# PRODUCTIVITY AND SOCIO-CULTURAL ASPECTS OF LOCAL POULTRY PHENOTYPES IN COASTAL KENYA

**MASTERS OF SCIENCE DEGREE THESIS**
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# Dedication:

**This thesis is dedicated to my whole family, and specifically my mother, Eunice Mwihaki Kamau, for her efforts in educating me, and my grandmother, Pherister Muthoni Kamau, who was always there to wake me up early in the mornings when I started school.**

# Preface

The study is comprised of two parts; **Part A** for the survey and **Part B** for the experiment. The survey was carried out to investigate the productivity of the rural poultry production system and the various socio-cultural aspects associated with the different phenotypes found within the district. The experiment was undertaken to investigate the productive performance of the various phenotypes (naked neck, frizzle feathered, dwarf, and normal) collected from different Agroecological zones in the district.

Consequently, the thesis has two manuscripts.

**Manuscript I**: A survey of village poultry production in the South Coast Kenya, Kwale district.

**Manuscript II**: Productive performance of different phenotypes of indigenous poultry in Coastal Kenya.

# Productivity And Socio-Cultural Aspects Of Local Poultry Phenotypes In Coastal Kenya

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## Summary

This first study, a survey was carried out in five villages of Kwale district, south coast Kenya, by the use of both PRA's tools and a structured questionnaire. A total of 107 households were interviewed. The objectives were to investigate the productivity of the chickens and various socio-cultural issues related to poultry.

Women provided most of the day-to-day management of poultry as compared to men. The mean (±SD) flock size per household was 16±10.3 birds, with a flock structure ratio of 2:5:8 (cock:hen:chicks). The productivity of the hens was found to be three clutches per year, with 14 eggs per clutch per hen and a hatchability of 84.6%. The main reasons for keeping poultry were for food (38%), sale (34%) and socio-cultural functions (24%). Socio-cultural aspects such as use in ceremonies, festivities and rituals were among the major consideration in the preference of the poultry phenotype, where plumage colour, cover and sex of the birds were considered. Ethno veterinary medicine was widely used by the poultry keepers (44%) to control diseases. Prices of the poultry products were found to vary considerably with the season.

In the second study, an experiment was carried out to assess the productivity of four phenotypes of local chicken (normal feathered and size, naked neck, frizzle feathered, and dwarf), collected from four agroecological zones, designated as *wet* (*CL2), Humid (CL3), sub-humid (CL4)* and *dry* (*CL5*). Data on mature body weights, mortality during rearing, egg quality characteristics, fertility, hatchability, and chick growth rates up to five weeks was collected.

The naked neck had a significantly higher body weights (1.4±0.33 kg and 2.2±0.52 kg for the females and males respectively). Egg weights ranged from 38±2.9 g to 45±4.5 g, with the naked neck having the highest. The overall mean eggshell thickness for the birds was 0.31mm. The highest rate of lay was observed to be 36% by the dwarf, which also had the highest shape index of 0.80±3.9. The Naked Neck had the highest ADG among the other four phenotypes (4.5 g/day).

It can be concluded that the naked neck phenotype is superior in the productivity when compared to other phenotypes. This can be increased by the combination with the other phenotypes. The three phenotypes are therefore relevant in tropical conditions and are worth being considered in the improvement of productivity of the local chickens. However in selecting such birds with characteristics that are determined by their genetic makeup, it's worth considering the goals and purposes of the people who rear them. It is important to ensure that the selected birds do not have any cultural hindrances, and would be accepted by the targeted rural people. In such instances, the birds will go a long way in increasing the welfare of the rural poor.

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***Samson Kamau Njenga***.

**TABLE OF CONTENT**

## 1. INTRODUCTION

**Background**

Kenya is one of the three East African countries bordering Tanzania to the south, Uganda to the west, Sudan and Ethiopia to the north, Somali to the east and Indian ocean to the south east. It is situated at longitudes $34^0$-$42^0$ East and latitudes $4^0$ North $4^0$ South. It has a human population of about 32 Mill. People (1999 Census) and a land area of 564,662 sq. Km. 80% of the population lives in the rural areas and 50% below the poverty line. Of the total land surface area, only 8 % is considered suitable for arable farming (Kenyaweb.com 2003). The rest of the land is low potential and mostly suitable for livestock farming. It is classified as arid and semi-arid lands, characterized by high ambient temperatures and low rainfall.

Kwale District lies within the Coastal lowlands (CL) zone group with mean annual temperature higher than 24 degrees Centigrade and mean maximum temperature lower than 31 degrees Centigrade. The main crops of this zone group are cashewnuts and coconuts. Within this zone group, main zones are distinguished and determined by the mean annual rainfall. In the district, there are five main agro-ecological zones ranging from CL2 (where 2 stands for 'sub-humid') to CL6 ('arid') characterized by leading crops and/or agricultural activities in each of them. About 72% of the district lies within agro-ecological zones CL5 and CL6 whose average annual rainfall ranges from 500 to 900 mm which is poorly distributed and unreliable. This makes the area suitable for ranching activities. Agro-ecological zones CL2 to CL4 are suitable for mixed farming. The only limiting factors in these zones are high evapo-trasnspiration rates, unreliability of rainfall and tsetse infection, which limits livestock development for large ruminants (Kenyaweb.com, 2003).

The poultry population in Kenya is about 29.8 million (m) chickens consisting of 21.8 m local chickens, 4.4 m broilers and 2.9 m layers. The local chickens are the main source of income for 90% of the rural households, which comprises 80% of the population. Therefore the local chickens are among the many local resources of poor people living in the rural areas, which could be harnessed and utilized for poverty alleviation, (Njue, 2002). Traditionally, poultry plays an important role in Kenya. The chickens have been and still are a major source of protein in form of meat and eggs.

The Kenyan government initiated improvement programmes as from 1976 up to the 1995 through the National Poultry Development Programme (NPDP), which was jointly funded by the Government of Kenya (GoK) and the Netherlands Government. However the emphasis was on commercial poultry production and rural poultry was only given attention at the beginning of 1990's (Nyange, 2000). The programme used the Black Shavers and Rhode Island Red pure breeds to upgrade the indigenous chicken through the cockerel exchange, supply of pullets and hatching eggs. Cockerels were reared up to maturity, mainly on government stations, and then they were exchanged for local cockerels owned by rural smallholder farmers. The supply of the pure breeds allowed the farmers to renew their flocks and remain independent from external suppliers. However this approach was (and still is) hindered by the fact that the pure breeds are more difficult to purchase and are becoming scarce, and when present, they produce less than the hybrids**.** In addition, there was a lack of proper and continuous monitoring of the breeding, and the exotic birds did not survive under the prevailing harsh conditions. The farmers were given advice on improved feeding and housing and were asked to remove the local cockerels. This approach led to a limited improvement due to the high mortalities, poor management, and above all, the programmes were usually planned without the farmers' participation. In addition the strategies did not pay attention to local social and cultural aspects of poultry production. Consequently, the cockerel and pullet exchange had a limited impact on the improvement of rural poultry production. Such activities have been attempted in other countries such as Malawi, Niger, Tanzania, Ethiopia and Bangladesh, with similar experiences (Sonaiya, 2002).

In 2003, the Smallholder Poultry Development Project was initiated in Kenya under the Agricultural Sector Programme Support (ASPS), funded by Danida in collaboration with GoK, and based on the Bangladesh Poultry model. This model is being tested in the two coastal districts, Kwale and Taita Taveta, for adaptation by the rural poor women. The ISA Brown hybrid hens are used together with local cocks to produce eggs that are given to broody local hens for hatching. The major challenge will be that the hybrids will require a constant external parent stock supply, which means the presence of a well managed hatchery facilities and grandparent stock, which is beyond the scope of smallholder farmers.

One way of overcoming the above challenges posed by past strategies in improving sustainable productivity is through genetic selection and development of suitable indigenous parent stock. The improvement of these poultry should be in line with the existing rural conditions to avoid the likelihood of maladjusted management. Selection over time may yield a stock that fit the local conditions. The rural poultry offers a wide range of genetic potential, as the local chickens are genetically heterogeneous, offering a wide range of phenotypes and genotypes to select from.

The local chickens appear to be genetically heterogeneous with no specific colour pattern and nondescriptive both in phenotype and genotype. The local birds seen in villages may have been crossed with exotic cocks in earlier years through the cockerel exchange programme, but such genes may have been dispersed and lost in the population because of unplanned breeding programmes and absence of selection (Njue et al, 2002). Indigenous poultry in sub-Saharan Africa is a very important part of the farming system. Despite the low productivity, it can and should be used as a tool for development in rural Africa and elsewhere. It offers a valuable means of generating income and providing nutrition to the rural population, majority of who die of hunger and malnutrition and are languishing in poverty.

Even though the indigenous birds are generally poor producers, there exist highly productive indigenous birds (Mathur 1989, Nwosu, 1979) and some are well adapted to their environments (Njue et al, 2002). The genetic resource base of the indigenous chickens in the tropics is therefore rich and should form the basis for genetic improvement through selection and multiplication to produce a breed adapted to the tropics. The task is to identify and select such individuals or families. The selected families and individual birds can then be used for crossing to improve production further.

The overall objective of this study was therefore to investigate the existing and potential levels of productivity of the local poultry stocks and assess their suitability in increasing productivity at the village level.

**Objectives**

1. Investigate various socio-cultural issues related to the different local phenotypes including the naked necks, frizzles and dwarfs.

2. To study the performance of the four phenotypes of indigenous chicken in terms of body weights, egg production, fertility, hatchability, growth rates and survivability.

3. To identify the indigenous poultry phenotype among the three that is well adapted to tropical coastal climate, (characterized by high ambient temperatures and high humidity), and which can be used in improvement programmes so as to increase the profitability of indigenous chicken production in coastal Kenya.

**Literature Review**

Some of the different indigenous breeds and strains that are abundant in Coastal Kenya and Sub-Sahara Africa in general are Dwarf breeds, Frizzle Feathered, Normal Feathered and Naked Neck chickens (Ndegwa et al, 1998). Very little research has been done to determine their effect to the existing or potential levels of productivity among the rural poultry stock. There is a need for their genetic evaluation in order to conserve the desirable genes e.g. disease resistance (Sonaiya, 2002) and promote them, consequently improving the productivity of the local birds within their local conditions.

In the process of adaptation to the local conditions, the scavenging chickens may have sufficiently evolved into distinguishable ecotypes with productivity characteristics that are identifiable and can be utilized for further improvement (Nyaga, 2002). There's a need to characterize the laying and growth patterns of the various 'types' in order to quantify their potentials, qualifying them to be termed as breeds. Apart from the Fayoumi breed developed in Egypt, there appears to be no record of a tropical adapted breed developed from indigenous chickens in Africa.

Horst (1999) recommends that for successful improvement of the indigenous breeds on productivity, production traits and characteristics related to adaptability should be considered. Such traits, determined by what he called tropically relevant genes, include the naked neck, frizzle feathered and dwarfism. The decisions on the use of ecotypes in improvement programs should be based on both the evaluation of genetic distinctness and performance data records.

The naked neck gene is a single autosomal dominant gene, *Na*. The gene is incompletely dominant with $Na/na^+$ birds showing an isolated tuft of feathers on the ventral side of the neck above the crop, while *Na/Na* birds either lack this tuft or it is reduced to just a few pinfeathers or small feathers. The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Hutt 1949, Somes 1990).
The relevance of the naked neck gene in the tropics lies in its association to heat tolerance. The reduction in feather coverage of 30-40% in naked neck birds facilitates better heat dissipation and improved thermoregulation resulting to a better relative heat tolerance under hot climates. Merat, (1990) has reviewed several favourable effects of this gene. He states that in high temperatures, near $30^o$ C or higher, homozygous *Na/Na* or heterozygous $Na/na^+$ naked neck birds had a better weight gain than normal $na^+/na^+$ birds. There was also an improvement in the carcass yield, laying rate, mean egg weight, eggshell strength and egg mass for the heterozygous genotype. However, he noted an increase in embryonic mortality, mostly during the last stages before hatching that was observed in the *Na/Na* and $Na/na^+$ birds.

Other favourable effects of this gene in high temperatures includes higher breast weight, superior growth rate, better feed conversion ratio and carcass traits (Yalcin et al, 1997, Patra et al 2002), reduced effect of high ambient temperatures on fertility (Ladjali et al, 1995), less body weight loss in heat stress (Mazzi et al 2002), superior levels of heat shock protein, Hsp 70 (Hernandes et al, 2002), lowest incidence of the pathologies such as cloacal cysts, ascites, prolapse, Marek's disease, coccidiosis, osteodystrophy and Salmonellosis (Fraga et al, 1999) and resistant to sudden death and ascites syndrome (Gonzales et al, 1998). Further, Combining the naked neck allele with other tropically relevant alleles such as frizzling has bee shown to result to a favourable additive effect to various productive parameters (Yunis and Cahaner, 1999; Horst et al 1995).

Frizzling is caused by a single incompletely dominant autosomal gene, *F*, restricted by an autosomal recessive modifier, *mf* (Hutt, 1949). The mode of action and the effect of this gene are well reviewed in the literature (Somes 1990). In unmodified homozygous frizzled birds, the rachises of all feathers are extremely recurved. These feathers are easily broken and therefore the birds appear quite bare. The modifying gene lessens the extreme aspects of the homozygotes so that they appear less woolly. *Unmodified heterozygotes* have the feather shafts and barbs of contour feathers recurved, to a much less extent than the homozygotes. This is modified so that some birds are almost indistinguishable from the wild type. The action of the *F* gene has been shown to be localized in the feather follicle and does not result from a metabolic disorder. The effect of this gene on production has been shown to be favourable by an increase in egg number and egg mass, alongside reducing mortality under hot conditions (Merat 1990). The only unfavourable effect of the gene found in the literature is mentioned by Somes (1990). He noted that Landauer in1932, maintained that the hatchability of eggs laid by heterozygous frizzles is subnormal and that it is still lower in eggs from homozygotes.

Dwarfism has been described in detail by Somes (1990), to be either the sex-linked dwarfism, with three different genes (*dw*,$dw^M$,$dw^B$) or autosomal dwarfism, ( *adw*). He states that the sex-linked dwarfism, *dw*, is a recessive sex-linked gene closely linked to the gold-silver and slow rapid feathering loci. It has a much greater dwarfing effect than any other previously discovered. Males are reduced in size by about 43% while females are reduced by 26-32%. He noted that the birds have a fertility and hatchability as good as the normal, but with Egg size reduced by 10%. Also the egg numbers are slightly reduced. Bantam Dwarfism $dw^B$ is a size reducing sex-linked recessive gene, closely related to the sex-linked feathering locus., The effect of this gene is less than the sex-linked dwarfism. It was shown to reduce the female size by 5-11% (when compared to normal ($Dw^+$/- ) females. In males, the heterozygotes $Dw^+/dw^B$ are reduced by about 5% while the homozygotes $dw^+/dw^+$ were reduced by 14%, when compared to normal $Dw^+/Dw^+$ males. The $dw^B$ allele seems to be recessive to its incompletely dominant normal $Dw^+$ allele and dominant over the *dw* allele (Somes 1990). The MacDonald Dwarfism $dw^M$ gene is a single sex-linked recessive belonging to the same locus as the *dw*, but suggested to be a different allele $dw^B$, as the $dw^B$ only reduced female body weights by 10%, shank length by 5%, with birds generally appearing normal. The $dw^M$ reduced the female body weights by 13.5%, shank length by 9%, with birds being definitely distinguishable from the normal by their smaller size. The dominance relationship between the $dw^M$ and the other two recessive alleles is unknown. Finally the only known Autosomal Dwarfism (*adw*) is a single autosomal gene, with an effect of reducing the body size by 30% and easily distinguishable when the birds carrying this gene are 6-8 weeks of age. The birds have an excellent viability, adult body weight of 1400 g, delayed sexual maturity, has an egg production of 87% of the normal and the egg size at one year of age is 57g. However, a reduced hatchability was reported by (Somes 1990).

From the above, it is therefore clear that the mode of action and the effect of these genes on productivity have been well documented. However their effect and relevance in the rural poultry flocks has not been investigated, yet they have been shown to be abundant in the tropics. There is therefore the need to revisit the local poultry resource and assess the contribution of these genes. This will assist on the genetic improvement on productivity and the conservation of the identified desirable genes.

## 2. MATERIALS AND METHODS

### A. SURVEY

The survey on indigenous poultry was carried out in the district to investigate various socio-cultural issues related to poultry and the productivity of the rural poultry. The survey was conducted in five villages located in different divisions. These villages were selected in collaboration with livestock production extension staff. The criterion used was the agro-ecological zones (AEZ), where one village per zone was selected, with considerations on accessibility and availability of indigenous poultry. A combination of Participatory Rural Appraisal (PRA) tools, where general information on poultry was gathered, and a structured questionnaire was used to collect specific information on flock size and structure, housing system, feeding, health, flock breeding and ownership pattern. A total of 107 households were selected at random and interviewed. (***See Manuscript I for details***)

### B. EXPERIMENT

149 birds (128 females and 21 males) of different phenotypes were randomly selected from the rural flock of four regions with different agroecological characteristics. The four phenotypes that were used in the experiment were the normal feathered and normal size *(No*), naked neck (*Na*), frizzle feathered (*Fr*) and the dwarf (*Dw*). The birds were collected and reared intensively in a government farm. Eggs were collected daily and selected for artificial incubation and the chicks were reared up to five weeks. Some eggs were selected for egg quality analysis (***See Manuscript II for details***).

## 3. RESULTS

### A. SURVEY

***Household Characteristics***: Most of the household's heads were men (87%). In the five villages the literacy level for women (59%) was lower than that of men. The main occupation was farming, with crops grown being maize, cowpeas, groundnuts, coconuts, sweet potatoes, cassava, beans, rice, millet, bananas and cashewnuts. The main use of the crops was for food (subsistence farming). Chickens were the most popular livestock type kept. 96% of the households interviewed kept chickens, followed by goats, cattle, ducks, sheep and pigeons. The results were the same when the matrix ranking was used. Chicken was ranked first in two of the villages. Goats were ranked second and Cattle were third.

***Objectives of Rural Poultry Production***: The main objectives of keeping indigenous chicken were home consumption, sale and the use in rituals. Other uses were in ceremonies, gifts and as a security. This was the trend in all the regions. Eggs were mostly for hatching, followed by home consumption and sale.

