}	55.127^{b}	54.064^{b}	40.882^{b}	60.378^{b}	50.540^{b}	63.981^{b}

*Values bearing different superscripts in the same column are significant ($P<0.01$) and ($P<0.05$)

Effect of Degree and Time of Defoliation of Leaves on Maize Grain and Residue Yields, and Nutritional Value of the Stover

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Abstract

The experiment was conducted at Bako Research Center during 2001 and 2002 cropping seasons with the objective of investigating the effects of varying degrees and time of leaf defoliation on maize grain, residue yield and nutritive value of the defoliated foliage and crop residue at grain harvest. Three defoliation time treatments; 15, 30 and 45 days after 100 percent silking and three degrees of defoliation viz. removing the lower half of leaves below ear, all leaves below ear and all plant components above ear were employed. In all defoliation treatments, ear leaf was not removed and for the treatment in which all plant components above ear were removed, defoliation was practiced by carefully cutting those plant parts above ear at the node just next to that which holds the ear. Leaves for those below ear were defoliated by carefully cutting the lamina at its junction with the leaf sheath; thus leaf DM at defoliation denotes lamina only. Grain yield was highest (7.86t/ha) for the treatment in which all leaves below ear were stripped and lowest (7.21t/ha) for the one where all plant components above ear were removed. A slight reduction in maize grain yield due to removal of the upper leaves as compared to the lower ones suggests that upper leaves are more important than the lower. The mean grain yield was superior for the treatment in which defoliation was imposed 45 days after 100 percent silking (8.29t/ha) when pooled over years and degrees of defoliation treatments. The concentration of CP showed a declining trend with lapse of time in maturity after 100 percent silking. The IVDMD values ranged from 54.02 to 56.34 percent; the highest value being for samples harvested at 30 days and the lower being for the treatment in which leaf removal was imposed at 15 days after 100% silking. High crude protein values were observed for the residue samples collected from plots in which all leaves above ear (2.78%) and lower half of leaves below ear (2.74%) were removed. The IVDMD values varied from 40.21% to 40.78%, the highest value being for the plots in which defoliation was imposed at 30 days after 100% silking. The CP concentration and in vitro DM digestibility values of the residue samples at grain harvest with variable degrees and time of defoliation background are very low; and the fiber components are high. The study generally demonstrated the beneficial aspects of defoliation when imposed 15 days after 100 percent silking compared to the other defoliation treatments and that of upper leaves as compared to the lower ones.

Keywords: Maize; Degree of defoliation; Time of defoliation; Grain; Residue; Nutritive value; Silking stage

Introduction

In maize growing zones of Western Oromia, it is common to remove some leaves and tassels of maize after pollination or silk senescence for livestock feed. This was also reported to be a common practice in Harerghe and Wello areas (Senait and Dejene, 1992). If leaf defoliation is imposed at a strategic time in such a way that the grain component is not significantly affected, the harvested leaf stripping can be used as a good source of quality forage in intensified maize production systems. Efforts to improve feed availability through leaf defoliation could result in manipulation of source-sink ratios on fertile maize plants that could affect grain yield, the component that is preferred for human consumption.

According to Mostafavi and Cross (1990), availability of products of photosynthesis, determined in part by the source-sink ratio, affects the growth rate of kernel and final kernel weight. Most of the dry matter in the grain of maize comes from photosynthesis that occurs after flowering (Allison and Watson, 1966; Swank *et. al,* 1982; Simmons and Jones, 1985). It is evident that the effects of manipulation of assimilate supply depend on the stage of grain development. When applied at silking, it was reported that leaf area removal decreases the rate of total dry matter accumulation (Frey, 1981). Defoliation treatments restricting carbohydrate supply reduce grain yield mainly by decreasing the number of kernels per ear via precocious cessation of kernel development in the apical portion of the ear (Tollenaar and Daynard, 1978; Frey, 1981). Tollenaar (1977) has also indicated assimilate reduction through partial leaf removal to have little effect on kernel growth rate when imposed after the final number of kernels per ear has been established but reduces kernel weight at maturity due to reduced duration of grain filling. In the present study it was hypothesized that post silking stress through topping and defoliation of leaf parts for forage could result in variable effects depending on the degree and time it is imposed. The objective of the present study was to investigate the effects of varying degrees and time of leaf defoliation on maize grain, residue yield and nutritive value of the defoliated foliage and crop residue at grain harvest.

Materials and methods

Location

The experiment was conducted at Bako Research Center during 2001 and 2002 cropping season. The Center is located about 250 Km west of Addis Ababa some 4 Km away from the main road to Nekemte at an altitude of 1650m.a.s.l. It lies at $09^{o}6'$N and $37^{o}09'$E. The area experiences a hot and humid climate and receives a mean annual rainfall of about 1219mm of which more than 80% falls in the months of May to September. Mean monthly minimum and maximum temperatures are about 14^{o}c and 28^{o}c, respectively, with an average monthly temperature of 21^{o}c. The daily mean minimum and maximum temperatures are 9.4^{o}c and 31.3^{o}c, respectively. Potential evaporation averages 60mm per month.

Treatments

Open pollinated maize, Kulani, released by Bako Research Center was used for this study. The crop was planted on well-prepared seedbeds at an intra-and -inter-row spacing of 25 and 75cm, respectively on 4 x $4.5m^2$ plots. At planting two seeds were drilled per hill that was later thinned to one plant at about three weeks after emergence. Three defoliation time treatments; 15, 30 and 45 days after 100 percent silking and three degrees of defoliation viz. removing the lower half of leaves below ear, all leaves below ear and all plant components above ear were employed. The two factors were combined in 3*3 factorial to make 9 treatments, which were arranged in completely randomized block design with four replications.

In all defoliation treatments, ear leaf was not removed and for the treatment in which all plant components above ear were removed, defoliation was practiced by carefully cutting those plant parts above ear at the node just next to that which holds the ear. Leaves for those below ear were defoliated by carefully cutting the lamina at its junction with the leaf sheath; thus leaf DM at defoliation denotes lamina only. The total annual DM included the dry weight of leaves removed during defoliation and the total stover harvested at grain maturity. At grain maturity, two middle rows were harvested and the stover was partitioned in to different plant components and dried in an oven at 60^0c for 72 hours to determine the dry matter yield.

Chemical analysis and *in vitro* DM digestibility

The chemical analyses of the whole residue samples were done at the International Livestock Research Institute Nutrition Laboratory, Addis Ababa. Nitrogen was analyzed using the Kjeldhal procedure and crude protein (CP) was calculated as N * 6.25. The fiber components viz. neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were determined by the procedures of Goering and Van Soest (1970). The *in vitro* DM digestibility (IVDMD) was determined using the Tilley and Terry (1963) *in vitro* technique.

Statistical analysis

All yield and yield component data of the two years were analyzed using the MSTATC statistical software. Year, degree of defoliation and time of defoliation were considered in the analytical model. Average grain yield values reported under recommended management practices for the variety both under on station and on farm conditions were used to evaluate the treatment effects and discuss the experimental results. To assess the quality traits, composite samples pooled over replications and collected during 2001 season were used and the total variance was partitioned in to the effect of degree of defoliation and time of defoliation. Significant mean differences were separated using least significant difference (LSD) procedure.

Results and discussion

Grain yield and yield components

The summary of the combined analysis of variance for grain yield and other yield components of maize are shown in Table 1. For all traits measured, no significant (P>0.05) year effect was observed and the effect of degrees of defoliation was significant for stalk, leaf, residue at grain harvest, and leaf dry weight at defoliation. Time of defoliation significantly (P<0.01-0.05) affected all parameters except cob dry weight (P>0.05) and that of leaf yield at grain harvest (P>0.05). The effect of the interaction of degrees of defoliation and time of defoliation was not significant (P>0.05) for grain, cob and leaf components but was highly significant for the rest traits mainly due to the differential response of time of defoliation across years particularly for stalk, husk and defoliated leaf DM yield; and due to the highly significant main effect of time of defoliation for total residue at grain harvest and total annual forage yield.

The mean grain yield and other yield components of maize are given in Table 2. Grain yield was highest (7.86t/ha) for the treatment in which all leaves below ear were stripped and lowest (7.21t/ha) for the one where all plant components above ear were removed. A slight reduction in maize grain yield due to removal of the upper leaves as compared to the lower ones suggests that upper leaves are more important than the lower and this finding is in agreement with the results of Senait and Dejene (1992) who reported upper leaves to be more important as compared to the lower ones for grain production. The cob component yield was also lowest when the top parts were removed and significantly highest stalk (4.62t/ha), leaf at grain harvest (2.83t/ha) and maize residue at grain harvest (10.34t/ha) were recorded for the treatment in which lower half of leaves below ear were harvested. This may perhaps be attributed to their insignificant contribution to assimilate production that is partitioned to these components, as most of the lower half of leaves below ear was dry when harvested. The DM yield of leaves at removal was superior for the harvesting system in which all components above ear were removed and lower for the one where lower half of leaves below ear were harvested.

With advancing stage of leaf defoliation, a significantly increasing trend was observed for grain yield (Table 2). The mean grain yield was superior for the treatment in which defoliation was imposed 45 days after 100 percent silking (8.29t/ha) when pooled over years and degrees of defoliation treatments. For the other yield components, narrow range of values was observed between defoliation time treatments when averaged over years and this is in contrary to the results reported by Eghareuba *et.al.* (1976) in which response to defoliation when imposed 10 days after 5 percent silking at 10 days interval over 40 days was reported to be non-significant. The finding in this report contrasts with that of Allison and Watson (1966) who have reported a reduction in maize grain yield due to leaf removal despite the stage it was practiced. Averaged over years and degrees of defoliation, significantly lowest yields were observed for all traits except leaf DM yield at defoliation when leaf removal was imposed 15 days after 100 percent silking. Grain, cob, leaf yield at grain harvest and defoliated leaf DM yield were superior for the treatment in which defoliation was imposed 45 days after 100 percent silking. On the other hand, mean DM yields were highest for stalk, husk, and maize residue at grain harvest and total annual residue when defoliation was imposed 30 days after 100 percent silking.

Chemical composition and *in vitro* DM digestibility

The concentration of CP, different fiber components and IVDMD of defoliated maize leaves for different degrees and time of defoliation are given in Table 3. The effect of degrees of defoliation was not significant for CP (P>0.05), acid detergent fiber and acid detergent lignin fractions. However, significant effects of degrees of defoliation were observed for NDF and IVDMD. The concentration of CP for the parts above ear was slightly lower; which may be attributed to the senescent tassels and above ear stalk components that are relatively lower in CP concentration as compared to the leaf blades. The relatively lower values for CP in the lower half of leaves below ear could be associated with the fact that the largest proportions of the leaves were dry when harvesting was practiced. The NDF values were significantly low for above ear components and similar values were observed for the lower half of the leaves below ear and all leaves below ear. The IVDMD values followed a similar trend as that of CP concentration.

The effect of time of leaf removal on CP, fiber fractions and IVDMD concentrations is also shown in Table 3. The influence of time of harvest was not significant (P>0.05) for CP, ADL and IVDMD but was observed to be significant for NDF and ADF (Table 3). The concentration of CP showed a declining trend with lapse of time in maturity after 100 percent silking stage and this is in agreement with reports of Diriba (2000) and Daniel (1990) for *Panicum coloratum* and *Chloris gayana,* respectively. A narrow range of values for different harvesting time treatments were observed for NDF and ADF concentrations and an increasing trend with time of maturity was observed for ADL concentration. The IVDMD values ranged from 54.02 to 56.34 percent; the highest value being for samples harvested at 30 days and the lower being for the treatment in which leaf removal was imposed at 15 days after 100 percent silking.

The chemical composition and *in vitro* DM digestibility values of maize residue collected at grain harvest for the different degrees of defoliation and harvesting time treatments employed in this study is shown in Table 4. All entities (P>0.05) except ADF (P<0.05) were not significantly affected by degrees of defoliation. The CP values were relatively higher for the residue samples collected from plots in which all leaves above ear (2.78%) and lower half of leaves below ear (2.74%) were removed and this could perhaps be due to the higher leaf proportion at grain harvest (Table 2). The IVDMD values varied from 40.21% to 40.78%, the highest value being for the plots in which defoliation was imposed at 30 days after 100% silking. Similarly, time of harvest had no significant (P>0.05) effect on all residue quality parameters. Generally, the CP concentration and *in vitro* DM digestibility values of the residue samples at grain harvest with variable degrees and time of defoliation history are very low; and the fiber components are high indicating the inadequacy of intake for animals subsisting on these low quality roughage diets.