***Types of chickens kept***: Most of the households (82%), had been keeping chickens for more than five years, 96% rearing indigenous breeds. The main reasons for keeping indigenous breeds were that they are easier to manage, readily available and resistant to diseases. There were several phenotypes of chickens that are kept in the district. These includes the normal feathered and size (normal), dwarf, naked neck, crested head and frizzled feathered. It was found out that there are beliefs attached to the types of chickens, which in turn affected the use and importance in regard to the type.

The normal is the only type that can be slaughtered to visitors, hence ranked first. The crested head was no different to the normal as its uses are the same. The naked neck, even though highly valued for its large size and more meat, cannot be slaughtered for visitors and therefore ranked after the normal. The frizzle feathered was ranked last as it is only used for rituals. However it can be slaughtered for home consumption. The dwarf was last due to its small size and fetches low prices during sale. However it was said to be more prolific than the rest of the types has a good mothering ability and kept for ornamental purposes.

The most preferred colours were red/brown, black and white. Red was said to have more uses in traditional medicine. The black was more preferred than the others as black is used in rituals involving children and was said to easily camouflage against predators, and therefore not easily spotted by kites. White is used for offering sacrifices in shrines and demanded in traditional sacrifices. The major criterion in colour preferences seems to be the uses of the colour in traditional treatments and the ease of camouflaging.

***Ownership and Day-to-day management of chickens***: Men own most of the birds, and on average it was indicated to be in the ratio of 13:10:6 for men, women and children. However, it was the women who provided most of the day-to-day management of the chickens.

## Production and Productivity

***Flock Structure***: The average flock size in the district was 16, (Table 1) with the ratio of Cock: Hen: Chicks being 2:5:8. The cock to hen ratio was about 1 to 3. The flock structure may vary from season to season depending on feed availability.
Most of the respondents (59%) indicated that there were three clutches per year, with an average of 13.9 eggs per clutch. The overall hatchability was 84.6%. Most respondents (97%), indicated that the source of the eggs were from their own flock.

*Table 1: Performance of local chickens in different AEZ's of Kwale district, Kenya*

| ***Variable*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| Mean Eggs per clutch ± SD (n) | 14.1 ± 2.9(21) | 14.4 ± 2.8(22) | 12.7 ±3.5(24) | 14.7 ±3.0(20) | 14.2 ± 3.0(18) | 13.9 ±2.0(105) |
| Hatchability (%) | 85.9 | 88.1 | 83.3 | 81.9 | 80.1 | 84.6 |
| Flock structure | | | | | | |
| Cocks | 1.5 | 1.5 | 1.8 | 1.6 | 1.1 | 1.7 |
| Cockerels | 2.4 | 2.0 | 2.9 | 1.8 | 1.4 | 2.2 |
| Hens | 4.4 | 3.5 | 5.1 | 4.3 | 3.5 | 4.5 |
| Pullets | 5.6 | 3.0 | 4.9 | 3.5 | 2.4 | 4.0 |
| Chicks | 8.0 | 7.5 | 9.1 | 5.7 | 4.8 | 7.9 |
| Mean Total Birds | 16.6 | 19.5 | 21.1 | 11.3 | 8.8 | 15.9 |
| ± SD (n) | ± 10.3 (21) | ± 7.9 (22) | ± 11.2 (24) | ± 9.2 (20) | ± 7.0 (18) | ± 10.3 (105) |

## Management

***Feeds and feeding***: Most farmers did mention that they provided supplemental feeds to their chickens. The major reason was to increase production, as they perceived that what they were getting from scavenging was not enough. The major supplementary feed given was bran (Table 2) possibly from maize, followed by household refusal, kitchen leftovers and very few (2%) gave their chickens commercial feeds. Nearly half of the farmers indicated that they were giving the supplemental feed in the morning. The average feed given was 1.6 Kg per day. This was in an average flock size of about 16 birds and a bird was getting an average of 100 g but only after harvest. A large proportion of farmers provided their chickens with drinking water, usually at any time of the day.

***Housing***: 95% of the farmers provided housing for their birds either in form of part of sleeping house, separate shelter or part of the kitchen. Most of the birds were housed in the farmers sleeping house.(Table 1)

***Disease Control***: The communities mostly use both traditional herbs (44.4%) and consultation of veterinary personnel (43.2%) in the area when the birds are sick. A few (11.1%) were able to buy medicines and treat the birds by themselves.

***Breeding***: Most farmers acquired their initial stock by purchasing and a few received them as gifts. Other ways mentioned were inheritance, exchange by other commodities and through contractual agreement. When adding their flocks, the major method was through breeding followed by purchase.

*Table 2*:*Management for local chickens in Kwale district, Kenya*

| ***Variable*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| Housing | | | | | | |
| Separate Shelter | 27.8 | 55.0 | 60.0 | 9.5 | 0 | 33.0 |
| Kitchen | 33.3 | 10.0 | 4.0 | 38.0 | 33.0 | 22.0 |
| Sleeping House | 38.9 | 35.0 | 36.0 | 54.4 | 67.0 | 45.0 |
| Supplementary feeding | | | | | | |
| Commercial | 0 | 2.6 | 2.0 | 4.3 | 0 | 1.9 |
| Kitchen leftovers | 13.5 | 31.6 | 23.5 | 17.4 | 22.9 | 21.7 |
| Cereals | 5.4 | 7.9 | 5.9 | 4.3 | 8.6 | 6.3 |
| Brans | 40.5 | 34.2 | 31.4 | 39.1 | 42.9 | 37.2 |
| Household refusal | 35.1 | 5.3 | 25.5 | 28.3 | 25.7 | 24.2 |
| Others | 5.4 | 18.4 | 11.8 | 6.5 | 0 | 8.7 |
| Methods of disease control | | | | | | |
| Traditional herbs | 33.3 | 47.6 | 47.1 | 46.7 | 46.2 | 44.4 |
| Veterinary services | 26.7 | 47.6 | 41.2 | 46.7 | 53.8 | 43.2 |
| Own treatment with drugs | 40.0 | 4.8 | 11.7 | 6.6 | 0 | 12.4 |
| Acquiring initial stock | | | | | | |
| Purchase | 85.7 | 77.3 | 52.0 | 85.0 | 83.3 | 75.5 |
| Exchange | 4.8 | 4.5 | 0 | 0 | 0 | 1.9 |
| Inheritance | 0 | 4.5 | 8.0 | 0 | 5.6 | 3.8 |
| Gift | 4.8 | 9.1 | 40.0 | 15.0 | 11.1 | 17.0 |
| Increasing existing stock | | | | | | |
| Breeding | 79.2 | 81.5 | 51.4 | 81.8 | 68.2 | 70.8 |
| Purchase | 20.8 | 18.5 | 37.1 | 18.2 | 31.8 | 26.2 |
| Gift | 0 | 0 | 2.9 | 0 | 0 | 0.8 |
| Inheritance | 0 | 0 | 8.6 | 0 | 0 | 2.3 |

*Values are percentages of interviewed farmers falling into various categories*

## Marketing

Most of the eggs produced are for brooding. Other uses are for home consumption and for sale. Most of the eggs are sold at the nearby shopping centres (72%) and the rest are sold at home. The eggs were sold at the highest prices when taken to the nearest town as compared to prices at the home or at the shopping centres, especially villages near the towns. Most of the farmers described the market for eggs as reliable, i.e. they could always sell their eggs whenever they wanted to sell. The major reason was that eggs from indigenous birds were highly valued as compared to eggs from commercial birds. When selling live birds, most of them were sold to middlemen who come from the neighbouring towns. Other buyers were neighbours and itinerary buyers who came at a given time when they have agreed with the farmers. The town business people and the neighbours were the major providers of chicken marketing information. 84% of the farmers reported that they don't get advice from extension agents, and the few that got the advice was on disease control and treatments of the birds.

When the buyers were buying the birds the most important attributes were weight or size, followed by colour and health of the birds (table 4). Minor considerations were sex and age of the birds. The attributes that the farmer was considering when setting the price of the birds were size and health of the birds. Other considerations were age and colour.

The prices varied with season (Figure 1). This was in the same pattern as the cropping system. The prices were better in July to October. This also varied by village. Half of the farmers indicated that they did faced problems in marketing their chickens. They sited problems such as low prices, few customers, transport problems, market levies, and lack of a specific designed place as a market for poultry.

*Table 3*:*Prices of birds and eggs in Kwale district of Kenya*

| ***Commodity*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| **Birds** | | | | | | |
| Cock | 263.3 ±64.6 | 279.5 ±52.7 | 285.7 ±33.1 | 243.0 ±74.7 | 213.9 ±37.1 | 259.0 ±59.3 |
| Cockerel | 180.4 ±55.0 | 169.5 ±30.9 | 198.1 ±40.0 | 146.5 ±53.4 | 133.9 ±33.7 | 167.5 ±48.3 |
| Hen | 187.4 ±54.6 | 166.9 ±27.2 | 166.3 ±37.5 | 130.3 ±23.8 | 112.7 ±16.8 | 154.9 ±43.8 |
| Pullet | 126.3 ±43.7 | 106.6 ±28.6 | 121.0 ±40.7 | 90.6 ±14.9 | 89.1 ±12.0 | 107.8 ±34.3 |
| Chicks | 69.3 ±31.0 | 48.5 ±8.9 | 53.1 ±20.8 | 46.7 ±10.7 | 47.5 ±19.3 | 53.6 ±21.4 |
| **Eggs** | | | | | | |
| Home | 4.00 ±1.6 | 4.80 ±0.4 | 3.56 ±0.9 | 4.80 ±0.5 | 5.00 ±0.0 | 4.20 ±1.0 |
| Village | 4.70 ±1.0 | 5.00 ±0.0 | 3.60 ±1.5 | 5.00 ±0.0 | 6.00 ±0.0 | 4.30 ±1.4 |
| Town | 6.70 ±1.5 | 6.00 ±0.0 | - | 5.00 ±0.0 | - | 5.70 ±1.2 |

*Table 4:Buyers and attributes considered in marketing of local chickens in Kwale district, Kenya*

| ***Variable*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| **Sale of eggs** | 0 | 7.7 | 19.2 | 21.6 | 0 | 11.7 |
| Buyers of Birds | | | | | | |
| Itinerary Buyers | 12.0 | 23.1 | 12.9 | 0 | 0 | 9.5 |
| Neighbours | 20.0 | 26.9 | 38.7 | 19.2 | 31.0 | 27.7 |
| Hoteliers | 8.0 | 0 | 9.7 | 11.5 | 6.9 | 7.3 |
| Shopkeepers | 4.0 | 3.8 | 6.5 | 0 | 34.5 | 2.9 |
| Town Business People | 28.0 | 46.2 | 22.6 | 53.8 | 0 | 36.5 |
| **Attributes for buying** | | | | | | |
| Weight/Size | 51.3 | 57.2 | 45.6 | 49.2 | 56.6 | 51.5 |
| Colour | 14.6 | 12.5 | 14.7 | 12.7 | 28.3 | 11.7 |
| Age | 2.4 | 5.4 | 7.4 | 1.6 | 2.2 | 4.0 |
| Sex | 9.8 | 8.9 | 11.8 | 9.5 | 6.5 | 9.5 |
| Health | 12.2 | 16.1 | 17.6 | 22.2 | 26.1 | 19.0 |
| **Attributes for setting the Price** | | | | | | |
| Colour | 6.9 | 8.3 | 7.5 | 8.5 | - | 6.7 |
| Size | 48.3 | 52.8 | 40.0 | 36.2 | 63.0 | 46.4 |
| Age | 3.4 | 16.7 | 17.5 | 14.9 | 3.7 | 12.3 |
| Health | 27.6 | 16.7 | 25.0 | 31.9 | 33.3 | 26.8 |

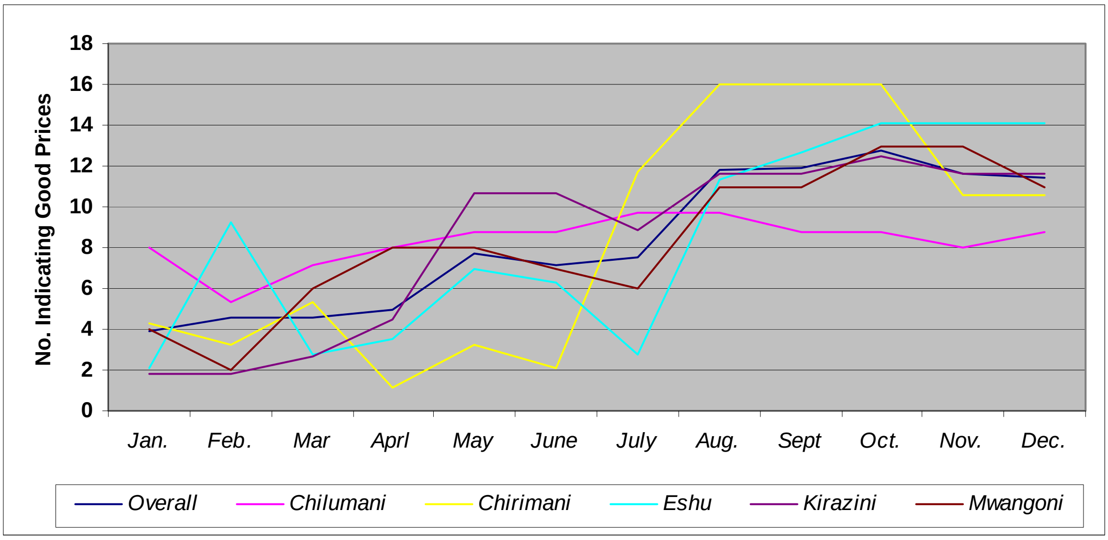


*Figure 1: Seasonal Variation of poultry prices five villages of Kwale district.*

**B. EXPERIMENT**

**I. Weights of birds selected from different Agro ecological zones of Kwale district.**

The overall body weights for the birds collected at random from all the four regions were 1.77± 0.49 Kg (males) and 1.32± 0.33 Kg (females). The phenotype had a significant effect on the body weights of the birds. The naked necks were significantly heavier than the normals and the dwarfs, but not significantly with the Frizzles. They were followed by the frizzles, normal and the dwarfs had the least weights. There was no significant difference between weights of birds from the last three genotypes (Table 5).

*Table 5: Productive Performance (LSMeans±SD) of the Different Phenotypes of the Birds Collected from Different Regions of Kwale District, Coastal Kenya.*

| Parameter | | PHENOTYPE | | | |
|---|---|---|---|---|---|
| | | Normal | Naked Neck | Frizzle | Dwarf |
| Mature Body Weights (Kg) | Male | 1.4 ± 0.14$^{b}$ *(5)* | 2.2 ± 0.52$^{a}$ *(4)* | 1.8 ± 0.50$^{ab}$ *(10)* | 1.7 ± 0.28$^{ab}$ *(2)* |
| | Female | 1.3 ± 0.32$^{b}$ *(40)* | 1.4 ± 0.33$^{a}$ *(46)* | 1.3 ± 0.37$^{ab}$ *(28)* | 1.2 ± 0.20$^{b}$ *(14)* |
| Mortalities (%) | | 74.4$^{a}$ | 45.1$^{b}$ | 56.1$^{ab}$ | 49.2$^{ab}$ |
| Rate of Lay (%) | | 23 | 33 | 27 | 36 |
| Egg Weights (g) | | 42.5±3.88$^{b}$ (85) | 45.8±4.48$^{a}$ (85) | 43.0±4.94$^{b}$ (85) | 38.1±2.90$^{c}$ (85) |
| Shape Index | | 0.76±2.96$^{b}$ | 0.75±2.83$^{b}$ | 0.76±3.28$^{b}$ | 0.80±3.85$^{a}$ |
| Yolk Colour Score (Start - End Experiment) | | 6 - 2 | 10 - 2 | 5 -3 | 5 - 1 |
| Egg Shell Thickness (mm) | | 0.32±0.009$^{ab}$ | 0.33±0.023$^{a}$ | 0.33±0.021$^{ab}$ | 0.30±0.037$^{b}$ |
| Fertility (%) | | 57.8 | 58.5 | 65.7 | 65.4 |
| Hatchability (%) | | 78.5 | 67.5 | 73.2 | 77.6 |
| Growth rates/ADG (>5 Wks) g/day | | 4.4±1.06$^{a}$ | 4.5±1.15$^{a}$ | 4.2±1.19$^{ab}$ | 3.6±1.04$^{b}$ |

*Means with common superscripts within a row are not significantly different (P<0.05)*

Birds from the humid zone were significantly heavier with average weight (Table 6). There was no significant difference between weights of birds from the other three zones. As the means are estimated as Least Square Means in a model including the effect of genotypes a possible effects of unbalanced numbers of genotypes across zones are eliminated. There were significant differences between the weights of the birds collected from zone 3 with all other zones in both males and females, except males of zone 2/3.

*Table 6*: Effect of Zone on the Body Weights (Kg) and Mortality (%) by of the 100 birds collected (LSMeans±SD).

| | | **Zone of Origin** | | | | **Overall** |
|---|---|---|---|---|---|---|
| | | **Humid (CL3)** | **Dry (CL5)** | **Sub humid (CL4/5)** | **Wet (CL2/3)** | |
| ***Mean Body Wts. (Kg)*** | Males | 2.2± 0.54[a] *(6)* | 1.4 ± 0.28[b] *(5)* | 1.4 ± 0.31[b] *(3)* | 1.6 ± 0.35[ab] *(3)* | 1.7 ± 0.51 *(17)* |
| | Female | 1.4 ± 0.23[a] *(21)* | 1.2 ± 0.32[b] *(17)* | 1.2 ± 0.29[b] *(22)* | 1.2 ± 0.25[b] *(23)* | 1.3 ± 0.28 *(83)* |
| | Overall | 1.6 ± 0.45[a] *(27)* | 1.3 ± 0.32[b] *(22)* | 1.2 ± 0.29[b] *(25)* | 1.3 ± 0.28[b] *(26)* | 1.4 ± 0.37 *(100)* |
| ***% Mortality*** | | 48.4[b] | 56.8[ab] | 77.5[a] | 42.2[b] | 56.2 |

*Means with common superscripts within a row are not significantly different (P<0.05)*

## II. Mortalities of the Parent Stock

There was a significance difference in mortalities between the phenotypes (Table 5). The Normal had the highest followed by the Frizzle and the Dwarf, though there was no significance difference. The naked neck had a significantly lower mortality than the other three phenotypes.

There were also significant differences when the mortalities were considered by zone of origin. The Sub humid zone (CL4/5) had the highest mortality, followed by the dry zone (CL5) with no significant difference. The wet zone (CL2/3) and the humid zone (CL3) followed these two zones with significantly lower mortalities than the sub humid zone but not the dry zone.

### III. Egg Production

The overall rate of lay was 29% for all the phenotypes. The Dwarf had the highest rate 36%, followed by the Naked Neck 33%; frizzle 27% and the Normal had the least with 20% (Table 5).

### IV. Weights Of Eggs

The egg weights were significantly different among the various phenotypes (Table 5). The Naked Neck had the highest weight, which was significantly different from all the other phenotypes. The Normal and the Frizzle had intermediate weights and the Dwarf had the least weight. There was variation of the egg weights over the laying period (Table 7). The differences were significant between August and May, and August and September.

*Table 7*: Effect Of Time/Month On Egg Weight Of The Different Phenotypes: LSMeans±SD of eggs from the different phenotypes in different Months

| **Month** | **Phenotype** | | | | ***Overall*** |
|---|---|---|---|---|---|
| | **Normal** | **Naked Neck** | **Frizzle** | **Dwarf** | |
| **April** | 44.3±4.76 (14) | 47.2±4.71 (14) | 41.3±2.67 (14) | 37.3±2.57 (14) | ***42.5±5.17 (56)*** |
| **May** | 40.8±2.97 (19) | 44.4±3.77 (19) | 41.8±3.86 (19) | 39.5±2.71 (19) | ***41.6±3.77 (76)*** |
| **June** | 43.4±2.43 (5) | 42.1±1.85 (5) | 42.5±4.43 (5) | 37.8±2.36 (5) | ***41.5±3.49 (20)*** |
| **July** | 43.0±2.18 (11) | 47.7±4.56 (11) | 43.8±2.51 (11) | 37.8±0.87 (11) | ***43.1±4.50 (44)*** |
| **August** | 43.3±4.62 (29) | 47.3±5.10 (29) | 45.1±6.81 (29) | 39.3±3.49 (29) | ***43.8±5.88 (116)*** |
| **September** | 42.5±2.14 (7) | 44.2±1.68 (7) | 43.6±2.76 (7) | 36.4±1.13 (7) | ***41.7±3.68 (28)*** |
| ***Overall*** | ***42.5±3.88$^{b}$ (85)*** | ***45.8±4.48$^{a}$ (85)*** | ***43.0±4.94$^{b}$ (85)*** | ***38.1±2.90$^{c}$ (85)*** | ***42.7±4.94 (340)*** |

*Means with common superscripts within a row are not significantly different (P<0.05)*

### V. Egg Quality: Shape indices, Yolk colours and Shell Thickness of the different genotypes.

#### a. Shape Indices

The overall shape index of the eggs was 0.77 (Table 5). The dwarf had the highest shape index, followed by the Naked Neck and Frizzle, and the normal had the least shape index. There was a significant difference between the shape indices of the dwarf and all the other phenotypes (Naked, Normal and Frizzle, which had no significant difference between them).

### b. Yolk colours

The Roche Scale Yolk Colour Fan Scores varied widely over time (Table 5). On the first trial, it ranged from five to ten, with the frizzle and the dwarf having the least with an average of 5. The naked neck had an average of 6, and finally the normal had the highest average of 10.
On the second trial, the yolk colours were very low but closely equal, with the frizzle having the highest with an average of 3. The naked neck and the normal had an average of 2, while the dwarf had the least average of 1.

### c. Egg Shell Thickness

The overall average eggshell thickness for the birds was 0.31mm(Table 5). The normal and the frizzle had the highest thickness with an average of 0.33 mm, the naked neck had 0.32 mm and the dwarf had the least eggshell thickness of 0.30 mm. There was a significant difference between the eggshell thicknesses of the normal/frizzle with the dwarf.

## VI. Fertility And Hatchability

There was no significant difference of the fertility of the eggs from different phenotypes, when the Least Square Means were considered (Table 5). The frizzle had the highest fertility, followed by the dwarf, and then the naked neck, and the normal had the least.

There was a high significance ($P<0.001$) when fertility was considered between lots (Table 8). The fertility of the second and third lot was significantly higher than the fifth and sixth lot.

*Table 8*: LSMeans of fertility and the hatchability of the different Lots of eggs incubated at different times.

| **Parameter** | **Lot** | | | | **Average** |
|---|---|---|---|---|---|
| | **Second** | **Third** | **Fifth** | **Sixth** | |
| **Fertility** | 64.5$^{a}$ | 75.5$^{a}$ | 58.1$^{b}$ | 49.2$^{b}$ | ***61.8*** |
| **Hatchability** | 71.2 | 72.7 | 74.6 | 78.4 | ***74.2*** |

*Means with common or no superscripts within a row are not significantly different (P<0.05)*

## VII. Growth Rates

Among the four phenotypes in considerations, the frizzle had the highest chick weight at the first week; followed by the naked neck and the normal and the dwarf had the least

(Table 9). By the last week of recording (week five), the naked neck had the highest weight.

*Table 9*: Weekly body weights ± SD (N) of the four phenotypes weighed from the first week up to fifth week

| ***Age In Days*** | ***Phenotype*** | | | | |
|---|---|---|---|---|---|
| | ***Normal*** | ***Naked Neck*** | ***Frizzle*** | ***Dwarf*** | ***Isa Brown X Local*** |
| ***7*** | 33.5±4.2<br>44 | 34.5±4.6<br>36 | 36.5±4.5<br>42 | 30.6±4.1<br>12 | 42.5±4.4<br>55 |
| ***14*** | 56.3±6.7<br>42 | 51.4±8.5<br>33 | 54.2±9.7<br>42 | 44.8±5.4<br>12 | 67.5±9.7<br>24 |
| ***21*** | 90.3±13.8<br>41 | 83.2±15.8<br>33 | 89.1±16.8<br>33 | 68.4±18.4<br>12 | 109.0±17.7<br>22 |
| ***28*** | 124.7±22.9<br>41 | 116.7±24.9<br>33 | 130.6±24.0<br>24 | 99.9±29.2<br>12 | 146.7±26.1<br>23 |
| ***35*** | 154.8±33.8<br>41 | 158.3±40.9<br>33 | 153.5±33.7<br>23 | 132.0±31.7<br>12 | 201.0±41.0<br>22 |

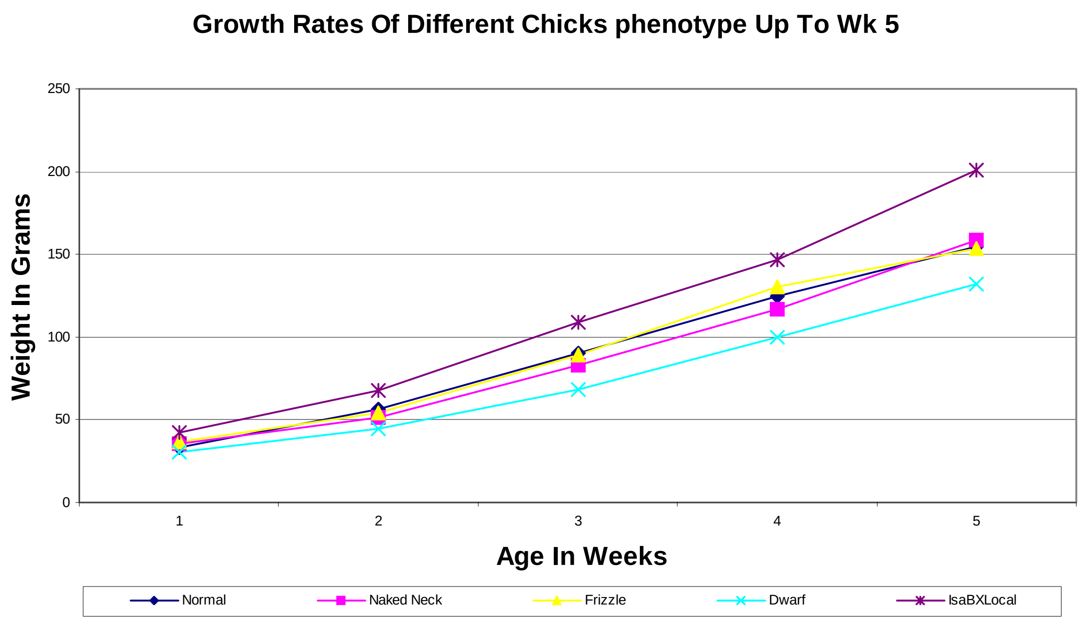


*Figure 2*: *Graph of weekly chick Weights up to Week 5 of the different phenotypes*

The average daily gain up to week five was significantly different among the different phenotypes, being highest among the Isa Brown X Local chicks (Figure 3). The Naked

Neck had the highest ADG among the other four phenotypes, with the dwarf having the least.

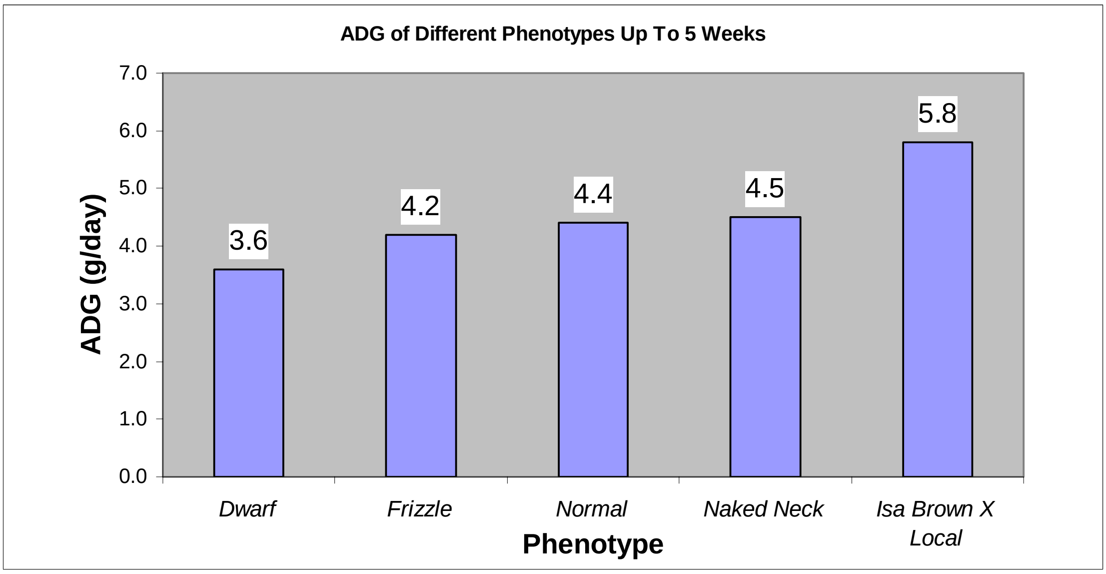


*Figure 3*: Average Daily Gain (ADG) of the different phenotypes up to 5 Weeks of Age.

## VIII. Behavioural Observations: Feather Pecking and Cannibalism

When the different chicks were reared together, there was no fighting observed. However at the age of four weeks, feather pecking and cannibalism was observed. It was noted that the frizzle feathered were the only birds that were being pecked. They were severely pecked on the back and wings. Some birds lost the entire extreme part of the wing. The frequency of attack increased when the bird was bleeding. Five frizzle feathered were observed to have been cannibalised/pecked in a group of about sixty birds.

# 4. DISCUSSION

## A. SURVEY

Majority of the farmers in the five villages selected relied on farming as their source of income, practicing subsistence farming. The income was therefore low. This kind of farming hardly meets their household food requirements. The level of education of the household heads was quite low, which means they cannot be employed in the formal sectors, which are mainly found in the urban centres. All these factors act to increase their poverty. One of the available resources that can be harnessed for improving their living standards is the poultry as nearly all (97%) of the households were rearing them. This was even higher than that reported in other findings (Stoltz, 1983), who indicated that 90% of the farmers do keep poultry.

The average flock size of 16 birds, with a Cock: Hen: Chicks ratio of 2:5:8, was in agreement with those recorded in Ethiopia. Tadelle (2003) reported a mean flock composition of 2.2 cocks, 5.4 hens and 8.5 chicks in five different agro ecological regions of Ethiopia.

The high proportion of male-headed households in this region can be explained by the fact that most rural societies are patriarchal (Muchadeyi et al, 2004). This in turns affects the decision making in the household as it was observed when ownership and decision-making were investigated. The level of education between the male and female household heads could contribute to this as well, as 84% of the women household heads had no formal education as compared to only 25% of the men. If poultry is to be used to benefit poor rural women, the low literacy levels should be considered. This includes the preparation of appropriate poultry extension and teaching materials. Contrary to many studies, it was indicated that ownership of chickens in this area was more for men than women in terms of numbers, even though women provided most of the labour. This means that it is important to involve both the men and women in development interventions, as they all play a crucial role; men making most of the decisions and women providing much of the day to day management.

The major reason why chicken is a major entry point to poverty alleviation initiatives is its presence among the poor, especially women. This was the case in this study as it was the livestock kept by majority of the households. The next in rank was found to be the goat, and it appears that, once the poultry production turns from subsistence to commercial, men tend to dominate. This means that for the poultry to be used to empower women, men have to be engaged in another activity, which could be goats.

The three major objectives of poultry rearing were found to be for food (38%) sale (34%) and cultural uses (19%). The use of poultry as a source of food is very important, as there are few alternative animal protein sources available for the poor. It has been shown that sub-Saharan Africa is the only region where both numbers and proportion of

malnourished children has been constantly rising in the past years and its expected to rise at least until the year 2020 (Rosegrant et al, 2001). Poultry meat and eggs contribute to a well balanced diet and offers an opportunity to reverse this trend, as there are few cultural or religious taboos that hinder the consumption of these products.
Besides providing food and income, poultry was also reared for socio-cultural purposes. The plumage colour, cover and sex were the most important considerations. A survey done earlier in different villages of the same district (Mwamachi et al, 1998) indicated similar results, where red/brown was the most preferred colour. In two of the villages black was more preferred than mottled. When introducing new breeds of poultry, colour should be a major consideration. If the colour of the introduced bird is preferred in traditional rituals, the birds will solely be used for such purposes. A case in point is where white Isa Brown cocks introduced in the district for improvement ended up being used for rituals (Personal experiences). When prescribed by traditional medicine men on the basis of colour, the birds are sold at a high price. Such consideration makes the community prefer and select birds with such traits. The Nigerian Hausa keep some unique types and colours of naked neck chickens because these birds are associated with spirits in local rituals (McCorkle, 1999).

The average flock size of 16 birds, with a Cock: Hen: Chicks ratio of 2:5:8, was in agreement with those recorded in Ethiopia. Tadelle (2003) reported a mean flock composition of 2.2 cocks, 5.4 hens and 8.5 chicks in five different agro ecological regions of Ethiopia.

The calculated hatchability compares favourably with that recorded in the literature, which ranged from 60-100% in different countries reported by Missohou et al, (2002), This hatchability reported were; Senegal (80%), Sudan (90%), Burkina Faso (60-90%), Tanzania (50-100%), Guinea (87.5%) and Ethiopia (71%). This is comparable and even higher with figures obtained from the experiment (67.5-78.5%, manuscript II). This can be explained by the minimal handling of eggs in the natural brooding conditions, where they are usually not moved from the nest after laying until the hen becomes broody and sit on them where they were laid. This is confirmed by the high use of eggs for brooding (55%) indicated in this survey. This reduces the risk of the eggs becoming dirty or being broken. Further the eggs are incubated before three weeks are over, as a clutch was shown to be having an average of 14 eggs.

The major feed supplement for the birds was indicated to be maize bran. This is known to be of low CP. Aganga et al, (2000), indicated a CP of 10.1% from the maize bran, where as the requirement for laying birds is known to be about 20%. Maize bran cannot therefore fulfil the CP nutrient requirements of the chickens. Further the amount of supplemental feed given to the chickens low. The scavengable feed resource base is known not to meet the protein requirements of the birds. There is therefore a need to increases the nutrition, and such an intervention could go along way in increasing the productivity of the local chickens. The supplementation levels especially with commercial feeds however should be limited if at all used, so as not to make the production uneconomically viable.

A major constraint mentioned in this study was diseases, and specifically Newcastle disease. The farmers indicated a seasonal occurrence of the diseases. This can be used to plan a vaccination schedule. The mentioned occurrence during drought and rainy season shows that the major predisposing factor is extreme weather. The farmers coped by selling the birds and use of ethnoveterinary medicine.
The high use of ethnoveterinary medicine to treat various diseases is in line with those mentioned in he literature. One of the adversely mentioned plants was a local herb the community called *Mbundzwi*. It is worth noting that the same plant was also used to treat human diseases by the traditional medicine men. Gueye (2002), reported a similar trend, where a close relationship in the mode of treatment between the birds and the rearers exists. He explained that there are 'humanised' relationships between the birds and the humans. The closeness is also observed in the housing where the birds share the house with the keepers, even though the major reason could be to avoid predators at night. Ethnoveterinary seems an alternative to the treatment of the poultry diseases. However the rates of application and specific prescriptions is lacking.

In marketing, major attribute considered for pricing by both the buyers and the sellers was the weight. Any intervention aimed at improving the body weights of the birds can therefore actually increase the profits that farmers get from their birds, when other considerations are taken care of. The high seasonal variations in prices are caused by demand of the birds during seasonal festivities. This was also observed by Tadelle (2003) in Ethiopia, who showed differences in prices of chickens in ordinary market days and on eves of different festivals. Poultry meat is usually regarded as a delicacy and the prices are high during these times. However during other times, the farmer indicated that the prices offered by the middlemen were poor. This is clear, as the same buyers were the major source of market information. The marketing strategies for the rural poultry products seems to be poor, and its one point where interventions could be developed to increase the profitability of this enterprises.

## B. EXPERIMENT

### I. Weights of birds selected from different Agro ecological zones of Kwale district.

The naked neck and the frizzle were found to have a higher weight than both the normal and the dwarf. These genes therefore had a favourable effect on the body weights. This is in agreement to the findings of Horst (1995) who found that the favourable effects were even higher in arid conditions. These two genes reduce the body surface covered by the feathers thereby giving the birds a better heat dissipation. This would in turn preserve more energy that could have been used in heat dissipation, and this energy is directed to productive functions including body weight gain. Several major genes found in the local populations have revealed their significance for adaptability and suitability to the given environment. These two genes have been reported to have a favourable effect on productivity when either the naked neck or frizzle were combined to the dwarf gene (Horst 1995, Mathur 2003).