Conclusion

In the present study, a non-significant effect of degrees of defoliation and a significant effect of time of defoliation was observed for grain. A respective mean grain yield of 7.86, 7.93 and 7.21 t/ha was recorded for lower half of leaves below ear, all leaves below ear and all leaves above ear removal treatments. An increasing trend in grain yield with delayed time of leaf defoliation after 100 percent silking stage was observed. The mean grain yield values were 7.16, 7.55 and 8.29 t/ha for 15, 30 and 45 days leaf removal, respectively. The average yield recorded at all levels of both factors were higher than the reported mean yield value that this variety gives under on station management situation (6.5 t/ha) and much higher than the yield reported under on farm (4.25 t/ha) management situation (Demisew *et. al.,* 2002). This implies the possibility of increasing quality forage output through adopting any of the techniques used in this study. Plant samples of above ear components contained 7.06 percent CP and leaves removed 45 days after 100 percent silking had CP concentration of 6.89 percent. All the rest degrees and time of defoliation treatments contained values higher than 7.5 percent being required for optimum rumen function (Van Soest, 1982). On the other hand, the CP and IVDMD values of the residue samples at grain harvest with different degrees and time of defoliation treatments were very low implying the importance of supplementary protein sources for achieving reasonable levels of animal productivity. The study also demonstrated the possibility of exploiting leaf harvesting system opportunities to obtain quality feed from maize based system.

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Table 1. Levels of significance from the analysis of variance for grain yield and other yield components of maize as influenced by year, leaf position and time of defoliation

Source	Grain	Cob	Stalk	Leaf	Husk	Residue	Defoliated leaves	Total forage
Year (A)	NS	NS	NS	NS	NS	NS	NS	NS
Degree of defoliation (B)	NS	NS	**	**	NS	*	**	NS
Time of defoliation (C)	**	NS	**	NS	*	**	**	**
BC	NS	NS	**	NS	**	**	*	**

* = Significant at P<0.05; ** = Significant at P<0.01; NS = Non significant

Table 2. The effects of degrees and time of leaf defoliation on maize grain (t/ha) and other yield components (t/ha) of maize

Degrees of defoliation	Grain	Cob	Stalk	Leaf at grain	Husk	Maize residue	Total annual forage	Leaf yield at removal
Lower half	7.86	1.59	4.61a	2.83a	1.33	10.34a	10.90	0.48c
All below	7.93	1.52	3.91b	1.94b	1.35	8.72b	10.07	1.39b
All above	7.21	1.33	3.79b	1.97b	1.28	8.38c	10.79	2.46a
SE	2.67	0.07	0.12	0.07	0.05	0.24	0.28	0.03
P level	NS	NS	**	**	NS	*	NS	**
Time of defoliation								
15days	7.16b	1.39	3.61b	2.19	1.24bc	8.44b	9.95b	1.46a
30days	7.55b	1.47	4.46a	2.23	1.45a	9.62a	10.94a	1.36b
45days	8.29a	1.58	4.24a	2.31	1.28b	9.39a	10.87a	1.50a
SE	1.74	0.04	0.09	0.06	0.04	0.16	0.17	0.02
P level	*	NS	**	NS	*	**	**	**

* = Significant at P<0.05; ** = Significant at P<0.01; NS = Non significant; degree of defoliation and time of defoliation means within column followed by different letters vary significantly

Table 3. Effect of degrees and time of defoliation on crude protein, fiber component concentrations and IVDMD (%) of defoliated maize leaves

Degrees of defoliation	CP	NDF	ADF	ADL	IVDMD
Lower half	8.77	62.18b	37.59	3.30	57.35a
All below	10.12	62.17b	33.59	3.04	57.54a
All above	7.06	61.93a	34.71	3.92	50.88b
SE	1.48	26.87	18.97	3.85	1.47
P level	NS	**	NS	NS	**
Time of defoliation					
15 days	10.36	62.00b	35.02b	2.94	54.02
30 days	8.69	61.79b	35.39b	3.09	56.34
45 days	6.89	62.48a	35.49a	4.22	55.42
SE	1.48	26.87	18.97	3.85	1.47
P level	NS	*	*	NS	NS

= Significant at P<0.05; ** = Significant at P<0.01; NS = Non significant; degree of defoliation and time of defoliation means within column followed by different letters vary significantly

Table 4. Crude protein, fiber components and *in vitro* DM digestibility of maize residue at grain harvest as influenced by the degrees and time of leaf removal

Degrees of defoliation	CP	NDF	ADF	ADL	IVDMD
Lower half	2.74	74.29	44.46a	4.27	40.21
All below	2.57	71.17	44.46a	4.48	40.78
All above	2.78	76.59	44.02b	4.65	40.21
SE	0.22	19.57	13.26	3.39	1.03
P level	NS	NS	*	NS	NS
Time of defoliation					
15 days	2.72	74.65	44.39	4.15	40.49
30 days	2.44	72.50	45.24	4.66	39.93
45 days	2.92	74.91	43.31	4.59	40.78
SE	0.22	19.57	13.26	3.39	1.03
P level	NS	NS	NS	NS	NS

* = Significant at P<0.05; NS = Non significant; degree of defoliation means within column followed by different letters vary significantly

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On-Farm Evaluation on the Effect of Supplementing Grazing Menz Sheep during the Dry Season in *Gerakeya Woreda* , North *Shewa*.

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Abstract

On farm trial was conducted at Gumer kebele (Gerakeya Woreda, North Shewa) to evaluate the effect of supplementing wheat bran and vetch hay to grazing Menz sheep during the dry season. Forty five yearling Menz rams with an average initial body weight of 17.04±0.41kg were arranged in a completely randomized design. Fifteen sheep were randomly allocated to each treatment (free grazing, free grazing + 360g Vetch hay + 160g wheat bran, free grazing + 500gm Vetch hay). Water was provided once per day and the supplemental feeds were offered on individual basis. Average daily body weight gain of 5.14g, 52.81g, and 39.41g was obtained for the control, vetch hay + wheat bran and sole vetch hay supplemented groups, respectively. The average daily net dry matter intake of the two supplemental feeds, vetch hay + wheat bran and vetch hay sole was 435.19g and 488.76g, respectively. The average final weight, daily weight gain and daily net dry matter intake of the animal in the three treatment regimes were significantly different (P<0.05) from each other. Average final weight and daily weight gain were higher for sheep supplemented with vetch hay + wheat bran followed by those receiving vetch hay only. The highest gross return obtained was from sheep supplemented with vetch hay + wheat bran (26.79 Eth. Birr/head). However, the highest net return was obtained from supplementing sole vetch hay (17.24 Eth. Birr/head). The result of this study suggested that sole vetch hay (500g/day/head) can be used as an important supplementation diet of sheep during the dry season.

Keywords: Menz Sheep, dry season supplementation, vetch hay, wheat bran, Cost- benefit analysis, *highlands*

Introduction

Although the role of livestock in supporting the livelihood of smallholder farmer in *Gerakeya Wereda* has increased more than ever due to recurrent crop failure they are still managed under the age-old traditions. For most of the year livestock are kept on degraded communal grazing lands with no practice of improved grazing management. In addition to grazing crop residue, which is inherently poor in crude protein, vitamins and mineral content, is the most important livestock feed resources during the dry season. In either case the available feed resource is inadequate both in quality and quantity of nutrient supply. On the other hand, farmers are not aware of improved livestock feeding systems.

The potential of sheep in the area as an important source of cash income is not utilized adequately due to the shortage of feed. As a result, prolonged time to reach marketable weight and poor body condition are the most common problems associated with sheep production in the area (SHARC, 2000). Research conducted on-station with the objective of combating the aforementioned constraints has generated useful technology on supplementary feeding of sheep during the dry season indicating the importance of supplementary feeding for better growth rate and improved body condition. Hence, this trial was conducted to evaluate the technology under farmers' management condition in the drought prone areas of *Gerakeya Wereda*.

Materials and Methods

Trial site and farmer/household

The trial was undertaken at Gumer kebele (Gerakeya Woreda, North Shewa). The altitude of the trial site ranges from 2200 to 2880 meter a.s.l. The area is characterized by crop-livestock mixed farming system and bimodal rain, Belg (short rain) and Meher (long rain) season. Wheat and barely is the dominant crop produced in the area. Fallowing is the common practice in the area. Although the feed shortage is the major constraint to livestock production (SHARC, 2000), livestock especially sheep is the major source of income for the households. The trial was conducted on three farmers' selected based on their long years experience of sheep farming and willingness to undertaken the trial.

Experimental animals and grazing/feeding management

Adequate amount of well-cured vetch (***Vicia dasycarpa***) hay was prepared for the experiment on farmers' field at *Gumer*. Forty five yearling *Menz* rams with an average initial body weight of 17.04$\pm$0.41kg were arranged in a completely randomized design. Fifteen sheep were randomly allocated to each treatment (free grazing, free grazing + 360g Vetch hay + 160g wheat bran, free grazing + 500g Vetch hay). Before the beginning of the experiment the animals were treated against internal parasite. The actual experiment was started after 15 days of acclimatization period. The experiment was carried out for 89 days between mid January and mid April 2003. During the experimental period the grazing land was dry and overgrazed. This poor situation aggravated by very limited availability of grazing land extends from December to June, and during this time mostly the sheep are observed uprooting the remnants of forage with their foreleg.

Data Collection and Statistical Analysis

The amount of feed offered for each treatment and left over was recorded every day for the duration of 89 days. Body weight gain was recorded fortnightly till the end of the experiment. Based on the collected data average daily weight gain was calculated for each treatment. Mean comparison was made to evaluate the statistical difference among the three treatments for average final weight, daily gain and daily dry matter intake. Finally the collected data was analyzed using one-way ANOVA model (MSTAT).

Socio-economic analysis

The amount of feed offered for each treatment was converted to economic values after valuing them in terms of their current market prices and opportunity cost. Accordingly, the price of vetch hay was valued taking the cost of production (fertilizer and seed only) and fallow (soil fertility advantage) was taken as the opportunity cost of the land. Wheat bran price was calculated by taking its field price. Final weight was not down adjusted since it is farmer managed on farm trial. Gross return was calculated by multiplying gross weight gain and price per kg for each treatment. Price per kg was obtained through estimating the price of each sheep in the near by market participants and dividing by mean final weight of each treatment. Finally, partial budgeting was undertaken to analysis the cost benefit analysis of this supplementation. At the end of the experiment, field day was arranged and weight gain performance of sheep under the different treatment groups were evaluated by the participants and nearby farmers.

Results and Discussion

After 89 days of the experiment, an average daily body weight gain of 5.14g, 52.81g, and 39.41g was obtained for the control, vetch hay + wheat bran, and vetch hay supplemented groups, respectively. The average daily dry matter intake of vetch hay + wheat bran, and vetch hay, was 435.19g and 488.76g, respectively (Table 1). The highest weight gain (52.81g) achieved through vetch hay + wheat bran supplementation is attributed to the combined effect of the protein source (vetch hay) and readily available energy source (wheat bran). This result has confirmed the explanation stated by Preston (1985) as cited by Rehirahe (2001) that a readily fermentable energy rich feed is required to provide sufficient energy for optimum rumen microbial fermentative digestion. The weight gain achieved through vetch hay and wheat bran supplementation (52.81 g) is greater than that reported by Sisay & Melaku (1994) which showed a daily body weight gain of 43g during the dry period on *Menz* ram lambs supplemented 50:50 ratio of Oat grain: *Noug* (***Guizotia*** ***abyssinica***) cake mixture with crude protein content of 22% (DM basis).

The average final body weight of sheep was significantly improved as a result of supplementation. The average daily dry matter intake of the two supplementary feeds was significantly different (P<0.05) from each other. The feed conversion efficiency calculated for supplementary feeds showed that vetch hay + wheat bran supplement was more efficient than sole vetch hay supplement (Table 1).

Table 1. Effect of Supplementing Sheep Grazing on Communal Lands on Weight Gain and Dry Matter Intake (mean ± standard error).

Variable	Treatments			CV (%)	LSD
	Grazing only	Grazing + Vetch hay	Grazing + Vetch hay + Wheat bran		
Mean initial wt (kg/head)	16.55(0.74) a	17.38(0.74) a	17.17(0.71) a	16.22	-
Mean final wt (kg/head)	17.01(0.66) a	20.89(0.66) b	21.87(0.63) b	12.31	1.81
Daily net DM intake of supplemental feeds (gm/head)	-	488.76(0.18) b	435.19(0.18) a	0.15	-
Gross wt gain (kg/head)	0.46	3.1	4.70	-	-
Feed conversion efficiency (%)	-	12.14	8.2		
Daily wt gain (gm/head)	5.17(3.98) a	39.44(3.98) c	52.81(3.85) b	45.23	10.99

* Values followed by the same letter within a row are not significant (P>0.05).

The partial budget analysis showed that supplementing 500g vetch hay /day, and 360g vetch hay + 160 g wheat bran/day resulted in a net return of 17.22 Eth. Birr and 16.05 Eth. Birr/head, respectively. The analysis also indicated that supplementing 500 g vetch hay /day resulted the highest net return per head with a marginal rate of return of 470 % over the control (grazing only), which is by far superior to farmer's minimum acceptable rate of return (50%) (Table 2). This result revealed that feeding vetch hay during dry season by growing vetch on fallow lands is profitable option. This can be practiced more in areas where fallowing is a common practice since growing vetch has an added advantage of improving soil fertility.