The dwarf in the experiment was observed to have a weight close to the normal. This was unexpected as other studies (Somes 1990) showed a reduction of body weights ranging from 24-36%. However, this disparity can be explained by the fact that there are several genes related to dwarfism (see the literature section), and more investigations are needed to identify the type of the specific gene present this population. The identification of the specific dwarfing gene was beyond the scope of this study.

The zone from where the birds were collected has a significant effect on the weights of the birds weighed at the beginning of the experiment. This is due to the zones having different climatical conditions (rainfall and temperatures), which in turn affect the types of crops grown, and consequently the scavengable feed resource base (SFRB). The humid (CL 2) and sub-humid (CL 3) zones had many different crops at the time when the birds were collected, including some green grasses. Here, the farmers had crops that are good for scavenging e.g. pulses (beans, peas) and groundnuts. The other zones were quite dry and therefore the feed resource was poor.

The humid and the sub humid zones are also relatively more densely populated than the semi arid zones zone 5 and 5/6. It has been shown that the productivity of the village chickens is determined by the relationship between the biomass of the chicken population and the SFRB (Kitalyi, 1998). The human population density and the closeness of the households could also increase the feed resource base, as it has been shown that the resource base is directly proportional to the amount of household waste discarded per family. The major crops that could form a good feed resource base include maize, coconut refuse, broken rice and cassava, which are widely grown in the humid and sub-humid zones.

## II. Mortalities of the Parent Stock

The naked necks had significantly less mortalities when compared to the other phenotypes. The frizzles and the dwarfs followed, and the normals had the highest mortalities. The naked necks, the frizzles and the dwarf genes have been associated with a higher disease resistance (Kitalyi, 1998). Haunshi et al, (2002), evaluating the possible influence of the naked neck and the frizzle gene on immunocompetence levels, reported a significantly higher haemolytic complement level in the serum of both the naked necks and the frizzles, when the antibody response to SRBC was assessed. The lowest incidences of pathologies (cloacal cysts, ascites, prolapse, Marek’s disease, coccidiosis, osteodystrophy and Salmonellosis) were found in naked neck birds as compared to normal birds (na/na) and these results, together with direct challenge and indirect immunity tests, suggest a greater disease resistance associated with the Na gene (Fraga et al, 1999).

The significant difference in mortalities between the different zones from where the birds were collected could be explained by the method used in sourcing and collecting them. In Kinango and Samburu, middlemen (traders) were contracted to buy birds for the research project from the villages. They went into the villages, bought the birds from the farmers and collected them in shades near the market places. It was noted that birds from these two zones developed signs of disease within a week, and most of them died. When the birds were confined in these houses/shades, they either contracted the disease, or were already infected when they were brought from the different homes in the village. The farmers could have sold diseased birds. Even though they were vaccinated with a live vaccine against Newcastle disease (La Sota strain), they developed signs of disease and several of them died. In Samburu, a disease outbreak was reported a week later after the research birds were collected.

In the other two villages (Msambweni and Matuga), the field officers identified the birds and left them with the specific farmer from whom the bird was bought. They then went round the farms and vaccinated them, and then collected them after about two weeks. These groups of birds did not contract disease as the first group.

The two methods indicate that their movement is an important aspect in disease control. The middlemen who move from village to the villages collecting birds could be spreading diseases. It is therefore very important to have a good marketing strategy of the village chickens as a way of controlling disease outbreaks.

### III. Egg Production

The mean % rate of lay of 29 for all the phenotypes means that, the birds can produce 106 eggs per hen per year under intensive management. This is in agreement with Tadelle (2000) who reported a production of 80 to 99 eggs per hen per year under improved or experimental conditions. This is a slight (uneconomical) increase as compared to the improved feeding, housing and health conditions provided to the birds. On the basis of input-output relationship, the increase from about 60 eggs per year per annum is not economically feasible. The projected total yearly egg production for the different phenotypes is shown in Table 7 below.

*Table 3: Productivity of the four phenotypes*

| **Parameter** | **Phenotype** | | | |
|---|---|---|---|---|
| | **Normal** | **Naked** | **Frizzle** | **Dwarf** |
| **Rate of lay (%)** | 23 | 33 | 26 | 36 |
| **Annual Egg Prod. (Numbers)** | 83 | 119 | 96 | 131 |
| **Mean Egg Wt. (g)** | 42.5 | 45.8 | 43.0 | 38.1 |
| **Total Yearly Egg Prod. (Kg)** | 3.6 | 5.8 | 4.2 | 5.0 |
| **Feed Efficiency (Kg feed/Kg Egg)** | 10 | 7 | 9 | 7 |

The Dwarfs had the highest hen day egg production among the four phenotypes. This was in agreement with Horst (1995) who suggested that there is a significantly lower depression in the productivity of dwarf layers due to heat stress than the normal types. He consequently argues that it improves the productive adaptability to heat stress. Furthermore, the dwarf, with a smaller body size, is expected to have a better-feed efficiency, and therefore better egg production. The feed efficiency of the Naked Neck and the dwarf was equal at 7 kg feed for 1 kg eggs. Tadelle (2000), reported a feed efficiency of 20kg feed for the Ethiopian birds, the big difference being due to the low numbers (34) and average weight (38 g) of the eggs produced.

However (Fairfull et al, 1990), argues that the dwarfing gene reduces egg numbers and the rate of egg production. He further states that the use of the dwarf gene to reduce body size of the female parent in broiler hatching egg production was only successful due to selection for modifying genes that are positive for egg production and the use of heterosis to overcome the depressing effect of the gene. This observation is based on a high yielding population that had segregated for the dwarf gene and production takes place under optimal conditions.

Other studies in Ethiopia (Tadelle, 2000) showed that, the melata ecotype (Naked Neck), had the highest hen day production of 0.19 among other ecotypes.

## IV. Weights Of Eggs

The egg weight mean for all the birds was 42.7±4.9 g. These results are in agreement with other reports from different African countries on local birds where the egg weights were reported as ranging from 30 – 49 g. (Missohou 2002). The scavenging birds are known to have a wide variation since they have not been selected for egg weights.

The egg weights were in the same order as the body weights of the birds. There seems to be a relation between the body weights and the egg weights. A genetic corrrelation of +.384 between egg weight and adult body weight in White Leghorns was reported as early as 1921 by Asmundson (Hutt, 1949) and was confirmed later by Sorensen et al (1980).

The naked neck phenotype has the heaviest eggs. Horst reported a favourable effect of the naked neck gene on egg weight when birds were reared under heat stress (Horst 1995). He also indicated the effect of the dwarf gene as reducing the egg weight. This is in agreement with the observed results where thw Dwarf had the least egg weights. However the frizzle gene in this case did not increase the egg weight as he reported.

Egg weight is a favourable consideration only when eggs are graded for sale at a higher price than the normal eggs. However in the rural setting, large eggs will be more desired by customers first even though the eggs will not fetch a higher price.

## V. Egg Quality: Shape indices, Yolk colours and Shell Thickness of the different genotypes.

The major genes were found to have an effect on the shape index. The dwarf had a shorter egg in length hence the high shape index. The difference in shape has been suggested to be hereditary (Hutt, 1949), only that the number of genes was not known. It's also not clear if the genes involved in determining the shape are associated with the dwarf. The shape index was found to decrease with an increase in the body weight.

The yolk colour of indigenous birds is known to be high as the birds eat green grasses and plants during scavenging. This gives the eggs a high consumer value and taste. Initially, the yolk colour score was high in all the phenotypes, but reduced substantially when assessed later. This difference is clearly associated with the feeding programme, where the birds were fed with green grasses during the wet period. When then they were fed with no grasses, the effect was shown in the yolk colour score, which reduced dramatically. This shows that the yolk colour is determined by the feed rather than genetic parameters.

The eggshell thickness was significantly different between the various phenotypes. This is agreement with Monira et al (2003) who states that it is influenced by breed. He found the thickness to be ranging from 0.31 to 0.35 mm between several breeds that are used today for egg production. These breeds were reared in Bangladesh and included the Barred Plymouth Rock, White Leghorn, Rhode Island Red and White Rock.

The shell thickness is important in reducing the breakages. They also have a better hatch

## VI. Fertility And Hatchability

The Frizzle had the highest fertility, followed by the Dwarf and the Naked Neck in that order. The normal had the least fertility. However there was no significant difference between the phenotypes. It has been shown that high ambient temperatures (>30 $^{o}$C) decreases fertility of breeder hens, but this effect was shown by Ladjali et al, (1995) to be greatly reduced in females carrying the naked neck gene (Na). Naked neck females showed a lower proportion of abnormal embryos than normally feathered females, which had the highest proportion of chimeras at 31 $^{o}$C. This effect of the Naked Neck was not seen, as the temperatures during rearing were 26$^{o}$ C.

The variation in fertility over time could be explained by the fertility of the cocks. Over time the cocks their fertility could have been affected by the type of feed, which has been formulated for egg production. The breeder feed was not easily accessible. Replacing the cocks could have solved these, but the genetic variation would have been introduced. The flock sizes were also too small to put several cocks into the flock.

On hatchability, the normal had the highest, the dwarf and the Frizzle being intermediate. The Naked neck had the lowest hatchability among the four phenotypes.

This is in agreement with other findings, which associated both the Naked Neck and the Frizzle with poor hatchability.
Merat, (1990) documented that the Naked Neck gene was found to be associated with an increased embryonic mortality, which was up to 10%. This occurred during the last stages before hatching. He suggested that the reduced hatchability seems due to malpositions of embryos, perhaps due to few feathers on the neck allowing the head to assume faulty positions. Landauer in1932, maintained that the hatchability of eggs laid by heterozygous frizzles is subnormal and that it is still lower in eggs from homozygotes (Somes, 1990).

## VII. Chick Weights and Growth rates

The crosses between the local cock and Isa brown had the highest chick weights. This was expected, as the Isa Brown is a well-developed breed. The farmers involved in the smallholder poultry project in the District were using these Crosses. The high ADG means that the birds can achieve a higher body weight in a shorter time than the local birds. However, if the Crosses will be used for reproduction, there will be a loss of heterosis as the Isa Brown is a hybrid meant for egg production. It can therefore be used only in the short-run and the farmers will have to buy more birds as parent stock.

The Naked Necks, the Frizzles and the Normals had similar growth patterns. Their weights were significantly different with the Crosses and the Dwarf throughout the five weeks. Towards the fifth week, the Naked Neck showed an increasing ADG more than the Frizzle and the Normal. The Dwarf had a significantly lower growth rate as expected. This was in relation to the final body weight.

Growth rate is an important trait that should be considered in the local poultry, as the main objective of keeping the birds is for meat production as compared to egg production. Therefore there are benefits in crossing the local breeds with early maturing birds in order to obtain a faster early growth.

## VIII. Behavioural Observations: Feather Pecking

Feather pecking, defined as pecking at and pulling out of feathers of another birds, was predominantly observed on frizzle-feathered birds (growers) only. The susceptibility of the frizzles to be pecked can be explained by the extreme body exposure of these birds. These birds were hatched from both the frizzle cocks and hens, and therefore there were some that were homozygotes. Homozygotes frizzles are known to have extremely recurved rachis and barbs in all feathers, which are easily broken (Somes, 1990). McAdie and Keeling (2000), showed that birds with damaged feathers are more susceptible to feather pecking and injurious pecking. They found out that damaged feathers received significantly more severe feather pecks than undamaged feathers. The body areas that had been manipulated and received severe feather pecks were the tail and rump feathers. Damaged feathers increased feather pecking by becoming an attractive target.

Other factors could have as well contributed to this behaviour of feather pecking. The behaviour was observed in the fourth week of age when all the phenotypes were reared together in one room without being fed grass. Bestman and Wagenaar (2002), showed that feather pecking behaviour was low in flocks using the outdoors run and recommended including a vegetative cover to the run and keeping the flock size at around 500 birds.

Though the frizzle feathered could have an advantage in heat dissipation, incorporating it in flocks reared in hot and humid climates might promote feather pecking and hence cannibalism. More studies are needed to assess the effects of this gene on feather pecking in a purely frizzled feathered flock and in a mixed flock e.g. with normal feathered birds.

## IX. Economic Importance

The growth rates of the different phenotypes were taken up to the fifth week. These growth rates can be used to project the final body weights of the birds. The naked neck displayed an earlier high rate when compared to the rest of the phenotypes. When this is compared to the body weights of the mature birds collected from the villages, where the naked neck had a significantly higher body weight, it is only justifiable to conclude that the naked phenotype has a better growth rate, and hence achieve a marketable body weight than the rest of the phenotypes.

This is more so, as weight and sizes were the most valued attributes by both the producers and the buyers when setting the prices of the birds. Further, at least in the study area, high body weight means that the birds can yield more meat as one of the major objectives of poultry production was shown to be provision of food, both in terms of meat and eggs.

A major hindrance amongst the rural poultry marketing system is the pricing, where it was not clear on the direct relationship between the weight and the price. It is however evident that the weight was one among the many factors that determined the price. More investigation on this relationship is needed.

As the birds were reared up to the fifth week, it was not possible to determine the actual cost-benefit analysis. However, the beneficial effects that could be achieved are as discussed above.

## 5. CONCLUSION

From the findings of this study it can be concluded that even though the overall productivity of the local birds is generally low, there exists differences in the productivity when they are considered by phenotypes. This shows that there is room for genetic improvement, if the birds are selected and multiplied further. The naked neck birds had a better performance in body weights, good survivability in the incidence of a disease outbreak, high egg weight, high eggshell thickness and better growth rates.

However in selecting such birds with characteristics that are determined by their genetic makeup, it's worth considering the goals and purposes of the people who rear them. Major assumptions are that the selected birds will not have any cultural hindrances, and would be accepted by rural people. In such instances, the birds will go a long way in increasing the welfare of the rural poor.

In coming up with the parent stock in a controlled environment, there may arise other problems previously unseen in the local birds. In the study, the frizzle feathered were observed to be more vulnerable to feather pecking. This might be an indication of the many challenges that can be encountered in the endeavour to select breeding or a parent stock for the identified birds.

This study has shown the importance of bird's movement in regard to diseases. Flocks that were sourced through the normal local marketing channels were observed to have a high mortality. A strategy to control poultry disease should therefore consider the marketing channels as practiced in the villages. This may include establishment of a central market place, where the birds are gathered in a particular day. The flow of the flocks should be 'one way', without the birds returning to the village.

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## MANUSCRIPT PAPER I

# A SURVEY OF VILLAGE POULTRY PRODUCTION IN THE SOUTH COAST OF KENYA, KWALE DISTRICT

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## *Abstract*

This study was carried in five villages of Kwale district, south coast Kenya, by the use of both PRA’s tools and a structured questionnaire. A total of 107 households were interviewed. The objectives were to investigate the productivity of the chickens and various socio-cultural issues related to poultry.

Most of the household heads (87%) were men. Women provided most of the day-to-day management of poultry as compared to men. The mean (±SD) flock size per household was 16±10.3 birds, with a flock structure ratio of 2:5:8 (Cock:Hen:Chicks). The productivity of the hens was found to be three clutches per year, with 14 eggs per clutch per hen and a hatchability of 83%. The main reasons for keeping poultry were for food (38%), sale (34%) and socio-cultural functions (24%). Socio-cultural aspects such as use in ceremonies, festivities and rituals were among the major consideration in the preference of the poultry phenotype, where plumage colour, cover and sex of the birds were considered. Ethno veterinary medicine was widely used by the poultry keepers (44%). Prices of the poultry products were found to vary considerably with the season.

# 1. INTRODUCTION

The poultry population in Kenya is about 29.8 million (m) chickens consisting of 21.8 m local chickens, 4.4 m broilers and 2.9 m layers (Njue, 2002). The local chickens are the main source of income for 90% of the rural households, which comprises 80% of the population. Therefore the local chickens are among the many local resources of poor people living in the rural areas, which could be harnessed and utilized for poverty alleviation.

Traditionally, poultry plays an important role in Kenya. The chickens have been and still are a major source of protein in form of meat and eggs. In addition, they are used to generate income when they are sold, used in sacrifices (healing ceremonies), as replacement stocks and as gifts. They are therefore an integral part of the day-to-day life of the rural populations, including the religious and socio-cultural aspects of these populations. The notion that the birds are poor producers is an underestimation as such roles are generally ignored, in part because they are extremely difficult to assess (Gueye, 2002).

For a better understanding of the role of the poultry in a society, it is necessary to know exactly the purposes for which the households keep the birds. These purposes define the breeding goals of the society, which are more multifaceted than in intensive productions (Kohler-Rollefson, 2000). Some of the considerations would include survivability, adaptation to prevailing conditions, devotedness to brooding, good mothering ability, fierceness to fighting away predators and appropriateness in socio-cultural functions (McCorkle, 1999). It therefore, any proposed intervention to improve the rural poultry stocks must first be carefully analysed in the context of both the productivity and as well as the purposes behind the society keeping a particular type of poultry. Further, the sheer disregard of these purposes and the overemphasis of production and marketing objectives may have contributed to the genetic diversity erosion, hence the claims of extinctions of some of the local poultry types.

The Kenyan government initiated improvement programmes as from 1976 up to the 1995 through the National Poultry Development Programme (NPDP). However the emphasis was on commercial poultry production and rural poultry was only given attention at the beginning of 1990’s (Nyange, 2000). The programme used the Black Shavers and Rhode Island Red pure breeds, to upgrade the indigenous chicken through the cockerel exchange, supply of pullets and hatching eggs. Cockerels were reared up to maturity, and then exchanged for local cockerels owned by rural smallholder farmers. The farmers were advised to remove the remaining local cockerels. This approach led to a limited improvement due to the high mortalities, poor management, and above all the programmes were usually planned without the farmers’ participation. In addition the strategies did not put into considerations the social and cultural functions of poultry production. Such activities have been attempted in other countries such as Malawi, Niger, Tanzania, Ethiopia and Bangladesh, with similar experiences (Sonaiya, 2002).

***Objective***: The objective of the survey was to collect data on the productivity of indigenous poultry in the district and investigate various socio-cultural issues related to poultry including uses, traditional rearing methods, types of indigenous poultry reared, ethno veterinary practices and gender issues related to poultry.

## 2. MATERIALS AND METHODS

***Site description:*** A survey was carried out in the district to investigate various socio-cultural issues related to poultry and the productivity of the rural poultry. The survey sites were selected in collaboration with the livestock extension staff. The criterion used was the AEZ; where one village per zone, easy accessibility and availability of indigenous poultry were considered. Five villages were selected and their location (Figure 1) and characteristics (Table 1) are shown below.