However, supplementing vetch hay + wheat bran can be taken as an option for the area because the highest weight gain and gross return is obtained through supplementing vetch hay + wheat bran. In addition, according to farmers' ranking during farmers' field day organized to evaluate and demonstrate the result of this trial, this treatment has ranked first in order of body condition. Supplementing vetch hay + wheat bran can be more profitable if farmers are organized to purchase the wheat bran since organizing farmers minimizes the cost of wheat bran.

Table 2. Partial budget, dominance and marginal rate of return analysis for the treatments.

Variable	Treatments		
	Grazing only	Grazing + Vetch hay	Grazing + Vetch hay + Wheat bran
Gross wt gain (kg/head)	0.46	3.51	4.70
Gross return (Br/head)	2.56	20.34	26.79
Costs that vary (Br/head)	-		
Vetch	-	3.12	2.24
Wheat bran	-	-	8.50
Total costs that vary(Br/head)	-	3.12	10.74
Net return (Br/head)	2.56	17.22	16.05*
Marginal Rate of Return(MRR) ,%		470	

* Dominated: Any treatment that has net benefits with less than or equal to those of a treatment with lower costs that vary is dominated and excluded from further consideration (MRR analysis). As to this analysis, supplementing vetch hay + wheat bran treatment has less net return than supplementing vetch hay even though the latter incurs lower total cost that vary and hence supplementing vetch hay + wheat bran treatment is dominated and excluded from MRR analysis

Assumptions

- Vetch hay field price 7 Br/Qt, taking the cost of production (fertilizer and seed only) of vetch
- Wheat bran field price 75 Br/Qt
- Gross return was calculated by multiplying gross weight gain and price per kg for each treatment. Accordingly, 5.56, 5.80 and 5.70 Br/head was calculated for grazing only, grazing +vetch hay and grazing + vetch hay + wheat bran treatment, respectively.

At the end of the experiment, field day was arranged and farmers in the surrounding were invited to evaluate the performance of sheep under the three treatment groups. According to farmers' evaluation, the performance of sheep in the two supplemented groups was good but farmers were impressed in the body condition of sheep supplemented with vetch hay + wheat bran.

Farmers have found this strategic supplementation as a very important means of maintaining their sheep in good body condition. Cultivating improved forage legumes (vetch) could be a suitable option to provide high quantity of good quality feed. Moreover, growing leguminous forages, like vetch can address the problem of soil fertility in the smallholder farms (Getnet, 1999). The advantage of growing vetch in increasing yield of subsequent cereal crops was underlined by the farmers and was considered as a viable option to deal with the high cost of commercial fertilizer. According to Teshome et al. (2003) 30.29% barley grain yield advantage of was obtained over the fallow in vetch-barley rotation system of Bale highlands.

Conclusion and Recommendation

From the result of this study suggested the sole vetch hay (500g/day/head) can be used as an important supplementation diet of sheep during the dry season at *Gumer Kebele* (*Gerakeya Woreda*, North *Shewa*) and similar areas. Especially this practice can be easily introduced in to the farming system as fallow land is a common practice in the area and it is important entry point for vetch production.

In such areas where seasonal weight loss is a serious problem, the weight gain performance achieved in this study under on-farm condition is encouraging and farmers can target peak market seasons such as Easter to fetch better income from sheep market. The highest weight gain observed from vetch hay + wheat bran treatment dictated the need for further evaluation of this and similar treatments for market oriented intensive sheep fattening for the area.

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Effect of cutting frequency on forage yield of Napier grass accessions (*Pennisetum purpureum*) under rain fed condition, Northwest Ethiopia

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Abstract

A trial was conducted during 1997 to 1999 consequently at Adet Agricultural Research Center, Northwest Ethiopia. The study was carried out to determine the effect of cutting frequencies (30, 60, 90, 120 and 150 days) on forage yield of Napier grasses (ILCA No 14984, ILCA No 4983 and X Variety) under rain fed condition by using split plot RCB design with four replications, in which Napier grasses and Cutting Frequency were taken as main in sub plots, respectively. Results of the analysis of variance of the mean dry matter forage yield of three years data revealed that a significant (P<0.01) variation due to year, cutting interval, and year/cutting interactions were noted. Moreover, the highest dry matter yield was achieved at harvesting interval of 150 days (5 months) as compared to the other treatment groups, with less plant count. However, an insignificant variation for mean dry matter forage yield was observed among the Napier grass accessions.

Introduction

The farming system in northwest Ethiopia is a mixed crop-livestock production system. Although, livestock farming is coupled with crop production, in which one cannot exist without the other. They are vital for crop production since cultivation is possible only by draft power and crop residues are the main feed source for livestock. Shortage of arable land, poor soil fertility and lack of animal feed are the major problems. Besides, the available natural pasture is low in productivity and crop residues are low in quality that cannot meet the feed demand. Hence, introduction of cultivated forage crops which are productive, high in quality and complementary to the production system is of paramount importance.

Among the different forage crops that were screened for the high and mid altitude areas of Northwest Ethiopia, Napier grass is promising and well adapted. Napier grass (*Pennisetum purpureum*) is also known as elephant grass. It is a tall perennial grass reaching over 3m high, resistant to drought and grows at altitudes up to 2400 masl (Hendeson and Preston, 1959), stout, deep-rooted, high in productivity and widely cultivated in countries where dairy production is highly practiced. It is a vigorous forage crop and established by root splits or stems cuttings, planted on fence lines, backyards, fed as fresh fodder and chopped to the animals during the dry season and could be used in soil conservation programs. Also, Napier harvested for artificial haymaking at 100 and 300cm height and showed a reduction of the dry matter intake due to the different physio-chemical characteristics of the plants in each cutting height (Ricardo *et.al.*, 1997).Therefore, this study was designed to assess the influence of cutting frequency on the dry matter yield of Napier grass lines.

Materials and Methods

The Napier grass accessions were planted at the beginning of the main rainy season in 1997 and continued until December 1999 at Adet Agricultural Research Center, Northwest Ethiopia in split-plot R.C.B. design with four replications. The area is located 11°17' N and 37°43' E at an altitude of 2240masl. The experimental material was planted on red soil type. The center is characterized by red and black soils. The annual rainfall of the area is 1285 mm and the average annual minimum and maximum air temperature are 8.8°c and 25.4°c, respectively(AARC, 1999).

The treatments consisted of three Napier grasses (ILCA no. 14984, 14983, X-variety) and five levels of cutting intervals (1,2,3,4,5 months) as main-plot and sub-plot, respectively. The crop was planted in well-prepared land at spacing of 0.5 and 1 m between plants and rows, respectively by root splitting. Fertilizer at the rate of 50 kg N/ha and 100 kg P_2O_5/ha was applied to all the plots as Starter dose. The different cultural practices such as weeding were done based on the recommendations. The first harvest was taken four months after planting and subsequent harvests were taken according to the treatments. Data on survival rate (Stand) of plants, growth habit, height at harvest, tolerance to frost and dry season were recorded. The weight of fresh herbage was recorded at each harvest and 200 gm fresh samples were dried at 65^0C for 72 hrs to determine dry matter/ moisture content. The data were analyzed by using MSTAT-C computer software(1989).

Results and Discussion

Survival Rate: Stand percent for the three Napier grasses were recorded after the establishment of the plants and found to be insignificant ($P<0.01$) for the different cutting intervals. The average survival rate was ranged 91.46% (ILCA No. 14984), 93.46% (ILCA No. 14983) and 94.84%(X-variety) (Table 1).

Dry matter yields and plant height: Data on Tables 1, 2, 3 and 4 indicated that forage yield increased with the age of crop from 1997 to 1999. It might be due to the well establishment of the plant, the development of more tillers, stems and leaves. The maximum forage yield was obtained at the second experimental year from Napier grass ILCA No. 14983 (44.7 t/ha), followed by ILCA NO. 14984 (38.7 t/ha) at 150 days cutting interval (Table 2). It was significantly higher than 30, 60, 90 and 120 days cutting intervals. The maximum dry matter forage yield at 150 days interval might be attributed to the development of more tillers, leaves and an increased plant height. On the other hand, the first experimental year, since it was an establishment's period, less tiller, stem, leaves developments and short plant height were noted (Table 1) whereas during the second experimental year, more tiller and stem to leaves ratio development were observed in the form of establishment and higher plant height. However, in the third experimental year, there were more tiller and stem, and less leaves (Table 3) due to the fact that the available nutrients were more depleted for the growth of plants in first and second experimental periods because P_2O_5 and N were applied as standard dose only. Similarly it was reported that dry matter yield increased with increasing N-rate but decreased with increasing cutting frequency (Mohammed *et al.,* 1988). Shalaby *et al.* (1989) found that the dry matter and organic matter digestibility of Napier grass decreased significantly with increasing cutting height from 75 to 125 cm. Moreover, the total digestible nutrients and digestible crude protein of Napier hay decreased significantly with increasing cutting height. In addition, Santana *et al.* (1994) indicated that cutting intervals were linearly and positively correlated with dry matter yield and negatively with forage crude protein content.

Combined mean value of the analysis of variance revealed that the dry matter fodder yield and height of the plant were varied significantly ($P<0.01$) at different cutting intervals through out the trial period. However, insignificant differences among the tested accessions were obtained. (Table 4).

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Table 1. Effect of cutting frequency on dry mater yield (t/ha), height (cm) and stand (5) of Napier grasses in 1997

Variety	Cutting frequency (day)																	
	30			60			90			120			150			Mean		
	DM	Ht	Sta	DM	Ht	Sta	DM	Ht	Sta	DM	Ht	Sta	DM	Ht	Sta	DM	Ht	Sta
ILCA No. 14984	6.1	65.8	92.5	7.2	114.0	90.8	14.4	126.7	95.0	8.4	198.7	91.6	3.9	101.2	87.5	8.0	119.5	91.5
ILCA No. 14983	5.3	51.1	94.1	10.7	132.5	93.3	14.1	133.5	96.7	10.0	218.1	91.7	4.4	127.8	92.5	8.9	132.6	93.7
X-variety	7.5	59.0	93.3	10.4	125.4	95.0	16.4	141.4	96.7	10.7	195.7	95.0	10.9	162.2	94.2	11.2	136.7	94.8
Mean	6.3^{b}	55.7^{c}	93.3^{a}	9.4^{b}	124.0^{b}	93.0^{a}	15.0^{a}	133.9^{b}	96.1^{a}	9.7^{b}	204.2^{a}	92.8^{a}	6.4^{b}	138.7^{b}	91.4^{a}	9.4	129.6	93.3
SE±																1.13	8.7	2.23
LSD (0.01%)																4.35**	33.46**	NS

Mean values within a row with different superscript are significant differ at 1% (**), no significant (NS)

Table 2. Effect of cutting frequency on dry mater yield (t/ha) and height (cm) of Napier grasses in 1998

Variety	Cutting frequency (day)											
	30		60		90		120		150		Mean	
	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht
ILCA No. 14984	6.1	48.1	17.0	80.0	20.2	104.8	24.3	132.9	38.7	159.3	20.8	105.0
ILCA No. 14983	7.2	38.8	22.9	79.9	24.9	82.2	28.4	145.2	44.7	181.8	25.6	105.5
X-variety	9.0	42.1	18.8	79.0	24.9	95.1	28.7	130.0	34.6	164.7	32.1	102.2
Mean	7.7^{c}	42.9^{d}	19.4^{bc}	79.6^{c}	23.3^{abc}	94.0^{c}	27.1^{ab}	136.0^{b}	39.3^{a}	168.6^{a}	32.2	104.2
SE±											4.15	6.31
LSD (0.01%)											15.96**	24.25**

Mean values within a row with different superscript are significant differ at 1% (**), no significant (NS)

Table 3. Effect of cutting frequency on dry mater yield (t/ha) and height (cm) of Napier grasses in 1999

Variety	Cutting frequency (day)											
	30		60		90		120		150		Mean	
	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht
ILCA No. 14984	6.4	42.0	7.8	91.3	22.2	100.2	15.8	113.9	29.6	147.2	16.4	98.9
ILCA No. 14983	5.0	29.6	9.9	81.5	13.9	77.6	11.9	125.0	27.8	143.2	13.7	91.7
X-variety	4.2	33.1	6.9	73.7	11.8	91.7	10.5	92.7	18.1	121.8	10.3	82.6
Mean	5.2^{a}	34.9^{c}	8.2^{ab}	82.1^{b}	16.0^{ab}	89.9^{b}	12.8^{ab}	110.5^{ab}	25.1^{a}	137.4^{a}	32.2	104.2
SE±											4.4	8.04
LSD (0.01%)											17.1**	30.92**

Mean values within a row with different superscript are significant differ at 1% (**), no significant (NS)

Table 4. Effect of cutting frequency on dry mater yield (t/ha) and height (cm) of Napier grasses over the three years (1997-1999)

Variety	Cutting frequency (day)											
	30		60		90		120		150		Mean	
	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht	DM	Ht
ILCA No. 14984	6.2	49.0	10.7	95.1	19.0	110.6	16.2	148.5	24.1	144.2	15.2	109.5
ILCA No. 14983	5.9	39.7	14.5	98.0	17.6	97.8	16.8	162.8	25.6	150.9	17.0	109.8
X-variety	6.9	44.7	11.9	92.7	17.7	109.4	16.6	139.5	21.2	149.6	14.9	107.2
Mean	6.3^{b}	44.5^{c}	12.4^{ab}	95.3^{b}	18.1^{ab}	105.9^{b}	16.5^{ab}	150.3^{a}	23.6^{a}	148.3^{a}	32.2	104.2
SE±											3.63	8.08
LSD (0.01%)											10.19**	29.87**

Mean values within a row with different superscript are significant differ at 1% (**), no significant (NS)

Impact of defoliation of maize leaf on grain, stover and undersown forage yield production

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Abstract

A trial to evaluate the influence of maize leaf defoliation at various growth stages on grain, stover and undersown forage production was conducted in 1999 and 2000 cropping seasons at Adet Agricultural Research Centre, Northwest Ethiopia. The study consisted of three growth stages of maize (later whorl, silking and milking) and five rates of maize leaf defoliation (0, 25, 50, 75 and 100%). Results from the analysis of variance showed that grain yield of maize were significantly affected by the rates of maize leaf defoliation. There was a significant effect on dry matter yield of stover and the defoliated leaf of maize due to rate of leaf defoliation. Dry matter yield of the undersown forage legume was significantly affected by the rates of leaf defoliation of maize. An optimum rate of maize leaf defoliation without affecting the grain, stover and dry matter yield of the undersown forage crops was found at the defoliation rate of 25-50 % of maize leaf. Therefore, defoliation of maize leaf up to 50% at the time of feed shortage did not have adverse grain and stover yield effects.

Introduction

In northwest region of Ethiopia, livestock feeding mainly depend on natural pasture and crop residues, which are low in quantity and nutritional values to animals' meets nutritional requirements. Consequently, productivity of livestock is low; draft power from oxen is minimal, thereby affecting food crop production. Moreover, land is scarce due to the high population and as a result there is an imbalance of the livestock number to the carrying capacity of the grazing lands.

For sustainable crop-livestock production and for the improvement of the quantity and quality of feed, several forage development strategies were developed to have a food-forage crop based production system. Undersowing of forage crop with food crops is one of the strategies where food and forage crops are grown simultaneously, which led for more efficient resource utilization and sustained feed production during the dry seasons (Habtamu et al., 1996). Farmers that grow maize for grain could also harvest other maize components as forage at different stages of plant maturity. Therefore, this trial was initiated to assess the influence of rate of maize leaf defoliation at various growth stages on the grain, stover and the undersown forage production.

Material and Methods

The trial was conducted in 1999 and 2000 crop seasons at Adet Agricultural Research Centre, Northwest Ethiopia. The area is located at 11^{o} 17' N latitude and 37^{o} 43' E longitude at an elevation of 2240 m above sea level. The centre is characterised by red and black soil types and the trial was carried-out on red soil. The study was conducted using 3 X 5 factorial RCB design with three replications consisting of three growth stages of maize (late whorl, silking and milking) and five-rates of maize leaf defoliation (0, 25, 50, 75 and 100%), respectively. The sub plot size was 3 × 5.1 m^2. The spacing between plants and rows was 0.3 and 0.75 m, respectively. A released maize variety (HB-660) was planted at the beginning of the rainy season on well-prepared red soil. DAP and Urea fertilizers were applied at a rate of 100 Kg/ha of each by broadcasting method. D.A.P. was applied at planting while half of the nitrogen fertilizer in the form of urea was applied at planting and at knee height stage of maize. *Vicia villosa* was undersown at knee height (final weeding) of maize. The seed rates for maize and forage legume were 25 and 30 kg/ha, respectively.

All the necessary data were collected, such as days to flowering of forage crop (10-50%), days to emergence of later whorl, silking, milking stages of maize, grain, stover yield components of maize and undersown forage crop. Maize and forage legumes were harvested from all the treatments at full maturity and 10-50% flowering stage, respectively. Grain yield of maize was determined at 12.5% moisture contents and individual samples of the maize stover components and undersown forage legume were taken and dried by oven at 65°C for 72 h until constant weight was obtained and the data was analyzed as per the method Snedecor and Cochran (1967).

Results and discussion

The mean grain, stover, dry matter yield of maize leaf defoliated and the undersown dry matter yield of *Vicia villosa* are presented in Tables 1, 2, 3 and 4, respectively. Results of the mean yield of the two years indicated that, the grain yield of maize, stover components of maize and dry matter yields of undersown forage crop were significantly ($P<0.01$) influenced due to the rate of maize leaf topping and an interaction of rates of maize leaf defoliation at later whorl, tassel and milking growth stages. Furthermore, the yield of the defoliated leaf of maize was significant ($P<0.01$) at different rate of maize leaf defoliation while there was no effect due to various growth stages on the defoliated maize leaf. Similarly, Hanway (1969) reported that the dry matter accumulation was reduced in defoliated treatments at tasseling and after silking stage in maize.

The highest grain and dry matter yield of stover were harvested when the maize leaf were defoliated at the rates of 0–50 % of the total leaves found per plant. Moreover, the highest (7.07 t/ha) and lowest (2.75 t/ha) grain yield was obtained at 0 and 100 % maize leaf topped, respectively. Grains yields of 6.17 and 6.07 t/ha were harvested when 25 and 50 % of maize leaf were defoliated. Since the defoliation of leaf was started from the bottom to up. Besides at the time of cutting 0, 25 and 50 % maize leaves of the upper part of the stalks did not harvested which caused highly significant differences in grain yield while the lower leaves make contribution mainly for stalk formation. Besides, topping 100 % of maize leaf led to the diminishing of the grain yield since the upper leaves, which contribute primarily to grain yield and are fully active after flowering (Palmer, 1969). On the other hand, the lowest (0 t/ha) and the highest (1.95, 2.01 t/ha) defoliated leaf components of maize were harvested at 0, and 75, 100 % rates of maize leaf topping, respectively. Moreover, the highest DM forage production was obtained when cutting 75 % and 100 % of maize leaf increasing, since light penetration through the canopy mainly for the undersown forage.

It is reported that in dense stands, there is competition for soil moisture, nutrients and more importantly light that highly reduced the dry matter yield of undersown forage (Singh, 1974). It is reported that in sorghum complete defoliation during anthesis led to decrease in dry matter (Pauli and Stickler (1961). Hanway (1969) reported that grain yield of corn hybrids were reduced as leaf defoliation increased, which was most critical at tassel growth stage leading to sever reduction in yield. Pendleton and Hammond (1969) found that removal of top, middle and bottom four leaves at silk stage resulted decreasing in grain yield of 38, 58 and 87 % of normal plant yield, respectively. Besides, the removal of all the leaves resulted in 99% reduction in grain yield.

In this study, it can be summarized that defoliation of maize leaf up to 50 per cent at the time of feed shortage did not have adverse effect on grain yield, stover component and under sown forage.

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Table 1. Mean grain yield (t/ ha) of maize as affected by rate of maize leaf defoliation at various growth stages

Growth stages	Rate of leaf defoliation (%)				
	0	25	50	75	100
Late Whorl	7.07^{ab}	6.17^{ab}	6.07^{ab}	4.95^{bcd}	2.75^{e}
Silking	6.53^{ab}	7.50^{a}	5.65^{abc}	3.92^{cde}	3.02^{de}
Milking	6.75^{ab}	6.10^{ab}	5.20^{bc}	6.12^{ab}	5.28^{bc}
Mean	6.78^{a}	6.59^{a}	5.64^{ab}	4.99^{ab}	3.68^{b}
SE (±) for leaf defoliation (a) = 0.28					
SE (±) a x b =0.48					
CV (%)=15.06					
LSD 1%=1.08 (a), NS (b), 1.88(a x b)					

*- Values within a column and mean values within a raw with different super script are statistically different at 1%

Table 2. Mean dry matter yield (t/ ha) of stover component (husk, leaves, tassel, stem, cob) of maize as affected by rate of maize leaf defoliation at various growth stages

Growth stages	Rate of leaf defoliation (%)				
	0	25	50	75	100
Late Whorl	15.93^{ab}	13.55^{bcd}	13.20^{bcde}	9.72^{fgh}	7.95^{gh}
Silking	14.70^{abc}	16.37^{ab}	11.63^{cdef}	8.83^{fgh}	7.20^{h}
Milking	17.38^{a}	13.93^{bcd}	10.17^{efgh}	10.95^{defg}	10.08^{efgh}
Mean	16.01^{a}	14.62^{ab}	11.67^{bc}	9.83^{c}	8.41^{c}
SE (±) for leaf defoliation (a) = 0.57					
SE (±) a x b = 0.98					
CV (%) =14.16					
LSD 1% = 2.23 (a), NS (b), 2.86 (a x b)					

*-Values within a column and mean values within a raw with different super script are statistically different at 1%.

Table 3. Mean dry matter yield (t/ ha) of the defoliated leaf components of maize as affected by rate of maize leaf defoliation at various growth stages

Growth stages	Rate of leaf defoliation (%)				
	0	25	50	75	100
Late Whorl	0.00^{c}	0.33^{bc}	1.06^{abc}	1.95^{ab}	2.01^{ab}
Silking	0.00^{c}	0.62^{bc}	1.16^{abc}	1.68^{abc}	2.03^{ab}
Milking	0.00^{c}	0.48^{bc}	1.05^{abc}	1.99^{ab}	2.48^{a}
Mean	0.00^{b}	0.47^{ab}	1.12^{ab}	1.92^{a}	2.06^{a}
SE (±) for leaf defoliation (a) = 0.09					
CV (%) = 24.90					
LSD 1% = 0.36(a), NS (b, a x b)					

*-Values within a column and mean values within a raw with different super script are statistically different at 1%.

Table 4. Mean dry matter yield (t/ ha) of the undersown forage legume as affected by rate of maize leaf defoliation at various growth stages

Growth stages	Rate of leaf defoliation (%)				
	0	25	50	75	100

Late Whorl	1.06^{d}	1.88^{abc}	1.45^{bcd}	1.65^{abcd}	2.23^{ab}
Silking	1.24^{cd}	1.38^{cd}	1.52^{bcd}	1.85^{abc}	2.37^{a}
Milking	1.54^{bcd}	1.56^{bcd}	1.68^{abcd}	1.83^{abcd}	1.41^{cd}
Mean	1.28^{b}	1.61^{ab}	1.55^{ab}	1.77^{ab}	2.00^{a}
SE (±) for leaf defoliation (a) = 0.10					
SE (±) a x b = 0.16					
CV (%) = 17.88					
LSD 1% = 0.38 (a), NS (b), 0.66 (a x b)					

*-Values within a column & mean values within a raw with different super script are statistically different at 1%.

Effect of season of grass establishment, Harvest time, seed rate and row spacing on seed yield and quality of perennial grass species

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Abstract

*Two sets of experiments were carried out at Sinana Agricultural Research Center, Experiment-I (1997-1999) and Experiment-II (1998-1999). Two grass species, namely, Rhodes grass (*Chloris gayana, *CV massaba) and colored guinea grass (*Panicum coloratum*) was evaluated in experiment-I with the objective to determine the optimum season of establishment and to identify the optimum time of seed harvest. The design used was Split plot with three replications, two grass species were used as a main plot treatment and six harvest times (10, 20, 30, 40, 50, and 60 days after full heading (DAFH)) as a sub-plot.*

*The result indicates that there was a significant (P<0.05) difference in seed yield and agronomic parameters between the 'Gana' or 'Belg' (March to July) and 'Bona' or 'meher' (August to December) grass establishment seasons. Average seed yield of 370.3 and 168.5 kg/ha was produced from Rhodes grass (*Chloris gayana*) and 127.1 and 122.4 kg/ha from* Panicum coloratum *from the 'gana' (*belg*) and 'bona' (Meher) season of establishment, respectively. Time of seed harvest had a significant (P< 0.05) effect on seed yields of the grasses. For 'gana' season grass establishment, the optimum time of harvest was between 30-60 DAFH of the grasses. At the end of 'bona' season there was dry weather as a result there was high seed shattering in late harvests. Therefore, the optimum time of seed harvest in 'bona' season was 10-30 DAFH of the grasses. Seed germination in the 'gana' and 'bona' seasons was 54.8% and 49.7% for Rhodes grass and 10.1% and 23.0 % for Panicum, respectively. In both seasons, early harvesting (10-20 DAFH) of the grasses resulted lower seed germination.*

*In experiment-II, effects of two grass establishment seasons, four seed rates (5, 10, 15 and 20 kg/ha), and four Spacing (20, 30, 40 cm and broadcasting) were assessed to determine the optimum for seed production of Phalaris grass (*Phalaris aquatica*, CV. Sirossa). Establishment of phalaris grass in the 'gana' (March to July) season resulted higher total Seed yield (222.5 kg/ha) compared to seed yield (175.0 kg/ha) of the 'bona' grass establishment season (P<0.05). The seed rates resulted no significant (P>0.05) effect on seed yield of phalaris. However, in both seasons, higher seed yield and uniform heads of phalaris was observed when sown at a seed rate of 10 kg/ha with a spacing of 40 cm.*

Introduction

Seed production methods for forage crops are quite different from those used with cereal crops. Each herbage plant has its own peculiarities. It is important to know the proper rate, method of seeding and the best stage of maturity for seed harvest. In tropics in general, seed production of perennial grasses meets with difficulties. Ripening seed may shed easily and rapidly. Flower spikes appear gradually and when some roots have ripe seed, others have only begun to flower (Bogdan, 1977). All these factors can reduce the potential yield of the grasses.