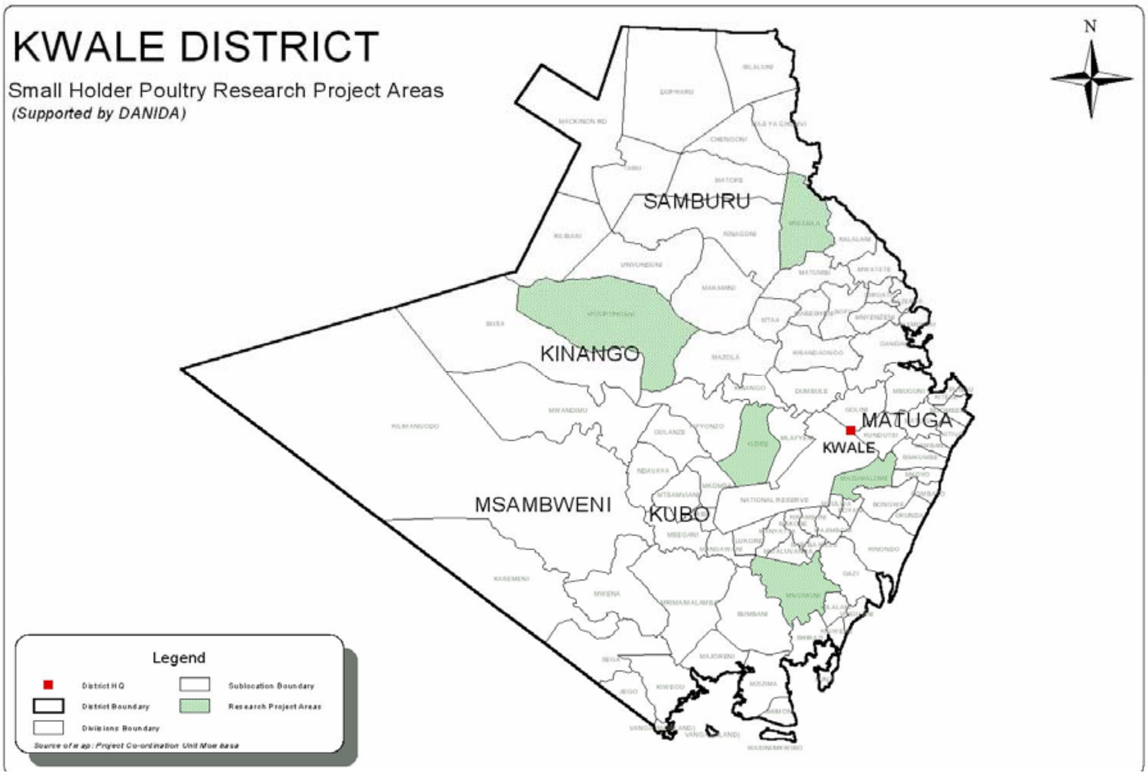


*Figure 1*: Map of Kwale showing the locations of Villages where the survey was done

*Table 1: Description of AEZ, Climatical conditions and major crops grown in the villages selected*

| ***Village (HH interviewed)*** | ***Agro-Ecological Zone*** | ***Altitude in m*** | ***Annual Mean Temp. (°C)*** | ***Annual Average Rainfall (mm)*** | ***Major crops grown*** |
|---|---|---|---|---|---|
| **Eshu (22)** | CL2 Marginal Sugar cane Zone (Wet)* | 1-60 | 26.3-26.6 | 1200-1400 | Cassava, Coconut, Beans, Rice, Cowpeas, Maize, Beans, Sugarcane, |
| **Chirimani (25)** | CL3 Coconut cassava Zone (Humid)* | 1-450 | 24.0-26.6 | 970-1250 | Cassava, Coconut, Beans, Cowpeas, Maize, |
| **Kirazini (21)** | CL4 Cashewnut cassava Zone (Sub humid)* | 1-250 | 25.0-26.6 | 850-1200 | Cassava, Coconut, Cashewnuts, Maize, |
| **Chilumani (21)** | CL5 Lowland Livestock Millet Zone (Dry)* | 120-650 | 24.3-27.5 | 600-900 | Sorghum, millet, cowpeas, green grams, pigeon peas, |
| **Mwangoni (18)** | CL6 Lowland Ranching Zone (Arid)* | 120-600 | 24.6-27.5 | 500-600 | Sorghum, millet |

*Adapted from Jaetzold & Schmidt, 1983.*
**These descriptions are meant for this study and do not strictly follow other definitions.*

***Methodology***: In the survey, a combination of Participatory Rural Appraisal (PRA) tools and a questionnaire was used to collect the baseline data. General information on poultry was gathered by the use of various PRA tools. These included Social Resource Map, Venn diagram, Timeline, Group profile, Season calendar, Gender profile and Matrix ranking.

Households were selected at random, and a questionnaire was administered and specific information on flock size and structure, housing system, feeding, health, flock breeding and ownership pattern was gathered.

**Data collection**

Data on the households were collected using a structured questionnaire. The sex of the household head, age, marital status, level of education and family size were recorded. The major source of income, crops types and livestock types reared was also recorded.

Data on poultry management, productivity and marketing were recorded. This included reasons for keeping the chickens, types kept (local and improved, as well as different phenotypes), and ownership of the poultry, flock structure, number of eggs laid, and hatchability. Other data collected were on nutrition and housing, diseases, predators and parasites control and breeding. Marketing aspects included variation of prices depending on where they are sold, types of buyers who buys both the eggs and the birds, attributes considered and prices of birds and eggs. The seasonal variations of the prices were also investigated. Data on preferences for different livestock types and poultry phenotypes was collected by the use of a matrix ranking.

**Data Analysis**

The data obtained was subjected to a descriptive analysis using the SPSS.

## 3. RESULTS

### Household characteristics

Most of the household's heads were men (87%), and the rest were female-headed households. Their age ranged from 20-90 years with a mean of 47 years. 60% of the household heads were in the age group of 41-60 years. In the five villages the literacy level was 59%. The main occupation was farming and with few people involved in trade and others formally employed. Crops grown were maize, cowpeas, groundnuts, coconuts, sweet potatoes, cassava, beans, rice, millet, bananas and cashewnuts. The main use of the crops was for food (subsistence farming). The main livestock types kept were chickens, cattle, goats, sheep and ducks. Chickens were the most popular livestock type.

### Poultry (Chickens) in relation to other livestock types

Chicken was ranked first in two of the villages, followed by Goats and Cattle. The questionnaire revealed that chickens were the livestock species largely kept by most households (96%), followed by goats, cattle, ducks, sheep and pigeons in that order.

The chickens were ranked first as they are affordable to buy, can be slaughtered for visitors, which is a great honour. They also reproduce faster, and is less demanding in terms of labour as they scavenge for themselves. The chickens have a ready market and could easily be sold. They can be used for traditional medicine or rituals, and have a more tasty meat as compared to the ducks. Eggs are used as food, as a medicine to cure chest problems.

The goats were ranked second as they were considered as capital; their buying price was more affordable as compared to cattle. The sheep has a low selling price as compared to goats. Sheep meat is not preferred and also the sheep are very susceptible to diseases, hence not readily reared. The ducks were ranked last as they were considered dirty and had a lot of droppings, thereby requiring a lot of work. They also require provision of water. Rabbits were considered to belong to children hence ranked last.

### Objectives of Rural Poultry Production

The main objectives of keeping indigenous chicken were home consumption, sale and the use in rituals. Other uses were in ceremonies, gifts and as a security. This was the trend in all the regions. Most farmers kept their chickens for home consumption. Eggs were mostly for hatching, followed by home consumption and sale.

***Types of chickens kept***: Most of the households (82%), had been keeping chickens for more than five years, 96% rearing indigenous breeds. The main reasons for keeping indigenous breeds were that they are easier to manage, readily available and resistant to diseases. There were several types of chickens that are kept in the district. These includes the normal feathered and size (normal), dwarf, naked neck, feathered head and frizzled

feathered. It was found out that there are beliefs attached to the types of chickens, which in turn affected the use and importance in regard to the type.
The normal is the only type that can be slaughtered to visitors, hence ranked first. The feathered head was no different to the normal as its uses are the same. The naked neck, even though highly valued for its large size and more meat, cannot be slaughtered for visitors and therefore ranked after the normal. The frizzle feathered was ranked last as it is only used for rituals and used for domestic consumption. However it can be slaughtered for home consumption. The dwarf was fourth due to its small size and fetches low prices during sale. However it was said to be more prolific than the rest of the types has a good mothering ability and kept for ornamental purposes. The community explained that such type is not native in the area, but was brought by the Kamba community at around 1954.

***Colour Preferences***: The most preferred colours were red/brown, black and white. Red was said to have more uses in traditional medicine. The black was more preferred than the others as black is used in rituals involving children and was said to easily camouflage against predators, and therefore not easily spotted by kites. White is used for offering sacrifices in shrines and demanded in traditional sacrifices.
The major criterion in colour preferences seems to be the uses of the colour in traditional treatments and the ease of camouflaging.

***Ownership, management and control of chickens***: Even though it was indicated that men own most of the birds, in the ratio of 13:10:6 for men, women and children, it was the women who provided most of the day-to-day management of the chickens. The women therefore were found to have more information of the birds. Women provide labour in the day-to-day management of poultry activities. Kirazini had no men providing the labour.

**Production and Productivity**

***Flock Structure***: The average flock size in the district was 16, with the ratio of Cock:Hen:Chicks being 2:5:8 (Table 1). The average numbers of birds per village is as shown below. Eshu village had the largest number with 21.1 while Kirazini had the lowest (8.8). The cock to hen ratio was about 1 to 2.6. The flock structure may vary from season to season depending on feed availability.
Most of the respondents (59%) indicated that there were three clutches per year, with an average of 13.9 eggs per clutch. The overall hatchability was 84.6%. Most respondents (97%), indicated that the source of the eggs were from their own flock.

*Table 2: Performance of local chickens in different AEZ's of Kwale district, Kenya*

| ***Variable*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| Mean Eggs per clutch ± SD (n) | 14.1 ± 2.9(21) | 14.4 ± 2.8(22) | 12.7 ±3.5(24) | 14.7 ±3.0(20) | 14.2 ± 3.0(18) | 13.9 ±2.0(105) |
| Hatchability (%) | 85.9 | 88.1 | 83.3 | 81.9 | 80.1 | 84.6 |
| Flock structure | | | | | | |
| Cocks | 1.5 | 1.5 | 1.8 | 1.6 | 1.1 | 1.7 |
| Cockerels | 2.4 | 2.0 | 2.9 | 1.8 | 1.4 | 2.2 |
| Hens | 4.4 | 3.5 | 5.1 | 4.3 | 3.5 | 4.5 |
| Pullets | 5.6 | 3.0 | 4.9 | 3.5 | 2.4 | 4.0 |
| Chicks | 8.0 | 7.5 | 9.1 | 5.7 | 4.8 | 7.9 |
| Mean Total Birds | 16.6 | 19.5 | 21.1 | 11.3 | 8.8 | 15.9 |
| ± SD (n) | ± 10.3 (21) | ± 7.9 (22) | ± 11.2 (24) | ± 9.2 (20) | ± 7.0 (18) | ± 10.3 (105) |

**Management**

***Feeding***: Most farmers did mention that they provided supplemental feeds to their chickens. The major reason was to increase production, as they perceived that what they were getting from scavenging was not enough. The major supplementary feed (Table 3) given was bran (possibly from maize) followed by household refusal, kitchen leftovers and very few (2%) gave their chickens commercial feeds. Nearly half of the farmers indicated that they were giving the supplemental feed in the morning. The average feed given was 1.6 Kg per day. This was in an average flock size of about 16 birds. A large proportion of farmers provided their chickens with drinking water, usually at any time of the day. The community explained that there was a close relationship between chicken population and harvesting time. The population, together with egg production is high during harvests. ***Housing***: 95% of the farmers provided housing for their birds either in form of part of sleeping house, separate shelter or part of the kitchen. Most of the birds were housed in the farmers sleeping house.

***Breeding***: Most farmers acquired their initial stock by purchasing and a few received them as gifts. Other ways mentioned were inheritance, exchange by other commodities and through contractual agreement. When adding their flocks, the major method was through breeding followed by purchase.

*Table 3: Management for local chickens in Kwale district, Kenya*

| ***Variable*** | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | ***Overall*** |
|---|---|---|---|---|---|---|
| Housing | | | | | | |
| Separate Shelter | 27.8 | 55.0 | 60.0 | 9.5 | 0 | 33.0 |
| Kitchen | 33.3 | 10.0 | 4.0 | 38.0 | 33.0 | 22.0 |
| Sleeping House | 38.9 | 35.0 | 36.0 | 54.4 | 67.0 | 45.0 |
| Supplementary feeding | | | | | | |
| Commercial | 0 | 2.6 | 2.0 | 4.3 | 0 | 1.9 |
| Kitchen leftovers | 13.5 | 31.6 | 23.5 | 17.4 | 22.9 | 21.7 |
| Cereals | 5.4 | 7.9 | 5.9 | 4.3 | 8.6 | 6.3 |
| Brans | 40.5 | 34.2 | 31.4 | 39.1 | 42.9 | 37.2 |
| Household refusal | 35.1 | 5.3 | 25.5 | 28.3 | 25.7 | 24.2 |
| Others | 5.4 | 18.4 | 11.8 | 6.5 | 0 | 8.7 |
| Methods of disease control | | | | | | |
| Traditional herbs | 33.3 | 47.6 | 47.1 | 46.7 | 46.2 | 44.4 |
| Veterinary services | 26.7 | 47.6 | 41.2 | 46.7 | 53.8 | 43.2 |
| Own treatment with drugs | 40.0 | 4.8 | 11.7 | 6.6 | 0 | 12.4 |
| Acquiring initial stock | | | | | | |
| Purchase | 85.7 | 77.3 | 52.0 | 85.0 | 83.3 | 75.5 |
| Exchange | 4.8 | 4.5 | 0 | 0 | 0 | 1.9 |
| Inheritance | 0 | 4.5 | 8.0 | 0 | 5.6 | 3.8 |
| Gift | 4.8 | 9.1 | 40.0 | 15.0 | 11.1 | 17.0 |
| Increasing existing stock | | | | | | |
| Breeding | 79.2 | 81.5 | 51.4 | 81.8 | 68.2 | 70.8 |
| Purchase | 20.8 | 18.5 | 37.1 | 18.2 | 31.8 | 26.2 |
| Gift | 0 | 0 | 2.9 | 0 | 0 | 0.8 |
| Inheritance | 0 | 0 | 8.6 | 0 | 0 | 2.3 |

***Disease Control***: The villagers said that as far as they could remember (1950's) the poultry populations were high but it has continued to decrease due to diseases and droughts. The claimed that there was a lot of food for the birds and diseases were few. The major diseases of poultry were mentioned as New castle disease (locally called *kideri*) and fowl pox. The fowl pox disease coincided with the season when the mangoes were maturing, and some farmers thought that the mangoes were causing the disease. There was a seasonal variation in the outbreaks of diseases. The highest deaths were seen in August and September just after harvesting. The spread of disease could be due to the wonderings of the birds after the harvesting, as they were not confined other outbreaks were indicated to occur during the rainy season.

The community mostly uses both traditional herbs (44.4%) and consultation of veterinary personnel (43.2%) in the area when the birds are sick (Table 3). A few (11.1%) were able to buy medicines and treat the birds by themselves. The most mentioned herb in almost all the villages was a tuber called *Bundzwi*. A hole is drilled into the tuber and put some mixture of water and maize bran are placed for the birds to eat. They also use *hot pepper* (chilly), Neem, sisal, Sow thistle (*Mchunga uchungu*) and detergents (*Omo*), dissolved in water for treating their birds.

The different types of predators mentioned were monkeys, large grey mongoose (*Kala*), honey burger (*Kicheche*), African striped weasel (*Chororo*), water mongoose (*Ndzusi)*, hawks, kites, crows and snakes. They were said to be hiding in bushes, and therefore the use of dogs for scaring and chasing them away was widely used. Other methods of controlling predators that were mentioned included construction of traps and use of a sisal sack to trap the hawks.

The ectoparasites mentioned were scaly mites *(matende)*, fleas and mites. These were controlled by burning of some bitter leaves (e.g. Bixa leaves and cashew nut husks) in the poultry house.

**Marketing**

Most of the eggs produced were for brooding and only a small percentage was for sale (Table 5). Other uses included home consumption and sale. Most of the eggs were sold at the nearby shopping centres (72%) and the rest are sold at home (Table 5). The eggs were sold at the highest prices when taken to the nearest town as compared to prices at the home or at the shopping centres. Most of the farmers described the market for eggs as reliable, i.e. they could always sell their eggs whenever they wanted to sell. The major reason was that eggs from indigenous birds were considered to be tastier and therefore highly valued as compared to eggs from commercial birds.

When selling live birds, most of them were sold to middlemen (town business people) who came from the neighbouring towns (Table 5). Other buyers were neighbours and itinerary buyers who came at a given time when they have agreed with the farmers.

The middlemen were said to be the major providers of chicken marketing information. 84% of the farmers reported that they don’t get advice from extension agents, and the few that got the advice was on disease control and treatments of the birds.

When the buyers were buying the birds the most important attributes were weight or size, followed by colour and health of the birds (Table 5). Minor considerations were sex and age of the birds. The attributes that the farmers were considering when setting the price of the birds were size and health of the birds. Other considerations were age and colour. The prices varied with season (Figure 2). The prices were better in July to October. This also varied by village. They sited problems such as low prices, few customers, transport problems, market levies, and lack of a specific designed market place and day.

*Table 5: Buyers and attributes considered in marketing of local chickens in Kwale district, Kenya*

| Variable | ***Dry*** | ***Humid*** | ***Wet*** | ***Sub-Humid*** | ***Arid*** | **Overall** |
|---|---|---|---|---|---|---|
| Sale of eggs | 0 | 7.7 | 19.2 | 21.6 | 0 | 11.7 |
| | | | | | | |
| Buyers of Birds | | | | | | |
| Itinerary Buyers | 12.0 | 23.1 | 12.9 | 0 | 0 | 9.5 |
| Neighbours | 20.0 | 26.9 | 38.7 | 19.2 | 31.0 | 27.7 |
| Hoteliers | 8.0 | 0 | 9.7 | 11.5 | 6.9 | 7.3 |
| Shopkeepers | 4.0 | 3.8 | 6.5 | 0 | 34.5 | 2.9 |
| Town Business People | 28.0 | 46.2 | 22.6 | 53.8 | 0 | 36.5 |
| | | | | | | |
| Attributes for buying | | | | | | |
| Weight/Size | 51.3 | 57.2 | 45.6 | 49.2 | 56.6 | 51.5 |
| Colour | 14.6 | 12.5 | 14.7 | 12.7 | 28.3 | 11.7 |
| Age | 2.4 | 5.4 | 7.4 | 1.6 | 2.2 | 4.0 |
| Sex | 9.8 | 8.9 | 11.8 | 9.5 | 6.5 | 9.5 |
| Health | 12.2 | 16.1 | 17.6 | 22.2 | 26.1 | 19.0 |
| | | | | | | |
| Attributes for setting the Price | | | | | | |
| Colour | 6.9 | 8.3 | 7.5 | 8.5 | - | 6.7 |
| Size | 48.3 | 52.8 | 40.0 | 36.2 | 63.0 | 46.4 |
| Age | 3.4 | 16.7 | 17.5 | 14.9 | 3.7 | 12.3 |
| Health | 27.6 | 16.7 | 25.0 | 31.9 | 33.3 | 26.8 |

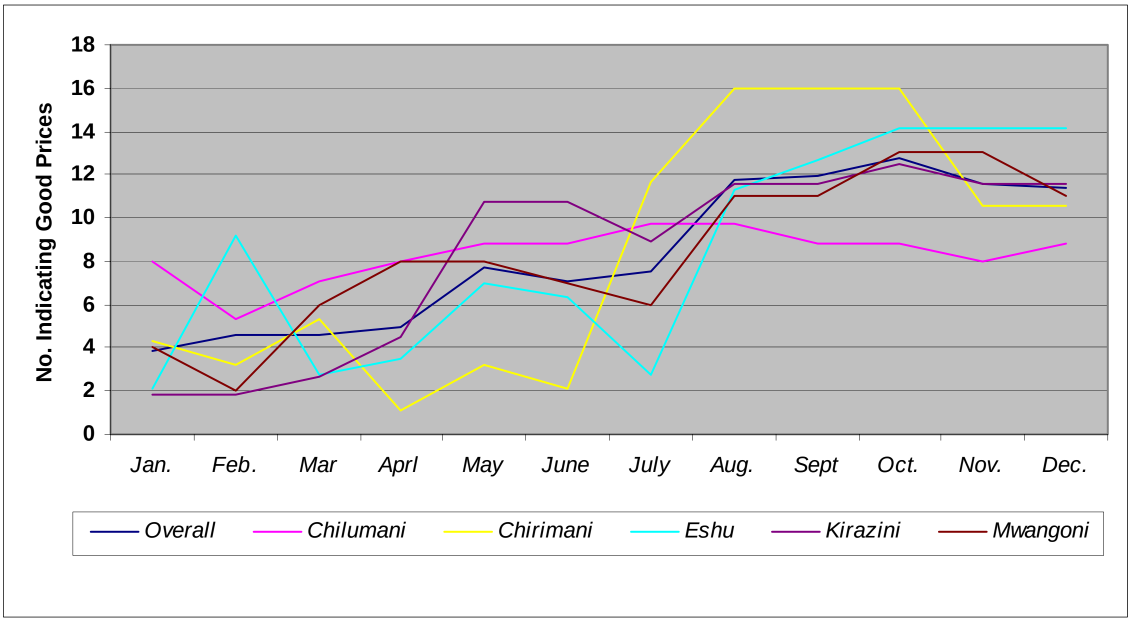


*Figure 2: Seasonal Variation of poultry prices five villages of Kwale district as indicated by farmers' perception as to when the prices were good.*

## 4. DISCUSSIONS:

The high proportion of male-headed households in this region can be explained by the fact that most rural societies are patriarchal (Muchadeyi et al, 2004). This in turns affects the decision making in the household as it was observed when ownership and decision-making were investigated. The level of education between the male and female household heads could contribute to this as well, as 84% of the women household heads had no formal education as compared to only 25% of the men. If poultry is to be used to benefit poor rural women, the low literacy levels should be considered. This includes the preparation of appropriate poultry extension and teaching materials. Contrary to many studies, it was indicated that ownership of chickens in the study area was more for men than women in terms of numbers, even though women provided most of the labour. This means that it is important to involve both the men and women in development interventions, as they all play a crucial role; men making most of the decisions and women providing much of the day to day management.

The major reason why chicken is a major entry point to poverty alleviation initiatives is its presence among the poor, especially women. This was the case in this study as it was the livestock kept by majority of the households. The next in rank was found to be the goat, and it appears that, once the poultry production turns from subsistence to commercial, men tend to dominate. This means that for the poultry to be used to empower women, men have to be engaged in another activity, which could be goats.

The three major objectives of poultry rearing were found to be for food (38%) sale (34%) and cultural uses (19%). The use of poultry as a source of food is very important, as there are few alternative animal protein sources available for the poor. It has been shown that sub-Saharan Africa is the only region where both numbers and proportion of malnourished children has been constantly rising in the past years and its expected to rise at least until the year 2020 (Rosegrant et al, 2001). Poultry meat and eggs contribute to a well balanced diet and offers an opportunity to reverse this trend, as there are few cultural or religious taboos that hinder the consumption of these products.

Among the villages, poultry was also reared for socio-cultural purposes. The plumage colour, cover and sex were the most important considerations. A survey done earlier in different villages of the same district indicated similar results, where red/brown was the most preferred colour. In the two villages where the survey was done black was more preferred than mottled (Mwamachi et al, 1998). Pg 10.

When prescribed by traditional medicine men, they are sold at a high price. Such consideration makes them prefer and hence select birds with such traits. The Nigerian Hausa keep some unique types and colours of naked neck chickens because these birds are associated with spirits in local rituals (McCorkle, 1999).

The average flock size of 16 birds, with a Cock: Hen: Chicks ratio of 2:5:8, was in agreement with those recorded in Ethiopia. Tadelle (2003) reported a mean flock composition of 2.2 cocks, 5.4 hens and 8.5 chicks in five different agro ecological regions of Ethiopia.

The calculated hatchability compares favourably with that recorded in the literature, which ranged from 60-100% in different countries reported by Missohou et al, (2002), This hatchability were; Senegal (80%), Sudan (90%), Burkina Faso (60-90%), Tanzania (50-100%), Guinea (87.5%) Ethiopia (71%) and Botswana. This hatchability can be explained by the handling of eggs where they are usually not moved (as the major use of eggs is brooding) from the nest after laying until the hen becomes broody and sit on them where they were laid. This reduces the risk of the eggs becomes dirty or being broken. Further the eggs are incubated before three weeks are over, as a clutch would be having an average of 14 eggs.

The major supplement for the birds was indicated to be maize bran. This is known to be of low CP and cannot therefore fulfil the nutrient requirements of the chickens. Further the amount of supplemental feed given to the chickens is well below the recommended amounts. The scavengable feed resource base is known not to meet the protein requirements of the birds. There is therefore a need to increases the nutrition, and such an intervention could go along way in increasing the productivity of the local chickens. The supplementation levels especially with commercial feeds however should be limited if at all used, so as not to make the production uneconomically viable.

A major constraint mentioned in this study was diseases, and specifically Newcastle disease. The farmers indicated a seasonal occurrence and they coped with sale of the birds. This can be used to plan a vaccination schedule. The mentioned occurrence during drought and rainy season shows that the major predisposing factor is extreme weather.
The use of ethno veterinary medicine to treat various diseases is in line with those mentioned in he literature. However the rates of application and specific prescriptions is lacking. One of the adversely mentioned plants is the Mbundzwi. It is worth noting that the same plant was also used to treat human diseases by the traditional medicine men. Gueye (2002), reported a similar trend, and explained that there are ‘humanised’ relationships between the birds and the humans. The closeness is also observed in the housing where the birds share the house with the keepers, even though the major reason could be to avoid predators at night.

A major attribute considered for pricing by both the buyers and the sellers was the weight. This shows improving the body weight can actually increase the profits that farmers can get from their birds. The high seasonal variations in prices are caused by demand of the birds during seasonal festivities. This was also observed by Tadelle (2003) in Ethiopia, who showed differences in prices of chickens in ordinary market days and on eves of different festivals. Poultry meat is usually regarded as a delicacy and the prices are high during these times. However during other times, the farmer indicated that the prices offered by the middlemen were poor. This is clear, as the same buyers were the major source of market information. The marketing strategies for the rural poultry products seems to be poor, and its one point where interventions could be developed to increase the profitability of this enterprises.

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## MANUSCRIPT PAPER II

# THE PRODUCTIVE PERFORMANCE OF DIFFERENT PHENOTYPES OF INDIGENOUS POULTRY IN COASTAL KENYA

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## Abstract

The productivity of four phenotypes of local chicken (Normal feathered and size, Naked Neck, Frizzle feathered, and Dwarf), collected from four agroecological zones, (*CL2, CL3, CL4* and *CL5* ) in south coast Kenya was studied. Data on mature body weights, mortality during rearing, egg quality charecteristics, fertility, hatchability, and chick growth rates up to five weeks was collected.
The naked neck had a significantly higher body weights, egg weights, eggshell thickness, growth rates up to 5 weeks and lower mortalities during rearing. However it had the lowest fertility. The dwarf had the highest hen-day egg production and the highest shape index, but with the least egg shell thickness and growth rates. The frizzle was intermediate in most of the parameters, except in fertility where it had the highest. The frizzle was also found to be more susceptible to feather pecking when reared with the other phenotypes. The normal had the highest mortality and hatchability. The agro ecological zone had a significant effect on the body weights and mortalities, with birds from the wet zones, CL2 and 3, having the highest body weights. Birds from The two dry zones CL4 and CL5 had the highest mortalities during rearing.
It can be concluded that the naked neck phenotype is superior in the productivity when compared to other phenotypes. This can be increased by the combination with the other phenotypes. The three phenotypes are therefore relevant in tropical conditions and are worth being considered in the improvement of productivity of the local chickens.

***Key words***: Phenotypes, Naked neck, frizzle, dwarf, body weights, egg quality, fertility, hatchability, growth rates, feather pecking.

# 1. Introduction

## Background

Kenya is one of the three East African countries bordering Tanzania to the south, Uganda to the west, Sudan and Ethiopia to the north, Somali to the east and Indian ocean to the south east. It is situated at 38’00 East and 1’00 North. It has a human population of about 32 Mill. People (1999 Census) and a land area of 564,662 sq. Km. 80% of the population lives in the rural areas and 50% below the poverty line. Of the total land surface area, only 8 % is considered suitable for arable farming (*kenyaweb.com*). The rest of the land is low potential and mostly suitable for livestock farming. It is classified as arid and semi-arid lands, characterized by high ambient temperatures and low rainfall.
Kwale District lies within the Coastal lowlands (CL) zone group with mean annual temperature higher than 24 degrees Centigrade and mean maximum temperature lower than 31 degrees Centigrade. The main crops of this zone group are cashewnuts and coconuts. Within this zone, main zones are distinguished and determined by the mean annual rainfall. In the district there are five main agro-ecological zones ranging from CL2 (where 2 stands for ‘sub-humid’) to CL6 (‘arid’) characterized by leading crops and/or agricultural activities in each of them. About 72% of the district lies within agro-ecological zones CL5 and CL6 whose average annual rainfall ranges from 500 to 900 mm which is poorly distributed and unreliable. This makes the area suitable for ranching activities. Agro-ecological zones CL2 to CL4 are suitable for mixed farming. The only limiting factors are high evapo-trasnspiration rates, unreliability of rainfall and tsetse infection, which limits livestock development for large ruminants ( *Kenyaweb.com, 2003*).

The poultry population in Kenya is about 29.8 million (m) chickens consisting of 21.8 m local chickens, 4.4 m broilers and 2.9 m layers. The local chickens are the main source of income for 90% of the rural households, which comprises 80% of the population. Therefore the local chickens are among the many local resources of poor people living in the rural areas, which could be harnessed and utilized for poverty alleviation, (Njue, 2002). Traditionally, poultry plays an important role in Kenya. The chickens have been and still are a major source of protein in form of meat and eggs.

The Kenyan government initiated improvement programmes as from 1976 up to the 1995 through the National Poultry Development Programme (NPDP), which was jointly funded by the Government of Kenya (GoK) and the Netherlands Government. However the emphasis was on commercial poultry production and rural poultry was only given attention at the beginning of 1990’s (Nyange, 2000). The programme used the Black Shavers and Rhode Island Red pure breeds, to upgrade the indigenous chicken through the cockerel exchange, supply of pullets and hatching eggs. Cockerels were reared up to maturity, mainly on government stations and then exchanged for local cockerels owned by rural smallholder farmers. The supply of the pure breeds allowed the farmers to renew their flocks and remain independent from external suppliers. However this approach was hindered by the fact that the pure breeds are more difficult to purchase and are becoming scarce, and when present, they produce less than the hybrids. In addition, there was a lack of proper and continuous monitoring, and the exotic birds did not survive under the prevailing harsh conditions. The farmers were given advice on improved feeding and housing and were asked to remove all remaining local cockerels. This approach led to a limited improvement due to the high mortalities, poor management, and above all the programmes were usually planned without the farmers' participation. In addition the strategies did not pay attention to local social and cultural aspects of poultry production. Such activities have been attempted in other countries such as Malawi, Niger, Tanzania, Ethiopia and Bangladesh, with similar experiences (Sonaiya, 2002).

In 2003, the Smallholder Poultry Development Project was initiated in Kenya under the Agricultural Sector Programme Support (ASPS), funded by Danida in collaboration with GoK, and based on the Bangladesh Poultry model. This model is being tested in the two coastal districts, Kwale and Taita Taveta, for adaptation by the rural poor women. The ISA Brown hybrid hens are used together with local cocks to produce eggs that are given to broody local hens for hatching. The major challenge will be that the hybrids will require a constant external supply, which means the presence of a well managed hatchery facilities and grandparent stock, which is beyond the scope of smallholder farmers.

One way of improving sustainable productivity is through genetic selection and development of suitable indigenous parent stock. The improvement of these poultry should be in line with the existing rural conditions to avoid the likelihood of maladjusted management. Selection over time may yield a stock that fit the local conditions. The rural poultry offers a wide range of genetic potential, as the local chickens are genetically heterogeneous, offering a wide range of phenotypes and genotypes to select from.

The local chickens appear to be genetically heterogeneous with no specific colour pattern and nondescriptive both in phenotype and genotype. The local birds seen in villages may have been crossed with exotic cocks in earlier years through the cockerel exchange programme, but such genes may have been dispersed and lost in the population because of unplanned breeding programmes and absence of selection (Njue et al, 2002). Indigenous poultry in sub-Saharan Africa is a very important part of the farming system. Despite the low productivity, it can and should be used as a tool for development in rural Africa. It offers a valuable means of generating income and providing nutrition to the rural population, majority of who die of hunger and malnutrition and are languishing in poverty.

Even though the indigenous birds are poor producers, there exist highly productive indigenous birds (Mathur 1989, Nwosu, 1979) and some are well adapted to their environments (Njue et al, 2002). The genetic resource base of the indigenous chickens in the tropics is therefore rich and should form the basis for genetic improvement through selection and multiplication to produce a breed adapted to the tropics. The task is to identify and select such individuals or families. The selected families and individual birds can then be used for crossing to improve production further.

Some of the different indigenous breeds and strains that are abundant in Coastal Kenya and Sub-Sahara Africa in general are Dwarf breeds, Frizzle Feathered, Normal Feathered and Naked Neck chickens (Ndegwa et al, 1998). Very little research has been done to determine existing or potential levels of productivity. There is a need for their genetic improvement in order to improve their productivity within their local environment, make use of the indigenous birds for crossing with imported exotic birds and conserve the desirable genes e.g. disease resistance (Sonaiya, 2002).

There's a need to characterize the laying and growth patterns of the various breeds in order to quantify their potentials. Apart from the Fayoumi breed developed in Egypt, there appears to be no record of a tropical adapted breed developed from indigenous chickens in Africa. In the process of adaptation to the local conditions, the scavenging chickens may have sufficiently evolved into distinguishable ecotypes with productivity characteristics that are identifiable and can be utilized for further improvement either alone or by crossing with other breeds (Nyaga, 2002).

Horst (1999) recommends that for successful improvement of the indigenous breeds on productivity, production traits and characteristics related to adaptability should be considered. Such traits, determined by what he called tropically relevant genes, include the naked neck, frizzle feathered and dwarfism. The decisions on the use of ecotypes in improvement programs should be based on both the evaluation of genetic distinctness and performance data records.

The overall objective of the study is therefore to investigate the local poultry stocks and assess their suitability in increasing productivity at the village level.

**Objectives Of The Study**

1. To study the performance of the four phenotypes of indigenous chicken in terms of mature body weights, egg production, egg quality characteristics growth rates, and survivability.

2. To identify the indigenous phenotype among the three that is well adapted to tropical coastal climate, (characterized by high ambient temperatures and high humidity), so as to increase the profitability of indigenous chicken production in coastal Kenya.

3. To identify the best phenotype among the three that can be used in smallholder poultry improvement programs.

**Literature Review**

The naked neck gene is a single autosomal dominant gene, *Na*. The gene is incompletely dominant with $Na/na^+$ birds showing an isolated tuft of feathers on the ventral side of the neck above the crop, while *Na/Na* birds either lack this tuft or it is reduced to just a few pinfeathers or small feathers. The resulting bare skin becomes reddish, particularly in males as they approach sexual maturity (Hutt 1949, Somes 1990).
The naked neck gene has been shown to have an association to heat tolerance. In high temperatures, near $30^o$ C or higher, homozygous or heterozygous naked neck birds were heavier than $na^+/na^+$ chicks. There was also an improvement in the carcass yield and had a better laying rate. The mean egg weight, eggshell strength and egg mass were also increased for the heterozygous genotype. An increase in embryonic mortality, mostly during the last stages before hatching was observed in *Na/Na* and $Na/na^+$ (Merat, 1990).
Reduction in feather coverage in naked neck (30-40%) birds facilitates better heat dissipation and improved thermoregulation resulting to a better relative heat tolerance under hot climates.