Among the perennial grass species tested so far at Sinana Agricultural Research Center, Rhodes grass (*Chloris gayana* cv. Massaba), *Panicum coloratum* and *Phalaris aquatica* cv. Sirossa, were found to be adaptable to Bale highlands and performed best in herbage productivity (Tekleyohannes and Worku 1997). However, field observation of the grasses showed problem of low seed yield, uneven seed maturity and high seed shattering. Hence, assessment of a range of harvesting time associated with the physiological stage and season of establishment of the grasses with respect to seed yield and quality is very crucial. This paper describes results of two sets of experiments. Experiment-I carried out with the objective to determine the optimum season of grass establishment and to identify the optimum time of seed harvest for Rhodes grass (*Chloris gayana*) and *Panicum coloratum* and Experiment-II carried out with the objective to determine the optimum season of establishment, seed rate and spacing for seed production of *Phalaris aquatica*.

Material and Methods

The experiments were carried out at Sinana Agricultural Research Center. The center is located at $07^{0}07'$ N latitude and $40^{0}10'$E longitude at an altitude of 2400 m a.s.l. The area is characterized by bimodal rainfall with the total annual rainfall ranging from 750-1000 mm. The amount ranges from 250-560 mm in *Ganna (Belg)* and 270-550 mm in *Bonna (Meher)* seasons. The two seasons are locally named by the time of crop harvest. The first season ('Ganna' or 'belg') commonly extends from March to July while the second ('Bona' or Meher) season extends from July to December. Average annual maximum and minimum temperatures are 21 ^{0}C and 9 ^{0}C, respectively. The soils type is clay in texture (dark brown vertisol), slightly acidic in reaction (pH 6.2), and having 3.9 % organic matter, 0.243 % total N, 30 ppm available phosphorus and 240 mg/kg K and CEC (Cataion exchange capacity) 64 meq/kg soil.

Experiment-I

The experiment was carried out from 1997 to 1999. Two grass species, namely, Rhodes grass (*Chloris gayana* CV. Massaba) and Colored guinea grass (*Panicum coloratum*) were used as main plot and six harvest times (10, 20, 30, 40, 50 and 60 days after full heading (DAFH) of the grass were used as sub plot treatments. The grasses were established in both 'gana' (March to July) and 'bona' (August to December) seasons of 1997. The plots replicated three times and retained until 1999. Fertilizer DAP at a rate of 100 kg/ha at planting and N-fertilizer at the rate of 23 kg/ha, after grass establishment, were applied. The seed rate used for the grasses was 15 kg/ha. Grass heads harvested, dried, threshed and cleaned manually.

Experiment –II

Phalaris grass (*Phalaris aquatica* CV. Sirossa) was established in both 'gana' (March to July) and 'bona' (August to December) seasons of 1998. The treatment factors were four seed rates of Phalaris (5, 10, 15, 20 kg/ha) and four spacing (20, 30, 40 cm and broadcasting). The experiment was laid out in RCBD with four replications. Fertilizer DAP at the rate of 100 kg/ha and urea (50kg/ha) were applied at sowing and after establishment of the grass, respectively. For both experiments, data were analyzed using MSTAT-C software.

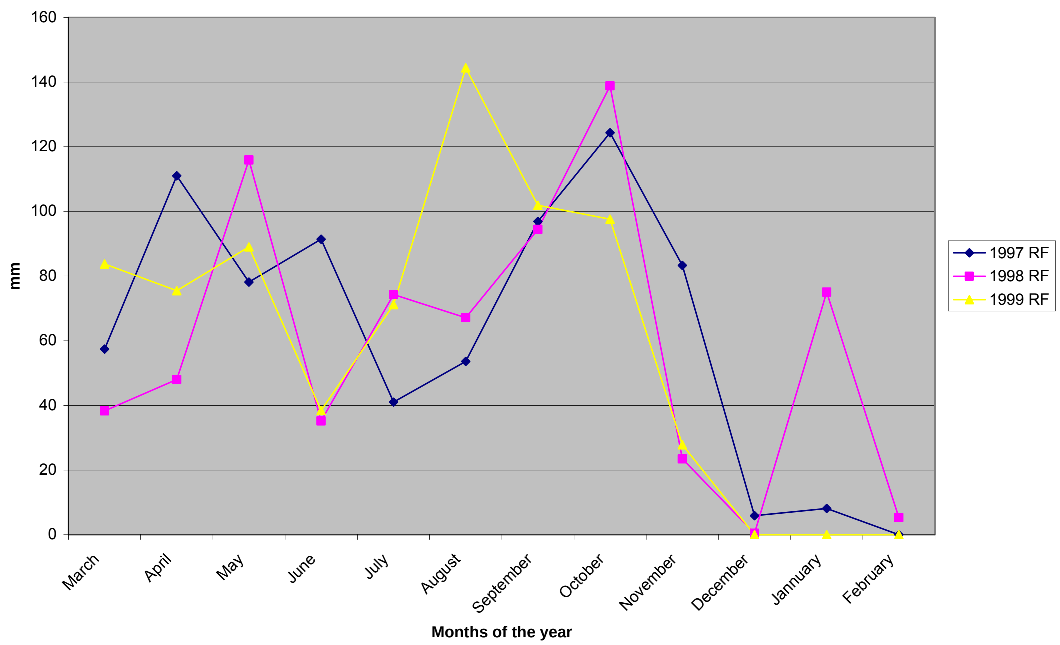
Result and Discussion

Experiment-I

Effect of season of establishment on seed yield of Chloris gayana and Panicum coloratum

Four seed harvests of *Chloris gayana* and *Panicum coloratum* were obtained when the grasses were established in 'gana' season (March to July) and three seed harvests were taken from 'bona' season (August to December) grass establishment. The total seed yields of *Chloris gayana* when established in 'gana' and 'Bona' seasons were 840.7 and 596.7 kg/ha, respectively and that of *Panicum coloratum* was 290.5 and 253.9 kg/ha. This indicates that for higher seed yield perennial grass species should be established in 'gana' (March to July) season than the 'bona' (August to December) season. This was due to the extended rainfall starting from March (beginning of 'gana' season) and extends up to October. However, when the grass was established in 'bona' season, the rainfall starts to rise from August but after October, it starts to decline (Fig. 1) this resulted lower seed yield of the grasses.

Fig. 1. Raiin Fall situation during the Experimental period



Effect of time of harvest on seed yield of Chloris gayana and Panicum coloratum

Time of seed harvest after full heading had significant (P<0.05) effect on seed yields of *Chloris gayana* and *Panicum coloratum*. When the grasses were established in 'gana' (March to July) season, seed yield of both Chloris and Panicum increased with time of harvest (10, 20, 30, 40, 50 and 60 days after full heading (DAFH) (Table 1). This was due to new emerging growths (heads) of the grasses as a result of extended rainfall starting from July (end of 'gana' season) (Fig. 1). Therefore, the optimum time of seed harvest for the 'gana' season grass establishment was between 30 to 60 DAFH of the grasses. However, seed yield of both Chloris and Panicum starts to decline markedly after 30 DAFH (Table 1) when the grasses were established in July or August ('bona' season). This was due to reduced rainfall after October and dry weather after December (Fig. 1), which resulted high shattering of seeds. Therefore, the optimum time of seed harvest for 'bona' (August to December) grass establishment season was 10 to 30 DAFH of the grasses.

Effect of time of seed harvest and season of establishment on percent seed germination of Chloris gayana and Panicum coloratum

The percent seed germination of Rhodes grass (*Chloris gayana)* was 54.8% and 49.7% in 'gana' (March to July) and 'bona' (August to December) grass establishment seasons, respectively. This indicates that season has no significant effect on seed germination of Rhodes grass. However, percent seed germination of Panicum was affected significantly by season, the mean percent seed germination being 10.1% and 23.0 %, respectively for the 'gana' and 'bona' grass establishment seasons. The lower seed germination of Panicum grass in 'gana' (March to July) season was due to variation in seed maturation with in a single panicle. Harvest time also has significant effect on seed germination of the grasses (Table 1). In 'gana' season, higher seed germination of Chloris was observed when harvested 40-50 DAFH. Harvesting 30-50 DAFH of Chloris and Panicum resulted higher seed germination of the grasses in 'bona' (August to December) grass establishment seasons (Table 1). In both seasons, early harvesting (10-20 DAFH) of the grasses resulted in lower seed germination. Generally, seed yield of forage crops is highly reduced if proper harvesting schedule is not applied according to species. Research done in the highlands (Getinet and Tadesse, 1996) also support the results of this experiment although variation in location and environmental effects are evident

Experiment-II

Effect of season of establishment on seed yield of Phalaris aquatica

Total seed yield of *Phalaris aquatica* were 222.5 and 175 kg/ha in 'gana' and 'bona' grass establishment seasons, respectively. This indicates that, the 'gana' grass establishment season is more suitable for phalais seed production. This was due to the extended rainfall starting from March up to December (end of the 'bona' season) (Fig. 1).

Effect of seed rate and row spacing on seed yield of Phalaris aquatica

Seed yield of phalaris grass was not significantly affected (P>0.05) by the seed rates. Relatively, however, the highest seed rate (20 kg/ha) resulted in lower seed yield in both seasons. Similarly, lower seed yield of phalaris was observed at 20 cm row spacing. This was due to dense and suppressed growth of the grass as evident from the highest seedling count/m^2 observed at row spacing of 20 cm and at the seed rate of 20 kg/ha (Table 2). On the other hand, sowing of phalaris grass at a row spacing of 30 to 40 cm and at a seed rate of 10-15 kg/ha showed lower plant population/m^2 (lower seedling counts/m^2) of the grass. This resulted vigorous growth of the grass and higher total seed yield (P<0.05). Uniform grass heads/plot and higher plant height at harvest was also observed at wider spacing and lower seed rates (Table 2)

Conclusion

The study showed that seed production from perennial grass species (*Chloris gayana* (Rhodes grass), *Panicum coloratum* and *Phalaris aquatica*) was significantly higher when the grasses are sown in the *'Gana'* or *'belg'* (March to July) season than the 'Bona' or *'meher'* (August to December) season of grass establishment. Time of seed harvest also varies with season of grass establishment. The optimum time of seed-harvest for 'Gana' (March to July) grass establishment season is between 30-60 days after full heading (DAFH) of the grasses. However, in 'bona' (August to December) grass establishment, there was dry weather and high seed shattering at the end of the season, therefore, the optimum time of seed harvest for this season is between 10-

30 DAFH of the grasses. Seed quality (germination) of *Chloris gayana* (Rhodes grass) was not affected by season. Good seed germination of Panicum, however, was observed when the grass was sown in the 'bona' (August to December) season. In both seasons, early harvesting (10-20 DAFH) result lower seed germination of the grasses.

Higher seed rate and lower spacing can result dense and suppressed growth of phalaris grass due to competition effect. This in turn reduces seed yield and head size uniformity of the grass. Therefore, the optimum seed rate and row spacing for seed production from phalaris grass was 10 kg/ha and 40 cm, respectively.

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Table 1. Effect of time of seed harvest and season of grass establishment on seed yield and percent seed germination of Chloris gayana and panicum coloratum, sown in 'Gana' (March o July) and 'Bona' (August to December) seasons of 1997.