The favourable effects of the naked neck gene has been shown in high temperature by higher breast weight, superior growth rate, better feed conversion ratio and carcass traits (Yalcin et al, 1997, Patra et al 2002), reduced effect of high ambient temperatures on fertility (Ladjali et al, 1995), less body weight loss in heat stress (Mazzi et al 2002), superior levels of heat shock protein, Hsp 70 (Hernandes et al, 2002), lowest incidence of the pathologies such as cloacal cysts, ascites, prolapse, Marek's disease, coccidiosis, osteodystrophy and Salmonellosis (Fraga et al, 1999) and resistant to sudden death and ascites syndrome (Gonzales et al, 1998). Combining two alleles (naked neck *Na* and Frizzling *F*) has bee shown to result to an additive effect (Yunis and Cahaner, 1999; Horst et al 1995).

Frizzling is caused by a single incompletely dominant autosomal gene, *F*, restricted by an autosomal recessive modifier, *mf* (Hutt, 1949). *Unmodified homozygotes* have the rachis extremely recurved in all feathers. The feathers are easily broken and they therefore appear quite bare. The modifying gene lessens the extreme aspects of the homozygotes so that they appear less woolly. *Unmodified heterozygotes* have the feather shafts and barbs of contour feathers recurved, to a much less extent than the homozygotes. This is modified so that some birds are almost indistinguishable from the wild type. The action of the *F* gene has been shown to be localized in the feather follicle and does not result from a metabolic disorder. Landauer in1932, maintained that the hatchability of eggs laid by heterozygous frizzles is subnormal and that it is still lower in eggs from homozygotes (Somes, 1990). The Frizzle gene increase egg number and egg mass and reduces mortality under hot conditions (Merat 1990).

Dwarfism has been described to be either the sex-linked dwarfism (*dw*,$dw^M$,$dw^B$) or autosomal dwarfism, ( *adw*).The sex-linked dwarfism, *dw*, is a recessive sex-linked gene closely linked to the gold-silver and slow rapid feathering loci. It has a much greater dwarfing effect than any other previously discovered. Males are reduced in size by about 43% while females are reduced by 26-32%. The birds are healthy and viable, with fertility and hatchability being as good as the normal. Egg size is smaller by 10% and egg numbers are slightly reduced. Bantam Dwarfism $dw^B$ is a size reducing sex-linked recessive gene, which was studied from the Golden Sebright bantam and was closely related to the sex-linked feathering locus. This was called the bantam gene $dw^B$, which reduced the female size by 5-11% when compared to $Dw^+$/-females. $Dw^+/dw^B$ males were reduced by about 5% when compared to $Dw^+/Dw^+$ males. The $dw^+/dw^+$ males were reduced by 9% when compare to $Dw^+/dw^B$ males. The additive effect means that homozygous males are reduced by 14% when compared to the normal size. The $dw^B$ allele seems to be recessive to its incompletely dominant normal $Dw^+$ allele and dominant over the *dw* allele (Somes 1990). The MacDonald Dwarfism $dw^M$ gene is a single sex-linked recessive belonging to the same locus as the *dw*. When the males were crossed with dw/- females all the $F_1$ males were all dwarfed. Further mating indicated that the dw/- and the $dw^M$ are different alleles and not the same gene. The $dw^B$ and $dw^M$ alleles could be different, as the $dw^B$ only reduced female body weights by 10%, shank length by 5%, with birds generally appearing normal. The $dw^M$ reduced the female body weights by 13.5%, shank length by 9%, with birds being definitely distinguishable from the normal by their smaller size. The dominance relationship between the $dw^M$ and the other two recessive alleles is unknown. Autosomal Dwarfism (*adw*) is a single autosomal gene reported in Cornell K strain of White Leghorns. It reduced the body size by 30% and is easily distinguishable by 6-8 weeks of age. The birds have an excellent viability, adult body weight of 1400 g, delayed sexual maturity, has an egg production of 87% of the normal and the egg size at one year of age is 57g. There is reduced hatchability. It's not known if this gene is part of the genotype of any of the bantams' breeds (Somes 1990).

However the effect of these genes in the rural poultry flocks has not been investigated, yet they have been shown to be abundant. There is therefore the need to revisit the local poultry resource and assess the contribution of these genes. This will assist on the genetic improvement on productivity and the conservation of the identified desirable genes.

## 2. Materials and Methods

The experiment was designed to study the productive performance of the four local phenotypes of chickens under the intensive management system. It was undertaken at the Matuga poultry-rearing unit in Kwale district, Coast Kenya. One of the rooms was used for rearing and was divided into four compartments each measuring 2m x 4m . The other rooms were used for brooding house and as a grower house.

***Experimental Birds***: 149 birds (128 females and 21 males) were randomly selected from the existing rural flock of four regions of the district. The four phenotypes that were used in the experiment were the normal feathered and normal size *(No*), naked neck (*Na*), frizzle feathered (*Fr*) and the dwarf (*Dw*). The regions had different Agro ecological characteristics shown in Table 1.

*Table 1: Description of AEZ, Climatical conditions and major crops grown per zone where the parent stock was selected.*

| ***Agro-Ecological Zone*** | ***Altitude in m*** | ***Annual Mean Temp. ( $^oC$ )*** | ***Annual Average Rainfall (mm)*** | ***Major crops grown*** |
|---|---|---|---|---|
| ***CL2*** Marginal Sugar cane Zone *(Wet)**** | 1-60 | 26.3-26.6 | 1200-1400 | Cassava, Coconut, Beans, Rice, Cowpeas, Maize, Beans, Sugarcane, |
| ***CL3*** Coconut cassava Zone *(Humid)**** | 1-450 | 24.0-26.6 | 970-1250 | Cassava,Coconut, Beans,Cowpeas, Maize, |
| ***CL4*** Cashewnut cassava Zone *(Sub humid)**** | 1-250 | 25.0-26.6 | 850-1200 | Cassava,Coconut, Cashewnuts, Maize, |
| ***CL5*** Lowland Livestock Millet Zone *(Dry)**** | 120-650 | 24.3-27.5 | 600-900 | Sorghum, millet, cowpeas, green grams, pigeon peas, |
| ***CL6*** *Lowland Ranching Zone (Arid)** | 120-600 | 24.6-27.5 | 500-600 | Sorghum, millet |

*Adapted from Jaetzold & Schmidt, 1983.*
**These descriptions are meant for this study and do not strictly follow other definitions.*

The birds were vaccinated with the NCD (La Sota strain) vaccine and left in the farms for two weeks before they were collected. After collection they were first housed in different compartments according to the region of origin before they were separated into various phenotypes. The birds were then wing tagged and weighed using a weighing balance.

***Rearing***: The birds were reared at the unit under the deep litter system with wood shavings. They were fed with layers mash *ad-lib* (20% CP and 2850 Kcal ME/Kg) and were provided with green grass at the first two months of rearing. Each room was provided with five laying boxes measuring 30 cm x 30 cm x 30 cm. Eggs were collected daily, labelled and stored for less than 14 days at room temperature, ($20^o$ C to $26^o$ C), before incubation.

***Treatment:*** The birds were dusted with Malathion poultry dust against soft ticks and mites, and the building was dusted with the same after four months. During rearing the birds were also vaccinated against Fowl Pox and Fowl Typhoid. There was an outbreak of disease the birds were treated with antibiotics. These were identified as Newcastle and Salmonellosis.

***Incubation***: The eggs were selected for artificial incubation according to size, shape, breakages and cleanliness, where either very small eggs or very large eggs, broken shells, blood stained or dirty eggs were discarded. They were fumigated with a mixture of 20 cc Formalin (40%) and 10 gm Potassium permanganate, in an airtight wooden box measuring about 0.3 $m^3$. They were then incubated in an automatic combined setter/hatcher incubator (Danki Type 1 800 LCD) with a capacity of 576 eggs, which turned automatically at $90^0$ every hour. The eggs were incubated under $37.8^o$ C and 75% RH for 18 days. They were candled at day 9 and moved to the hatching tray at day 18. The incubator was set at $36.7^o$ C and 80% RH for the last three days. After each batch, the incubator was cleaned with pressurized disinfected water.

***Chick rearing***: After hatching the chicks were transferred to the unit, with four brooders as per the phenotype, and fed with chick and duck mash *ad lib.* Electric bulbs were used to provide light and heat. The chicks were vaccinated against New Castle disease during the first week of rearing. Their growth rates were recorded weekly up to five weeks.

***Egg quality analysis*:** Some eggs were selected for egg quality analysis i.e. egg weight, shell thickness, yolk colour and shape index. The eggs were broken and the contents placed on a metallic tray. Then the eggshells were soaked in water and the eggshell membrane was removed. They were then air-dried at room temperature.

**Data collection**

***Parent stock body weights***: Individual body weights were taken by the use of a hanging scale balance. The birds were placed in a hollow container, hanged on the balance and the weights taken by reading the scale.

***Egg quality***: Data on egg quality characteristics was collected twice during the experimental period. The eggs were weighed by the use of an electronic digital balance. Egg width and length was measured by the use of a calliper and the shape index calculated as the ratio between the width and the length of the egg. Yolk colours were read by adjusting the score of the Roche scale colour fan. The eggshell thickness was measured from two points at the equator line by the use of a digital micrometer. The average shell thickness was calculated from the two readings.

***Egg production***: All the eggs laid were recorded daily for the whole experimental duration over a period of 176 days (8th April to 31st September). The egg production was calculated in terms of rate of lay i.e. percentage of the total number of eggs produced divided by the total number of hens alive per day This was calculated for the two phases (8th April to 12th July and 13th July to 31st September).

***Fertility and Hatchability***: The incubated eggs were candled at the ninth day, and the fertility was calculated as the percentage of eggs set divided by fertile eggs. The chicks were removed from the hatcher as from the second day of hatching and the hatchability calculated as the percentage of eggs hatched divided by the total fertile eggs.

***Chick weights***: The chicks were weighed weekly from the first week until the fifth week by the use of an electronic digital balance. The growth rates were calculated per phenotype as change in weight gain from week one to week five divided by the total number of days.

**Data analysis**

The data was analysed using the following models.

***Model 1: Mature Body Weights Of The Birds***

$$Y_{ijklmn} = \mu + S_i + Z_j + G_k + \varepsilon_{ijk}$$

Where $Y_{ijklmn}$ =Observation for a given variable

$\mu$ = Overall general mean common to all observations

$S_i$ = effect due to the ith sex of the bird (i=1, 2), (where applicable)

$Z_j$ = Agro ecological Zone effect due to jth zone (j=1, 2, 3, 4)

$G_k$ = Genetic effect due to kth phenotype (k=1, 2, 3, 4)

$\varepsilon_{ijkl}$ = random error effects peculiar to each observation.

***Model 2: Mortality***

$$\mathbf{Y_{ijk}} = \boldsymbol{\mu} + \boldsymbol{Z_i} + \boldsymbol{P_j} + \boldsymbol{\varepsilon_{ijk}}$$

Where $\mathbf{Y_{ijk}}$ =Observation for the given variable (either fertility or hatchability)

$\boldsymbol{\mu}$ = Overall general mean common to all observations

$\boldsymbol{Z_i}$ = Zone of origin effect due to ith source (i=1, 2, 3, 4)

$\boldsymbol{P_j}$ = Phenotypic effect due to ith genotype (j=1,2,3,4,)

$\boldsymbol{\varepsilon_{ijk}}$= random error effects peculiar to each observation.

***Model 3: Egg Weights***

$$\mathbf{Y_{ijk}} = \boldsymbol{\mu} + \boldsymbol{P_i} + \boldsymbol{M_j} + \boldsymbol{\varepsilon_{ijk}}$$

Where $\mathbf{Y_{ijk}}$ **=**Observation for a given variable

$\boldsymbol{\mu}$ = Overall general mean common to all observations

$\boldsymbol{P_i}$ = Phenotypic effect due to ith genotype (k=1, 2, 3, 4),

$\boldsymbol{M_j}$ = effect due to the ith month of laying (j=1,2,3,4,5,6),

$\boldsymbol{\varepsilon_{ijk}}$= random error effects peculiar to each observation

***Model 4: Fertility and Hatchability***

$$\mathbf{Y_{ijk}} = \boldsymbol{\mu} + \boldsymbol{P_i} + \boldsymbol{L_j} + \boldsymbol{\varepsilon_{ijk}}$$

Where $\mathbf{Y_{ijk}}$ =Observation for a given variable (either fertility or hatchability)

$\boldsymbol{\mu}$ = Overall general mean common to all observations

$\boldsymbol{P_i}$ = Phenotypic effect due to ith genotype (k=1, 2, 3, 4)

$\boldsymbol{L_j}$ = effect due to the ith lot of the setting (j=1,2,3,4,5,6)

$\boldsymbol{\varepsilon_{ijk}}$= random error effects peculiar to each observation.

Statistical Analysis was performed by the use of Analysis of variance (ANOVA) using General Linear Model (GLM) procedure of SAS® software Version 8.2.

## 3. Results

**Weights of birds selected from different Agro ecological zones of Kwale district.**

The overall body weights for the birds collected at random from all the four regions were 1.77± 0.49 Kg (males) and 1.32± 0.33 Kg (females). The phenotype had a significant effect on the body weights of the birds. The naked necks were significantly heavier than the normals and the dwarfs, but not significantly with the Frizzles. They were followed by the frizzles, normal and the dwarfs had the least weights. There was no significant difference between weights of birds from the last three genotypes (Table 2).

*Table 2: Productive Performance (LSMeans±SD) of the Different Phenotypes of the Birds Collected from Different Regions of Kwale District, Coastal Kenya.*

| Parameter | | PHENOTYPE | | | |
|---|---|---|---|---|---|
| | | Normal | Naked Neck | Frizzle | Dwarf |
| Mature Body Weights (Kg) | Male | 1.4 ± 0.14$^{b}$ *(5)* | 2.2 ± 0.52$^{a}$ *(4)* | 1.8 ± 0.50$^{ab}$ *(10)* | 1.7 ± 0.28$^{ab}$ *(2)* |
| | Female | 1.3 ± 0.32$^{b}$ *(40)* | 1.4 ± 0.33$^{a}$ *(46)* | 1.3 ± 0.37$^{ab}$ *(28)* | 1.2 ± 0.20$^{b}$ *(14)* |
| Mortalities (%) | | 74.4$^{a}$ | 45.1$^{b}$ | 56.1$^{ab}$ | 49.2$^{ab}$ |
| Rate of Lay (%) | | 23 | 33 | 27 | 36 |
| Egg Weights (g) | | 42.5±3.88$^{b}$ (85) | 45.8±4.48$^{a}$ (85) | 43.0±4.94$^{b}$ (85) | 38.1±2.90$^{c}$ (85) |
| Shape Index | | 0.76±2.96$^{b}$ | 0.75±2.83$^{b}$ | 0.76±3.28$^{b}$ | 0.80±3.85$^{a}$ |
| Yolk Colour Score (Start - End Experiment) | | 6 - 2 | 10 - 2 | 5 -3 | 5 - 1 |
| Egg Shell Thickness (mm) | | 0.32±0.009$^{ab}$ | 0.33±0.023$^{a}$ | 0.33±0.021$^{ab}$ | 0.30±0.037$^{b}$ |
| Fertility (%) | | 57.8 | 58.5 | 65.7 | 65.4 |
| Hatchability (%) | | 78.5 | 67.5 | 73.2 | 77.6 |
| Growth rates/ADG (>5 Wks) g/day | | 4.4±1.06$^{a}$ | 4.5±1.15$^{a}$ | 4.2±1.19$^{ab}$ | 3.6±1.04$^{b}$ |

*Means with common superscripts within a row are not significantly different (P<0.05)*

Birds from the humid zone were significantly heavier than birds from other zones (Table 3). There was no significant difference between weights of birds from the last three zones. As the means are estimated as Least Square Means in a model including the effect of genotypes a possible effects of unbalanced numbers of genotypes across zones are eliminated (Table 3).
There were significant differences between the weights of the birds collected from zone 3 with all other zones in both males and females, except males of zone 2/3.

*Table 3: Effect of Zone on the Body Weights (Kg) and Mortality (%) by of the 100 birds collected (LSMeans±SD).*

| | | **Zone of Origin** | | | | **Overall** |
|---|---|---|---|---|---|---|
| | | **Humid (CL3)** | **Dry (CL5)** | **Sub humid (CL4/5)** | **Wet (CL2/3)** | |
| ***Mean Body Wts. (Kg)*** | Males | $2.2 \pm 0.54^{a}$ *(6)* | $1.4 \pm 0.28^{b}$ *(5)* | $1.4 \pm 0.31^{b}$ *(3)* | $1.6 \pm 0.35^{ab}$ *(3)* | $1.7 \pm 0.51$ *(17)* |
| | Female | $1.4 \pm 0.23^{a}$ *(21)* | $1.2 \pm 0.32^{b}$ *(17)* | $1.2 \pm 0.29^{b}$ *(22)* | $1.2 \pm 0.25^{b}$ *(23)* | $1.3 \pm 0.28$ *(83)* |
| | Overall | $1.6 \pm 0.45^{a}$ *(27)* | $1.3 \pm 0.32^{b}$ *(22)* | $1.2 \pm 0.29^{b}$ *(25)* | $1.3 \pm 0.28^{b}$ *(26)* | $1.4 \pm 0.37$ *(100)* |
| ***% Mortality*** | | $48.4^{b}$ | $56.8^{ab}$ | $77.5^{a}$ | $42.2^{b}$ | 56.2 |

*Means with common superscripts within a row are not significantly different (P<0.05)*

**Mortalities of the Parent Stock**

The birds developed symptoms of disease immediately after collection. The most prominent symptoms were tracheal rales, droopiness, lameness, greenish, whitish, and yellowish diarrhoea. Within a period of three weeks, a total of 57 birds had died. The birds were treated with antibiotics. A Post mortem done on some of the birds indicated that the birds had Newcastle disease and Salmonellosis.

There was a significance difference in mortalities between the phenotypes (Table 2). The Normal had the highest followed by the Frizzle and the Dwarf, though there was no significance difference. The naked neck had a significantly lower mortality than the other three phenotypes.

There were also significant differences when the mortalities were considered by zone of origin (Table 3). The Sub humid zone (CL4/5) had the highest mortality, followed by the dry zone (CL5) with no significant difference. The wet zone (CL2/3) and the humid zone (CL3) followed these two zones with significantly lower mortalities than the sub humid zone but not the dry zone.

**Egg Production**

The overall rate of lay was 29% for all the phenotypes. The Dwarf had the highest hen day production of 36%, followed by the Naked Neck 33%; frizzle 27% and the Normal had the least with 20% (Table 2).