Time of seed harvest (DAFH)*	Chloris gayana (Rhodes grass)						Panicum coloratum					
	Seed yield kg/ha		% Seed germination		Total seed harvest kg/ha		Seed yield kg/ha		% Seed germination		Total seed harvest kg/ha	
	Gana (1st harvest)	Bona (1st harvest)	Gana (1st harvest)	Bona (1st harvest)	Gana (4 harvests)	Bona (3 harvests)	Gana (1st harvest)	Bona (1st harvest)	Gana (1st harvest)	Bona (1st harvest)	Gana (4 harvests)	Bona (3 harvests)
10	142.7d	520.0a	45.3c	40.5c	824.7	918.6	103.8	145.2ab	6.2	12.3d	337.9	266.9
20	240.2cd	379.3a	59.2ab	30.4d	779.6	762.4	126.5	110.4ab	12.7	22.9c	362.6	233.0
30	344.5bc	170.0b	56.3b	68.6ab	812.5	539.2	130.6	212.0a	12.9	39.3a	287.3	353.8
40	424.3b	182.7b	63.5a	23.9d	709.1	481.3	121.5	190.7a	8.7	26.2bc	259.7	336.1
50	439.2b	156.4b	63.8a	72.2a	783.4	440.9	143.3	72.0ab	6.0	31.3b	261.0	224.4
60	630.7a	202.4b	40.5c	62.5b	1134.7	437.7	137.1	4.1b	13.9	6.1d	235.3	109.4
Mean	370.3	168.5	54.8	49.7	840.7	596.7	127.1	122.4	10.1	23.0	290.5	253.9
LSD	122.7	152.0	6.475	7.55			NS	152.0	NS	7.52		
CV %	29.1	45.9	14.38	18.51			29.1	45.9	82.7	39.76		

*DAFH= Days after full heading of the grass; NS= Non Significant (P>0.05); 'Gana'= March to July; "Bona'= July to December

Table 2. Effect of seed rate and row spacing on seed yield of Phalaris grass (Phalaris aquatica) grown in 'Gana" (March to July) and 'Bona' (August to December) season of 1998-1999

Seed rate (kg/ha)	Plant height (cm)		seedling counts/ m²		Head size uniformity %		Seed yield (kg/ha)					
							'Gana' season grass establishment			'Bona' season grass establishment		
	Gana	Bona	Gana	Bona	Gana	Bona	1st harvest	2nd harvest	Total seed	1st harvest	2nd harvest	Total seed
5	182.1a	92.6	70.7c	132.8c	80.0	48.3a	111.4	118.3	229.7	14.1	164.1	178.1
10	170.8b	96.6	161.7c	240.4b	74.6	34.1ab	101.5	127.3	228.8	14.3	169.2	183.5
15	171.8b	91.3	284.2a	320.3a	75.3	22.0bc	107.7	126.0	233.7	12.3	165.0	177.3
20	173.0b	91.9	237.8a	327.6a	75.9	13.5c	91.3	106.7	198.0	13.3	147.7	161.0
LSD(P<0.05)	7.967	NS	54.8	60.7	NS	15.72	NS	NS	NS	NS	NS	NS
CV %	6.41	14.3	40.8	33.4	8.74	74.9	29.3	24.3	18.85	33.9	17.1	15.9
Row spacing (cm)												
20	172.8	91.9ab	283.7a	295.0a	74.2	25.6b	96.5	111.7	208.2B	12.3bc	154.2	166.5
30	170.1	86.5b	179.5b	278.3a	77.2	20.9b	109.4	129.6	238.9A	11.1c	157.8	168.9
40	175.3	93.3ab	185.0b	205.8b	75.9	26.6b	112.2	126.6	238.7A	14.9ab	171.2	186.2
broadcasting	179.5	100.6a	88.3c	242.0ab	78.4	44.8a	93.8	110.4	204.3B	15.6a	162.7	178.3
LSD(P<0.05)	NS	9.51	84.8	60.7	NS	15.72	NS	NS	29.87	3.259	NS	NS
CV%	6.41	14.3	40.8	33.4	8.74	74.9	29.3	24.3	18.85	33.9	17.1	15.9

Herbage yield Potential of annual forage crops grown under minimum tillage system in fallow season of the Bale highlands

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Abstract

*On-farm experiment was conducted for three years (1999-2002) at two sites around Sinana Agricultural Research Center (Selka-Odda and Selka-Shallo) to assess herbage yield potential of four annual forage crops vetch (*Vicia dasycarpa*, CV. lana), medics (*Medicago scutellata*), sweet clover (*Melilotus altisumus*) and fodder oat) grown under minimum tillage system in fallow season of the Bale highlands. The minimum tillage system practiced was one round ox-plow after broadcasting forage seeds. A fallow plot was included as a control and effect of the forage crops on subsequent barley crop was assessed. The result showed that the forage crops successfully established in the fallow season under the minimum tillage system. Fodder oat showed significantly (P<0.05) higher DM yield at both sites followed by vetch. Lower DM yield was observed at both sites from medics and sweet clover. Mean DM yields of vetch, snail medics, sweet clover and oats were 1.1, 0.4, 0.3 and 2.1t/ha at Salka-Odda and 1.7, 0.6, 0.6 and 2.8 t/ha at Salka-Shallo, respectively.*

Barley yields were significantly lower in the subsequent 'gana' (March to July) season of 1999 and 2002 due to moisture stress. Results of 2001 showed no significant effect of forage precursors (P>0.05) on barley grain and biomass yields at both sites. However, compared to the fallow, the plots under forage precursors (except the plots under fodder oats) resulted higher grain and biomass yields of barley. Even there was no significant (P>0.05) barley grain yield loss due to cultivation of fodder oat in the fallow season. Thus, annual forage crops such as vetch and oats can be cultivated under minimum tillage system in the 'bona' (July to December) fallow season of the Bale highlands with the advantage of getting additional forage without affecting subsequent crop yield

Introduction

In Sinana district of Bale zone, rainfall is distributed bimodally with the annual total of approximately 750-1000 mm being split roughly equally between two seasons; the first or 'gana' rains from March to July and the second or 'Bona' rain from August to December (Fig. 1.). Both seasons are suitable for crop production. However, few farmers practice double cropping to utilize both rainy seasons to produce sequentially two crops on the same piece of land. Most farmers prefer to fallow their land in one of the two annual cropping seasons (Alemayehu and Franzel, 1987), due to the narrow time gap that exists between the two production seasons.

A number of studies have identified and stressed the importance of several double cropping management variables such as, tillage system, planting methods, cultivar selection, fertilization, weed control and residue management. Among these, development of reduced tillage practices contributed greatly for the success of double cropping practices in many areas by enabling a second crop to establish with the least delay, reduced labour and energy requirement, decrease soil erosion and run off and maintain soil structure (Asefa et al 1992).

In view of the feed shortage problem of Bale highlands, utilization of fallow seasons for forage production through a double cropping system is one opportunity to alleviate the feed shortage problem of the area. The objective of the current experiment was to assess the fodder yield potential of annual forage crops grown in fallow season under minimum tillage system and to assess the effect of the forage crops on the yields of subsequent barley.

Material and Methods

The experiment was carried out under on farm condition for three years between 1999-2002, at Salka-Odda and Salka-Shallo (sites around Sinana Agricultural Research Center). The areas are located at an altitude of 2400 m a.s.l. The area is characterized by bimodal rainfall. The amount ranges from 250-560 mm in Ganna (Belg) and 270-550 mm in Bonna (Meher) seasons. Accordingly there are two distinct seasons favorable for crop production. The two seasons are locally named by the time of crop harvest. The first season, commonly extends from March to July is "Ganna" (belg) while the second season which extends from July to December is called "Bona" (Meher). Average annual maximum and minimum temperatures are 21 ^{0}C and 9 ^{0}C, respectively. The soil is clay in texture (dark brown vertisol). Four annual forage crops, namely vetch (*Vicia dasycarpa,CV. lana*), Snail medics (*Medicago scutellata*), sweet clover (*Melilotus altisumes*) and fodder oat (Avena sativa) were sown in 'bona' (August to December) season of 1998, 2001 and 2002. A fallow plot was included as a control. Prior to ploughing, seeds of the forage species were randomly assigned to experimental plots and broadcasted. Subsequently, the plots were ploughed once with local-ox plow same time covering the seeds. So, the minimum tillage in this experiment refers to one round ox-plough after broadcasting forage seeds. The plot size was 5m x 5m. The design used was RCBD with three replications. A seed rate of 30, 10, 10 and 80 kg/ha was used for vetch, Medics, sweet clover and fodder oats, respectively. No fertilizer and weeding were used for the forage precursor crops.

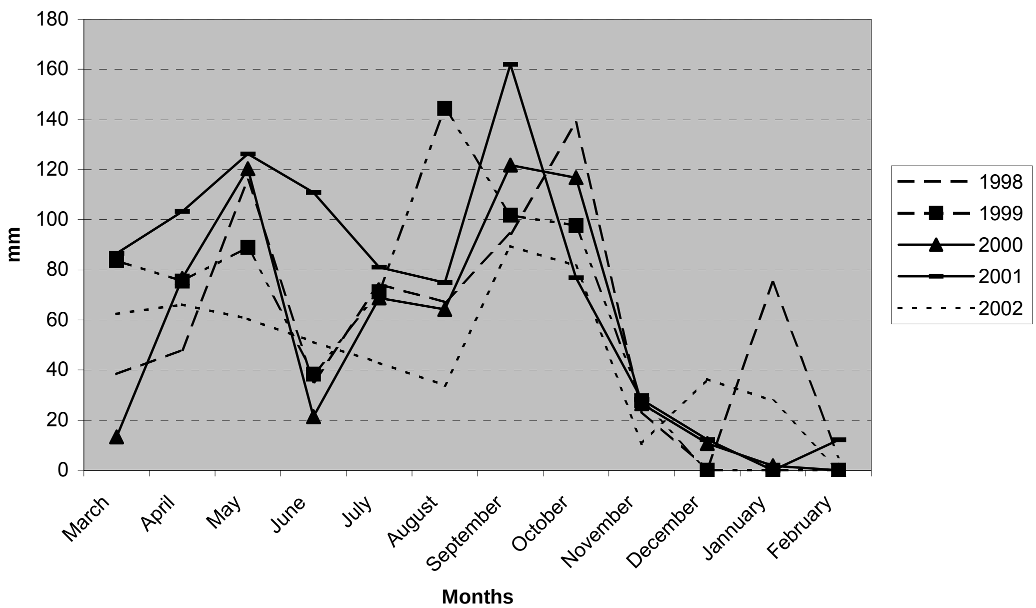
In 'gana' season (March to July) of 1999, 2001 and 2002 all plots which were under forage precursors in the previous season were ploughed beginning in February for seed bed preparation using the local ox-plow. All plots were sown with the local barley 'Aruso" at a seed rate of 150 kg/ha. Seed of barley and fertilizer (41-20 kg N-P/ha) was broadcasted and covered with one pass ox plow. Weeding was done twice for the barley crop. All yield and agronomic data were collected and analyzed using MSTAT-C Software.

Results and Discussion

The forage crops successfully established in the fallow season under minimum tillage system. Among the forage crops, fodder oat showed significantly ($P<0.05$) higher dry matter yield at both sites followed by vetch, snail medics and sweet clover. Mean DM yield of fodder oat, vetch, Medics and sweet clover was 2.1, 1.1, 0.4 and 0.3 t/ha at Salka Odda and 2.8, 1.7, 0.6 and 0.6 t/ha at Salka Shallo, respectively. The forage yield level obtained for the species can be considered substantial since the forages are sown under minimum tillage system, with no fertilizer and weeding practices. Mean forage yield was substantially lower in the year 1998 at both locations compared with the forage yield of 2001 and 2002 (Table 1).

In 'Gana' (March to July) season of 1999 and 2002 there was severe moisture stress due to low rain fall (Fig. 1) and hence barley yields were reduced substantially (Table 2). In this seasons lower barley grain yield was observed under forage-legume precursors (vetch, medics and sweet clover) compared to the fallow and fodder oat precursors. However, in 2001 the rainfall was optimal (Fig. 1) and hence barley yields were significantly higher compared to the yields of 1999 and 2002. Plots under fodder oats resulted lower barley grain and biomass yields in the subsequent season though the effect was not significant (P>0.05). This was as expected since fodder oat has lower N-contribution to the subsequent crop.

Fig 1. Rainfall situation during the experimental period



Conclusion

In Bale highlands farmers usually fallow their lands after harvest of 'Gana' ('belg') season barley due to the narrow time gap between the 'gana' and 'bona' seasons. The study, however, showed that farmers in Bale highlands can obtain a forage yield of 1-2 t/ha dry matter if they cultivate their fallow land with forage crops such as vetch and fodder oats under minimum tillage practice (one-pass ox plow after broadcasting forage seeds), without negatively affecting crop yields in the subsequent season.

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Table 1. Dry matter yield (t/ha) of forage crops sown under minimum tillage system at Salka-Odda and Salka Shallo in 'Bona' season (July to December) of 1998-2002

Forage precursors	Selka-Odda				Salka-Shallo			
	1998	2001	2002	Mean	1998	2001	2002	Mean
Vetch	0.58b	1.1ab	1.52a	1.1	1.26b	2.2	1.54b	1.67
Medics	0.12c	0.74b	0.22b	0.36	0.26c	1.21	0.45c	0.64
Sweet clover	-	0.50b	0.17b	0.34	0.02c	1.62	0.17c	0.60
Fodder oats	1.0a	1.66a	3.68a	2.1	2.14a	2.66	3.64a	2.81
Mean	0.4	1.0	1.4		0.9	1.9	1.4	
LSD	0.4045	0.6626	1.357		0.6566	29.23	0.9435	
CV%	47.8	33.4	48.6		35.7	NS	32.5	

Table 2. Grain yield (q/ha) of barley crop grown after the harvest of forage precursors in the subsequent 'Gana' (March to July) season of 1999, 2001 and 2002 at Salka-Odda and Salka Shallo

Forage precursors	Salka-Odda			Salka-Shallo	
	1999	2001	2002	2001	2002
Vetch	3.4	23.9	3.2	14.1	6.1
Medics	3.1	24.7	2.9	16.7	7.5
Sweet clover	2.2	22.8	3.0	14.1	7.1
Fodder oats	4.6	19.0	3.7	11.9	8.4
Fallow	4.3	20.0	2.9	12.1	8.1
Mean	3.5	22.1	3.1	13.8	7.6
LSD	1.352	NS	NS	NS	1.735
CV%	31.6	26.4	47.8	22.1	18.7

Feed Resources Base of Ethiopia: Status, Limitations and Opportunities for Integrated Development

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Abstract

Livestock feed resources in Ethiopia are mainly natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products. Feeding systems include communal or private natural grazing and browsing, cut-and-carry feeding, hay and crop residues. At present, Livestock are fed almost entirely on natural pasture and crop residues. Grazing is on permanent grazing areas, fallow land and cropland after harvest. Forage availability and quality are not favorable year round and hence gains made in the wet season are totally or partially lost in the dry season.

At present, around dairy and fattening areas there is insignificant production of improved pasture and forages. The contribution of agro-industrial by-products is also minimal and restricted to some urban and peri-urban farms (dairying, poultry and fattening). In the past two decades, considerable efforts have been made to test the adaptability of pasture and forage crops to different agro ecological zones; several useful forages have been selected for different zones. The medium and large-scale private enterprises could benefit from those findings.

Keywords: Feed resource; Ethiopia; limitation; opportunities

Introduction

Many researchers and development workers agreed that natural pasture comprises the largest feed resource: but estimates of the contribution of this feed resource vary greatly. Alemayehu, 1998a, estimated that 80-85 percent of all feed comes from natural pasture while some estimates indicate the natural pasture provides 88-90 percent. This is because the quantity and quality of native pasture varies with altitude, rainfall, soil and cropping intensity. Currently, with the rapid increase of human population and increasing demand for food, grazing lands are steadily shrinking being converted to arable lands, and are restricted to areas that have little value or farming potential such as hill tops, swampy areas, roadsides and other marginal land. This is particularly evident in the mixed farming highlands and mid altitudes.

Grasslands are generally in regions of moderate precipitation, between 250 and 750 mm. Grasses in different parts of the country vary according to the altitude. Most grasses are used as forage and grasslands are usually for grazing, but also provide tall and strong grass for thatch.

Natural Pasture

The grassland region of Ethiopia accounts for some 30.5 percent of the area of the country and is most extensive in the western, southern and southeastern semi-arid lowlands. On the more humid side, open grassland and grassland with some trees are common; grasses may cover as much as 90 percent of the area. In the drier parts patches of bush are common and the proportion of grass is reduced to about 70 percent. Incense and honey harvesting are common. Natural pastures provide more than 90 percent of the livestock feed in lowlands, with a wide range of grasses, legumes, and other herbs (1998b).

Area and Productivity

Recent information on the area and productivity of natural pasture is scarce because of the expensive (in terms of time and money) nature of data collection. Previous estimates of areas and productivity are very variable. The total grazing and browsing land was estimated to be 61-65 million hectares (Alemayehu, 1998a), but it is changing due to increasing population and cropping. Productivity estimates also vary, probably due to variation in time and ecological change, rainfall, soil type and cropping intensity.

The previous estimate of natural pasture yield for the lowlands was one ton DM/ha while for the highland and mid altitude on freely drained soils it was 3 tons DM/ha, and, on seasonally water-logged fertile areas yields were about 4-6 tons DM/ha (Alemayehu, 1998a). MoA (1984) estimate was 1.5 and 0.56 tons DM/ha for the highland and lowland respectively. Another yield estimate for different highland zones (MoA, 1989) was as follows:

- For High Potential Cereal/Livestock Zones (HPC/LZ) of savannah grass land and humid temperate pasture was 2 and 2.5 tons ha/year respectively.
- For both Low Potential/Cereal Livestock Zone (LPC/LZ) and for high potential Perennial/Livestock Zone (HPP/LZ) Pasture (Savannah grassland) was 1.5 and 2 tons DM/ha/year respectively.

Species Composition

Natural grasslands constitute the main highland pastures. Besides grasses, they contain 28 Trifolium species out of which 8 are endemic (Kahurananga, 1986). The highlands have been divided into different altitude zones for the description of the grassland vegetation designated by the characteristics of the plants (Alemayehu, 1985; Kahurananga, 1986). The proportion of legumes tends to increase with increasing altitude; particularly above 2,200 metres, there is a wide range of annual and perennial *Trifolium* spp., and annual *Medicago* spp. At lower altitudes native legumes are less abundant and commonly have a climbing or sprawling habit with a large variation in their range and density in wet bottomlands. This appears to be only partly due to edaphic differences. In the lowlands browse and shrubs are dominant plants.

Conditions and Trends of Grazing-lands

In the highlands plant growth is slow due to low temperature. The high stocking density and intensity of cultivation is out of proportion to the carrying capacity In the lowlands, short growing season suit only fast maturing plants; limited rainfall and recurrent drought, shrub invasion and overgrazing are major features of lowland grasslands. Overgrazing and seasonal feed shortage are evident in the country. Many studies have indicated, the grazing lands (except protected areas) of the country are in poor to very poor condition and will deteriorate further unless there is immediate action (1998a).

Pasture and Forage Crops

Over the past two decades several forages have been tested in different ecological zones; and considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. As a result, quite a number of useful forages have been selected for different zones. Improved pasture and forages have been grown and used in government ranches, state farms, farmer's demonstration plots and dairy and fattening areas. Forage crops are commonly grown for feeding dairy cattle with oats and vetch mixtures, Fodder beet, Elephant grass mixed with Siratro and Desmodiums, Rhodes/lucerne mixture, Phalaris/Trifolium mixture, hedgerows of Sesbania, Leucaena and Tree-lucerne being commonest. In suitable areas yield of oat-vetch mixtures are commonly 8-12 tons dry matter per hectare. Yield of improved pasture and forage grasses and legumes ranges from 6-8 tons and 3-5 tons dry matter per hectare respectively; and for tree legumes 10-12 tons dry matter per hectare. Due to land scarcity and crop-dominated farming there has been limited spontaneous introduction of improved pasture and forages. During the Fourth Livestock Development Project, different strategies and species for pasture and forage development were selected (Alemayehu, 2002). These strategies and forages have been promoted widely into the crop-livestock system, traditional grazing areas, and around homesteads, within soil and water conservation structures and under plantation crops and forestry. Details of new species, usage, improved management, their integration in the farming system and local seed production are discussed below.

Crop Residues

In the highlands and mid altitude, various food crop residues: cereals (teff, barley, wheat, maize, sorghum and millet), pulse crop residues (fava beans, chickpeas, haricot beans, field peas, lentils), oil crop residues and reject vegetables are providing a considerable quantity of dry season feed supply in most farming areas of the country. Currently, with the rapid increase of human population and expansion of arable land and with the steady decrease in grazing land, the use of crop residues is increasing. On average crop residues provide 10 to 15 percent of total feed intake. The same report suggested that in some localities under special crop/livestock production systems, the intake could increase up to 50 percent (MoA, 1998, Alemayehu, 1998a). The availability of crop residues is closely related to the farming system, the type of crops produced and intensity of cultivation. In integrated crop/livestock systems the potential of using crop residues, as livestock feed is greatest.

Agro-industrial by-products

Agro-industrial by-products produced in Ethiopia include: by-products from flour milling, sugar factory, abattoir and brewery by-products. These products are mainly used for dairy and fattening animals (1998a).

Limitations of Feed Resources

- **Feed Quality and Quantity:** Natural grazing is the major source of livestock feed, and in the lowlands livestock production is almost totally dependent on it. However, grazing lands do not fulfill the nutritional requirements of animals particularly in the dry season, due to poor management and their inherent low productivity and poor quality. In the highlands with the rapid increase of human population and high demand for food, pastures are steadily being converted to farmlands. Marginal lands unsuitable for cultivation such as waterlogged, flooded soils and steep lands are left for grazing and their productivity is very low. Another population-associated problem is environmental degradation due to deforestation and overgrazing which have substantially reduced soil fertility and further reduced productivity.
- **Ecological Deterioration:** Gradual encroachment of cultivation into grazing lands is common in both highlands and mid-altitude areas. So many meadows in the flood plains have been converted into croplands. Due to vegetation clearance many steep areas have become vulnerable to wind and water erosion. Important browse that was dry season forage has been wiped out to supply urban fuel and construction wood. Natural grazing land is deteriorating rapidly due to lack of attention and its carrying capacity declining due to high stocking, especially in pastoral areas. Pastoralism is becoming less and less possible and a riskier

business. Since the ecosystem is very fragile, the abuse and mismanagement of resources has created severe problems for people in grazing lands; indigenous people who are adapted to live in the dry lands are facing an ecological crisis.

- **Overgrazing:** Grazing and browsing animals overstock natural pastures; areas near water points are generally the most affected and unpalatable plants dominate grazing lands. In many pastoral areas since the number of stock has socio-cultural value, it has a synergistic effect with the diminishing grazing lands. Soils are under risk of degradation with reduced infiltration, low permeability and a reduction in the water holding capacity. The result is a decrease in the ability of the soil to support plant production.
- **Land Tenure/Change of Ownership:** In Ethiopia grazing land ownership is thought to be communal, where ethnic groups used to manage grazing lands. However, the federal or regional state can allow private investment in pastoral areas. Besides the loss of grazing land, investment may prevent free movement of pastoralists and initiate urbanization. If the nomadic pastoralists' sustainable way of life changes to sedentary farming the tragedy of the commons will become real-unless some adjustment is made.
- **Border Conflict:** Most extensive grazing lands are limited by ethnic boundaries and are often in border areas. There is conflict between tribes within the country and sometimes with neighboring countries. This has a profound effect on border grazing land.
- **Drought:** One of the most unfortunate characters of Ethiopia's climate is great variability of rainfall from year to year. Ethiopia is known for recurrent drought and famine. Drought is particularly common in the pastoral area where rainfall is erratic and unreliable. Nomadic pastoralists have adapted to live with the situation but other factors (listed here) have made them vulnerable to famine.
- **Weed and Bush Encroachment:** As a result of overgrazing many natural grazing lands are invaded by unpalatable weeds and woody plants. In pastoral areas misunderstanding of the traditional knowledge has lead to restriction of management with fire. Fire is a natural component of tropical ecosystems; its absence has created bush encroachment.
- **Soil Fertility:** The annual food and livestock feed deficit of the country is attributed directly to soil erosion and nutrient export. About half of the highlands are vulnerable for water erosion and the remainder has been cultivated without conservation measures for thousands of years.
- **Lack of Seed and Planting Materials:** The absence of quantity and quality seed and seedling production limits the vast expansion of improved pasture and forage development (especially around the dairy farming and fattening areas).

Opportunities for Improvement of Feed Resources

Pasture and forage genetic resources

Biological resources are fundamental to human well-being in agriculture, livestock, export earning, economic output and for their ecological services and functions. Ethiopia has an immense ecological diversity and a huge wealth of biological resources. The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms.

- **Pasture Species:** Since Ethiopia is known to be the centre of origin and diversity for a number of domesticated crops, it is also known to be the centre of diversity for pasture and forage species. There are several centers of origin of the cultivated grasses (such as *Chloris* spp., *Panicum* spp., *Setaria* spp. etc.). For the tropical species the main centre is Eastern Africa, from where many promising species and varieties have been selected. In Ethiopia, the large numbers of indigenous grass species and the very great variation within the species make the country a rich potential source of new and better tropical pasture grasses. Until now there are a total of 736 grass species from 181 genera that are documented in Ethiopia, of which 164 species from 68 genera are reported to be important (medium to high level) for pasture and forage purpose.

- **Herbaceous Legumes:** Ethiopia is a centre of diversity for herbaceous legumes such as the genera *Trifolium*, *Vigna*, *Lablab*, *Neonotonia*, and others. There are a total of 358 herbaceous forage legume species from 42 general documented in Ethiopia. Reports indicate that about 58 species from 31 genera are potentially important for pasture and forage. Currently 2076 accessions from 140 species and 35 genera are systematically collected and conserved.
- **Browse trees/Shrubs:** Browse trees or shrubs are important animal feed in Ethiopia especially in the arid, semi-arid and mountain zones, where large numbers of the country's livestock are found. They provide protein, vitamins and mineral elements, which are lacking in grasslands pastures during the dry and/or cold season and serve as standing feed reserves to be built up, so that herds are able to survive critical periods of rainfall shortage. In Ethiopia there are 179 browse species from 51 genera, which is not exhaustive, of which 51 species from 31 genera are recorded as promising browse species. Currently 185 accessions from 41 species and 18 genera are systematically collected and conserved by ILRI (IBCR/E 2001).

Biodiversity conservation

Conservation and use of grass germplasm has made a significant contribution to the economic development of Ethiopia through the national pasture and forage research programme. The International Livestock Research Institute ILRI (ex. ILCA) has done much to fill the gap by collecting grasses from different parts of Ethiopia and by acquiring access to world collections of forage grass germplasm. Currently over 371 accessions of grasses from 77 species and 37 genera, 2076 accession of legumes from 140 species and 35 genera and 185 accession of browse from 41 species 18 genera are collected and conserved. In recent years the Forage and Pasture Genetic Resource Conservation and Research Department was established under the Institute of Biodiversity Conservation and Research/Ethiopia (IBCR/E) to carry out the conservation of pasture and forage genetic resources.

Pasture rehabilitation

Because of Ethiopia's diverse climate, there are a number of valuable wild grasses and legumes and browse plants. The highlands are rich in pasture species, especially legumes. Herbaceous legumes tend to increase with increasing altitude. There is a wide diversity of annual and perennial *Trifolium* species and annual *Medicago* in the highlands, particularly above 2,000 metres. At lower altitudes annual legumes are less abundant, but there are a number of browse species adapted to the dry conditions. Despite the fact that research on natural improvement is minimal, most trial results are positive. To improve the vegetation composition and the nutritional value of degraded pastures, research on oversowing with legumes and grasses has indicated that vetches (*Vicia dasycarpa* and V. *atropurpurea*) and local clovers (*Trifolium* sp.) were successful in the highlands. In mid-altitudes the perennial *Desmodium uncinatum* has shown superior establishment with Rhodes grass (*Chloris gayana*) and Siratro (*Macroptilium atropurpureum*). Research and development testing over the last two decades identified promising forages that are suitable for pasture rehabilitation in a wide range of agro-ecological zones. Weed Control Weeds are major problems in both perennial and annual pasture and forage crops; unless they are controlled productivity will be low. In Ethiopia weed control by herbicides, machine mowing and topping and hand weeding have been tried; hand weeding is the best method. Since family and hired labour is plentiful and cheap there is an opportunity to use it for weed control, so there is a considerable opportunity to foster the development of improved pasture and forage crops on a large scale without a major problem of weed infestation.

Sown pastures and forages

Climate and land availability provide a good opportunity for forage production. In Ethiopia most improved tropical species can be grown in the lowlands (1,500-2,000 metres) and temperate species grow from above 2,100 metres up to 3,000 metres (Alemayehu, 2002). Introduced improved forage yield is higher than the naturally occurring swards and has higher nutritional value. In addition the length of the productive season is longer for cultivated pastures than for native pastures which provides an opportunity for dairy and fattening production to develop and use pasture and forage on a large scale.

Greater use of leguminous fodder trees and shrubs assists in increasing soil fertility, controlling soil erosion and providing firewood and timber. These legumes are well adapted to the current edaphic and grazing condition, they can be readily integrated into farming systems, they retain their feeding value into the dry season and show great success in the higher potential areas of the country.

Pasture establishment is relatively difficult in the highlands compared to the humid, warmer and lower areas, because of the soil and climate. In the wet season water logging, relatively low soil temperature, and reduced long and short radiation limits the establishment and subsequent growth of pasture in the highland. In these areas, for the best environmental condition for seed and seedling establishment and growth, perennial pasture is usually sown during the short rains (March and April) but annual forages are usually sown in June (IAR, 1983).

Conventional methods of establishing pasture are tedious and labour demanding, especially in the highlands; better ways are the low-cost methods such as backyard, undersowing and oversowing, which are more attractive to farmers. These strategies provide farmers proper use of their land for cultivation of crop/pasture and forage/trees, where products can be used for food, feed and firewood respectively. Some perennial grasses can be planted vegetatively; *Festuca arundinacea*, *Phalaris arundinacea*, and *Setaria sphacelata* are well adapted to waterlogged conditions and easily established by root splits.

There is also considerable opportunity for the use of fodder tree-legumes in agroforestry. Woody legumes provide: a fodder hedge planted around the backyard, firewood, wood for construction of houses and farm equipment, wind breaks, for ceremonial purposes and for stabilizing bunds and gullies. The current promotion of fodder trees-legumes in the national agro-forestry system is a good opportunity for extension of a forage programme within farming systems; and contributes to environmental protection and natural resource management and even to food security.

Integration of pasture and forage into farming systems

One of the best opportunities for highland farmers to use land efficiently will be through the introduction of pasture and forages in the farming system. In trials in the highlands on wheat and barley under-sown with lucerne, annual clovers, tall fescue, perennial rye grass, *Setaria* and

Phalaris, the sowing of both cereals and forages was at the same time. All under-sown forages established successfully except lucerne and there was no significant reduction of cereal yield. The establishment of forages was much better under wheat than under barley (IAR, 1983). Since fallowing cropland is common in the highlands, under-sowing cereals with forages could significantly relieve the feed problems of the area.

Table 1. Recommended Improved Pasture and Forage Strategies and. Species

Strategy	**Low Altitude (1,500-2,000 m)**	**Medium Altitude (2,000-2,400 m)**	**High Altitude (>2,400 m)**
1. Backyard Forage	Leucaena leucocephala, Sesbania sesban, Cajanus cajan, Chloris gayana, Setaria spp., Panicum maximum, Pennisetum purpureum, Desmodium uncinatum, Medicago sativa	Chamaecytisus palmensis, Medicago sativa, Sesbania sesban, Cajanus cajan, Phalaris aquatica, Pennisetum purpureum, Vicia dasycarpa	Chamaecytisus palmensis, Phalaris aquatica, Vicia dasycarpa, Avena sativa, Medicago sativa,
2. Undersowing	Lablab purpureus, Vigna unguiculata, Macroptilium atropurpureum, Desmodium uncinatum, Stylosanthes fruticosa, Vicia dasycarpa, Cassia spp.	Vicia dasycarpa, Macroptilium atropurpureum, Desmodium intortum	Vicia dasycarpa
3. Forage Strip	Leucaena leucocephala, Sesbania sesban, Cajanus cajan, Panicum maximum, Setaria sphacelata	Chamaecytisus palmensis, Sesbania sesban, Cajanus cajan, Desmodium intortum Macrotyloma axillare, Trifolium semipilosum, Vicia dasycarpa, Phalaris aquatica Setaria sphacelata, Macroptilium atropurpureum, Macrotyloma axillare, Desmodium intortum ,Stylosanthes fruticosa	Chamaecytisus palmensis, Vicia dasycarpa, Phalaris aquatica
4. Oversowing	Stylosanthes fruticosa, Macroptilium atropurpureum, Cassia spp., Desmodium uncinatum		
5. Livestock exclusion Areas	Cenchrus ciliaris, Leucaena leucocephala, Sesbania sesban, Macroptilium atropurpureum, Stylosanthes fruticosa, Macrotyloma axillare, Desmodium uncinatum, Paspalum plicatulum	Chamaecytisus palmensis, Sesbania sesban, Macrotyloma axillare, Macroptilium atropurpureum	Chamaecytisus palmensis, Phalaris aquatica, Vicia dasycarpa, Medicago sativa, Avena sativa
6. Conventional pasture and forage	Stylosanthes fruticosa, Macroptilium atropurpureum, Desmodium unicnatum, Chloris gayana, Panicum maximum, Setaria sphacelata	Phalaris aquatica, Setaria sphacelata, Desmodium intortum, Vicia dasycarpa	Medicago sativa, Vicia dasycarpa. Phalaris aquatica, Dactylis glomerata, Avena sativa

Source: Alemayehu Mengistu (2004)
Note: The forage strategies and species have been introduced and developed in the different farming systems. Thus: a) sowing stock exclusion degraded grazing areas as a conservation measure (900 ha); b) over-sowing with grass or legume seed by broadcasting on communal pasture and on road sides (911,000 ha); c) establishing forage strips and alley strips (18,600 ha); d) backyard forage production by providing an array of multipurpose tree (10 million seedlings) and forage legumes and grasses; e) under-sowing, particularly with annual legumes in maize and sorghum fields (17,500 ha); and f) sowing of pastures with perennial trees (82 ha) have been established and covered. The strategies are found to be very cost effective (low input and out put management) easily accepted by farmers and provide best opportunity to integrate them in crop/livestock/forestry farming systems.

At research sites in the mid-altitude area, maize was under-sown with Desmodium, phasey bean, *Chloris* (Rhodes grass), *Panicum* and *Cenchrus* after the first weeding. Almost all forages established, and there was no maize yield reduction (IAR, 1983). There is a good opportunity for integration of pasture and forage crops in the existing farming system.

As a result of these findings, in Ethiopia heavy emphasis is put on the use of forage legumes in cropping systems (through under-sowing, improvement of fallows, and establishment of tree legumes hedges) to partly address the major problems of long-term sustainability of crop production. Extensive use of tree legumes in a number of strategies can have an effect, in the long term, on firewood supplies, including the release of dung, which would otherwise have been burnt. The increased forage supply and improved use of forage (dairy and fattening system) will provide another opportunity for generating dung.

There is a wide opportunity for the use of forage pulse crops to be incorporated in the farming system; adapted and recommended crops are: Cowpea, Pigeon pea and *Phaseolus acutifolius*. These can be used for food and feed especially during the dry season.

Pasture and forage seed production

Many of the temperate and tropical pasture and forage crops that have been tested and grown in Ethiopia have no problem of flowering and setting seed. This provides a good opportunity for the country to establish local seed production in the existing farming system. The current local pasture and forage seed production systems adopted in the country are:

- **Farmer contract seed production system: -** involves the production of annual and perennials under contract with individual farmers and/or farmer's cooperatives.
- **Seed production on ranches: -** this is mostly for perennial legumes and grass seed.
- **Seed production on specialized plots: -** this is undertaken in a few areas by some governmental and non-governmental organizations.
- **Opportunistic seed production:** - involves the collection of seed from developed opportunistic pasture/forage sites.

Under these systems over 200,000 tons of forage seed were produced from 1988 to 2002. Of the seeds produced: Vetch, Lablab, Cowpea, Axillaris, Siratro, Stylos, *Desmodium*, Oats, Rhodes, *Panicum*, Tree-lucerne, *Leucaena* and *Sesbania* are dominant. Large local seed production is under way using farmers' contracts (Alemayehu, 2001).

Irrigation

The irrigation potential of the country is high; the potential area for irrigation is estimated to be about 3,000,000 hectares. Small-scale traditional irrigation has been practiced for decades throughout the highlands, small streams are seasonally diverted for limited dry season cropping. This is a good opportunity to grow off-season pasture and forage crops. Medium and large-scale schemes are of much more recent origin, mostly in the rift valley for cash crops. There is some irrigated forage in the rift valley growing lucerne/Rhodes mixture for commercial fattening and dairy farming. The potential for irrigated forage is untapped and still there is a great opportunity for producing seasonal and long term irrigated pasture and forages.

Better grazing land resource management

At every point of resource management, community knowledge and participation, from the beginning to the end through evaluation and monitoring is vital. Ethiopia's farming people have traditional laws which govern the community, adopted for thousands years. The presence of traditional community rules provides an opportunity in the management of the grazing and other land resources. Current government policies encourage peoples' participation and community participation from project conception through planning and implementation to monitoring and evaluation undertaken on the decisions of the resource users and managers.

On top of these, protection and penalizing of illegal acts against management of grassland resources, the community exercise their own acceptable by-laws. This provides the best opportunity for correct management of grazing land resources. Based on these, a number of recommended management rules are developed to assist grazing land problems and management. These rules are based on community by-laws.

Recommended rules for grazing land management in Ethiopia

- Respect, promote and encourage the traditional sustainable natural grazing land resource use by the local community.
- Promote the means to zero grazing and controlled grazing and encourage people to see their animals in economic terms (market value) rather than social prestige.
- Encourage the cut and carry system of feeding, forage development around homesteads crop farms and hillsides.
- Promote agro-forestry, which also increases firewood, construction material, implements and crafts and forage production.
- Increase animal production through the best utilization of pasture and forages. Integrate soil and water conservation enclosure with sustainable forage production.
- Mobilize indigenous and scientific knowledge into different localities through networks.

In addition to their role in animal feed, pasture and forages in Ethiopia can make a significant contribution to sustainable uses like: watershed management, soil erosion control, soil fertility maintenance, in general to natural resources management and thus to national food security.

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