**Weights Of Eggs**

The egg weights were significantly different among the various phenotypes (Table 2). The Naked Neck had the highest weight, which was significantly different from all the other phenotypes. The Normal and the Frizzle had intermediate weights and the Dwarf had the least weight.

There was variation of the egg weights over the laying period (Table 4). The differences were significant between August and May, and August and September.

*Table 4: Effect Of Time/Month On Egg Weight Of The Different Phenotypes: LSMeans±SD of eggs from the different phenotypes in different Months*

| **Month** | **Phenotype** | | | | ***Overall*** |
|---|---|---|---|---|---|
| | **Normal** | **Naked Neck** | **Frizzle** | **Dwarf** | |
| **April** | 44.3±4.76 (14) | 47.2±4.71 (14) | 41.3±2.67 (14) | 37.3±2.57 (14) | ***42.5±5.17 (56)*** |
| **May** | 40.8±2.97 (19) | 44.4±3.77 (19) | 41.8±3.86 (19) | 39.5±2.71 (19) | ***41.6±3.77 (76)*** |
| **June** | 43.4±2.43 (5) | 42.1±1.85 (5) | 42.5±4.43 (5) | 37.8±2.36 (5) | ***41.5±3.49 (20)*** |
| **July** | 43.0±2.18 (11) | 47.7±4.56 (11) | 43.8±2.51 (11) | 37.8±0.87 (11) | ***43.1±4.50 (44)*** |
| **August** | 43.3±4.62 (29) | 47.3±5.10 (29) | 45.1±6.81 (29) | 39.3±3.49 (29) | ***43.8±5.88 (116)*** |
| **September** | 42.5±2.14 (7) | 44.2±1.68 (7) | 43.6±2.76 (7) | 36.4±1.13 (7) | ***41.7±3.68 (28)*** |
| ***Overall*** | ***42.5±3.88[b] (85)*** | ***45.8±4.48[a] (85)*** | ***43.0±4.94[b] (85)*** | ***38.1±2.90[c] (85)*** | ***42.7±4.94 (340)*** |

*Means with common superscripts within a row are not significantly different (P<0.05)*

## Egg Quality

### a. Shape Indices

The overall shape index of the eggs was 0.77(Table 2). The dwarf had the highest shape index, followed by the Naked Neck and Frizzle, and the normal had the least shape index. There was a significant difference between the shape indices of the dwarf and all the other phenotypes (Naked, Normal and Frizzle, which had no significant difference between them).

### b. Yolk colours

The Roche Scale Yolk Colour Fan Scores varied widely over time (Table 2). On the first trial, it ranged from five to ten, with the frizzle and the dwarf having the least with an average of 5. The naked neck had an average of 6, and finally the normal had the highest average of 10.

On the second trial, the yolk colours were very low but closely equal, with the frizzle having the highest with an average of 3. The naked neck and the normal had an average of 2, while the dwarf had the least average of 1.

### c. Egg Shell Thickness

The overall average eggshell thickness for the birds was 0.31mm (Table 2). The normal and the frizzle had the highest thickness with an average of 0.33 mm, the naked neck had 0.32 mm and the dwarf had the least eggshell thickness of 0.30 mm. There was a significant difference between the eggshell thicknesses of the normal/frizzle with the dwarf.

## Fertility And Hatchability

There was no significant difference of the fertility of the eggs from different phenotypes, when the Least Square Means were considered (Table 2). The frizzle had the highest fertility, followed by the dwarf, and then the naked neck, and the normal had the least.

There was a high significance (P<0.001) when fertility was considered by lot (Table 5). The fertility of the second and third lot was significantly higher than the fifth and sixth lot.

*Table 5: LSMeans of fertility and the hatchability of the different Lots of eggs incubated at different times.*

| | **Lot** | | | | **Average** |
|---|---|---|---|---|---|
| | **Second** | **Third** | **Fifth** | **Sixth** | |
| **Fertility** | $64.5^{a}$ | $75.5^{a}$ | $58.1^{b}$ | $49.2^{b}$ | ***61.8*** |
| **Hatchability** | 71.2 | 72.7 | 74.6 | 78.4 | ***74.2*** |

*Means with common or no superscripts within a row are not significantly different (P<0.05)*

**Growth Rates**
Among the four phenotypes in considerations, the frizzle had the highest chick weight at the first week; followed by the naked neck and the normal. The dwarf had the least. By the last week of recording (week five), the naked neck had the highest weight (Figure 2).

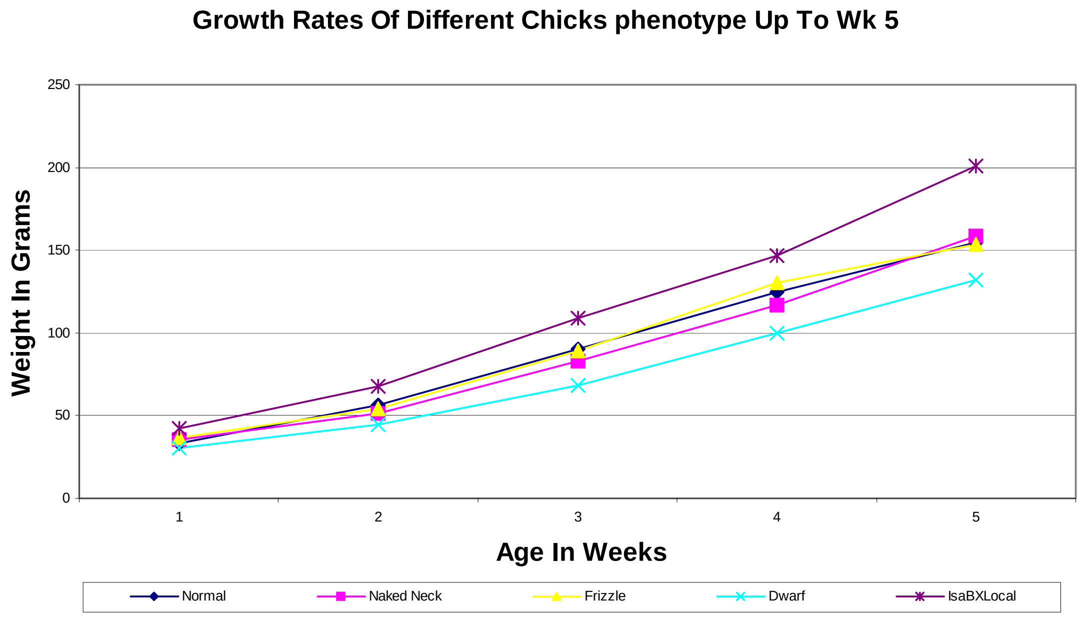


*Figure 2: Graph of weekly chick Weights up to Week 5 of the different phenotypes*

The average daily gain up to week five was significantly different among the different phenotypes, being highest among the Isa Brown X Local chicks (Figure 3). The Naked Neck had the highest ADG among the other four phenotypes, with the dwarf having the least.

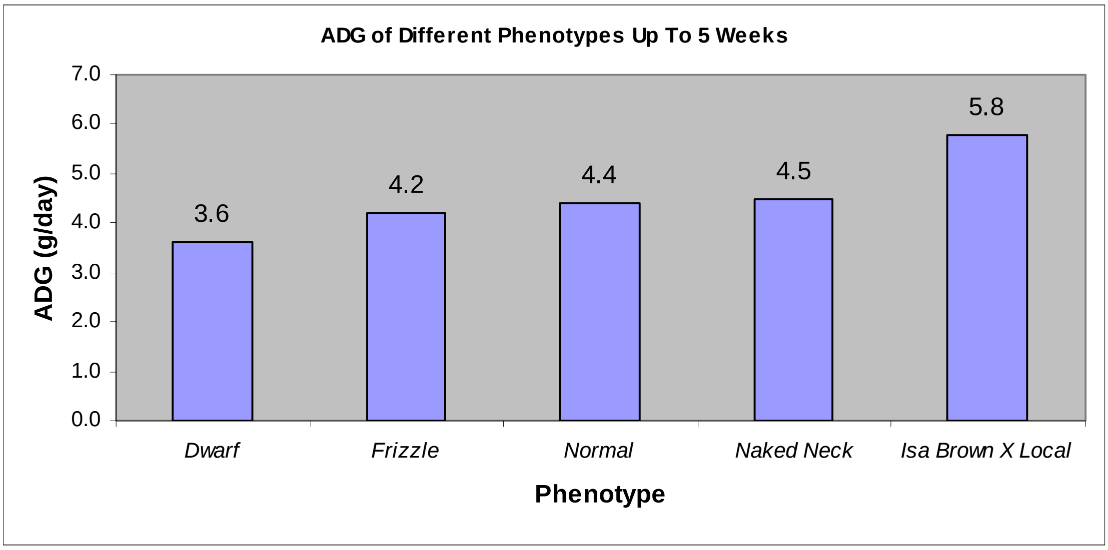


*Figure 3: Average Daily Gain (ADG) of the different phenotypes up to 5 Weeks of Age.*

## IX. Behavioural Observations: Feather Pecking and Cannibalism

When the different chicks were reared together, there was no fighting observed. However at the age of four weeks, feather pecking and cannibalism was observed. It was noted that the frizzle feathered were the only birds that were being pecked. They were severely pecked on the back and wings. Some birds lost the entire extreme part of the wing. The frequency of attack increased when the bird was bleeding. Five frizzle feathered were observed to have been cannibalised/pecked in a group of about sixty birds.

## 4. Discussion

### I. Weights of birds selected from different Agro ecological zones of Kwale district.

The naked neck and the frizzle were found to have a higher weight than both the normal and the dwarf. These genes therefore had a favourable effect on the body weights. This is in agreement to the findings of Horst (1995) who found that the favourable effects were even higher in arid conditions. These two genes reduce the body surface covered by the feathers thereby giving the birds a better heat dissipation. This would in turn preserve more energy that could have been used in heat dissipation, and this energy is directed to productive functions including body weight gain. Several major genes found in the local populations have revealed their significance for adaptability and suitability to the given environment. These two genes have been reported to have a favourable effect on productivity when either the naked neck or frizzle were combined to the dwarf gene (Horst 1995, Mathur 2003).

The dwarf in the experiment was observed to have a weight close to the normal. This was unexpected as other studies (Somes 1990) showed a reduction of body weights ranging from 24-36%. However, this disparity can be explained by the fact that there are several genes related to dwarfism (see the literature section), and more investigations are needed to identify the type of the specific gene present this population. The identification of the specific dwarfing gene was beyond the scope of this study.

The zone from where the birds were collected has a significant effect on the weights of the birds weighed at the beginning of the experiment. This is due to the zones having different climatical conditions (rainfall and temperatures), which in turn affect the types of crops grown, and consequently the scavengable feed resource base (SFRB). The humid (CL 2) and sub-humid (CL 3) zones had many different crops at the time when the birds were collected, including some green grasses. Here, the farmers had crops that are good for scavenging e.g. pulses (beans, peas) and groundnuts. The other zones were quite dry and therefore the feed resource was poor.

The humid and the sub humid zones are also relatively more densely populated than the semi arid zones zone 5 and 5/6. It has been shown that the productivity of the village chickens is determined by the relationship between the biomass of the chicken population and the SFRB (Kitalyi, 1998). The human population density and the closeness of the households could also increase the feed resource base, as it has been shown that the resource base is directly proportional to the amount of household waste discarded per family. The major crops that could form a good feed resource base include maize, coconut refuse, broken rice and cassava, which are widely grown in the humid and sub-humid zones.

## II. Mortalities of the Parent Stock

The naked necks had significantly less mortalities when compared to the other phenotypes. The frizzles and the dwarfs followed, and the normals had the highest mortalities. The naked necks, the frizzles and the dwarf genes have been associated with a higher disease resistance (Kitalyi, 1998). Haunshi et al, (2002), when evaluating the possible influence of the naked neck and the frizzle gene on immunocompetence levels, reported a significantly higher haemolytic complement level in the serum of both the naked necks and the frizzles, when the antibody response to SRBC was assessed. The lowest incidences of pathologies (cloacal cysts, ascites, prolapse, Marek's disease, coccidiosis, osteodystrophy and Salmonellosis) were found in naked neck birds as compared to normal birds (na/na) and these results, together with direct challenge and indirect immunity tests, suggest a greater disease resistance associated with the Na gene (Fraga et al, 1999).

The significant difference in mortalities between the different zones from where the birds were collected could be explained by the method used in sourcing and collecting them. In Kinango and Samburu, middlemen (traders) were contracted to buy birds for the research project from the villages. They went into the villages, bought the birds from the farmers and collected them in shades near the market places. It was noted that birds from these two zones developed signs of disease within a week, and most of them died. When the birds were confined in these houses/shades, they either contracted the disease, or were already infected when they were brought from the different homes in the village. The farmers could have sold diseased birds. Even though they were vaccinated with a live vaccine against Newcastle disease (La Sota strain), they developed signs of disease and several of them died. In Samburu, a disease outbreak was reported a week later after the research birds were collected.

In the other two villages (Msambweni and Matuga), the field officers identified the birds and left them with the specific farmer from whom the bird was bought. They then went round the farms and vaccinated them, and then collected them after about two weeks. These groups of birds did not contract disease as the first group.

The two methods indicate that their movement is an important aspect in disease control. The middlemen who move from village to the villages collecting birds could be spreading diseases. It is therefore very important to have a good marketing strategy of the village chickens as a way of controlling disease outbreaks.

## III. Egg Production

The rate of lay of 29 for all the phenotypes means that, the birds can produce 106 eggs per hen per year under intensive management. This is in agreement with Tadelle (2000) who reported a production of 80 to 99 eggs per hen per year under improved or experimental conditions. This is a slight increase as compared to the improved feeding, housing and health conditions provided to the birds. On the basis of input-output relationship, the increase from about 60 eggs per year per annum is not economically feasible. The total yearly egg production for the different phenotypes will be as shown below.

*Table 7: Productivity of the four phenotypes*

| **Parameter** | **Phenotype** | | | |
|---|---|---|---|---|
| | **Normal** | **Naked** | **Frizzle** | **Dwarf** |
| **Rate of lay (%)** | 23 | 33 | 26 | 36 |
| **Annual Egg Prod (No.)** | 83 | 119 | 96 | 131 |
| **Mean Egg Wt. (g)** | 42.5 | 45.8 | 43.0 | 38.1 |
| **Total Yearly Egg Prod. (Kg)** | 3.6 | 5.8 | 4.2 | 5.0 |
| **Feed Efficiency (Kg feed/Kg Egg)** | 10 | 7 | 9 | 7 |

The Dwarfs had the highest rate of lay among the four phenotypes. This was in agreement with Horst (1995) who suggested that there is a significantly lower depression in the productivity of dwarf layers due to heat stress than the normal types. He consequently argues that it improves the productive adaptability to heat stress. Furthermore, the dwarf, with a smaller body size, is expected to have a better-feed efficiency, and therefore better egg production. The feed efficiency of the Naked Neck and the dwarf was equal at 7 kg feed for 1 kg eggs. Tadelle (2000), reported a feed efficiency of 20kg feed for the Ethiopian birds, the big difference being due to the low numbers (34) and average weight (38 g) of the eggs produced.

However (Fairfull et al, 1990), argues that the dwarfing gene reduces egg numbers and the rate of egg production. He further states that the use of the dwarf gene to reduce body size of the female parent in broiler hatching egg production was only successful due to selection for modifying genes that are positive for egg production and the use of heterosis to overcome the depressing effect of the gene. This observation is based on a high yielding population that had segregated for the dwarf gene and production takes place under optimal conditions.

Other studies in Ethiopia (Tadelle, 2000) showed that, the melata ecotype (Naked Neck), had the highest hen day production of 0.19 among other ecotypes (rate of lay of 19%).

## IV. Weights Of Eggs

The egg weight mean for all the birds was 42.7±4.9 g. These results are in agreement with other reports from different African countries on local birds where the egg weights were reported as ranging from 30 – 49 g. (Missohou 2002). The scavenging birds are known to have a wide variation since they have not been selected for egg weights.

The egg weights were in the same order as the body weights of the birds. There seems to be a relation between the body weights and the egg weights. A genetic corrrelation of +.384 between egg weight and adult body weight in White Leghorns was reported as early as 1921 by Asmundson (Hutt, 1949) and was confirmed later by Sorensen et al (1980).

The naked neck phenotype has the heaviest eggs. Horst reported a favourable effect of the naked neck gene on egg weight when birds were reared under heat stress (Horst 1995). He also indicated the effect of the dwarf gene as reducing the egg weight. This is in agreement with the observed results where thw Dwarf had the least egg weights. However the frizzle gene in this case did not increase the egg weight as he reported.

Egg weight is a favourable consideration only when eggs are graded for sale at a higher price than the normal eggs. However in the rural setting, large eggs will be more desired by customers first even though the eggs will not fetch a higher price.

## V. Egg Quality: Shape indices, Yolk colours and Shell Thickness of the different genotypes.

The major genes were found to have an effect on the shape index. The dwarf had a shorter egg in length hence the high shape index. The difference in shape has been suggested to be hereditary (Hutt, 1949), only that the number of genes was not known. It’s also not clear if the genes involved in determining the shape are associated with the dwarf. The shape index was found to decrease with an increase in the body weight.

The yolk colour of indigenous birds is known to be high as the birds eat green grasses and plants during scavenging. This gives the eggs a high consumer value and taste. Initially, the yolk colour score was high in all the phenotypes, but reduced substantially when assessed later. This difference is clearly associated with the feeding programme, where the birds were fed with green grasses during the wet period. When then they were fed with no grasses, the effect was shown in the yolk colour score, which reduced dramatically. This shows that the yolk colour is determined by the feed rather than genetic parameters.

The shell thickness was significantly different between the various phenotypes. This is agreement with Monira et al (2003) who states that it is influenced by breed. He found the thickness to be ranging from 0.31 to 0.35 mm between several breeds that are used today for egg production. These breeds were reared in Bangladesh and included the Barred Plymouth Rock, White Leghorn, Rhode Island Red and White Rock. The shell thickness is important in reducing the breakages. They also have a better hatch

## VI. Fertility And Hatchability

The Frizzle had the highest fertility, followed by the Dwarf and the Naked Neck in that order. The normal had the least fertility. However there was no significant difference between the phenotypes. It has been shown that high ambient temperatures (>30 $^{o}$C) decreases fertility of breeder hens, but this effect was shown by Ladjali et al, (1995) to be greatly reduced in females carrying the naked neck gene (Na). Naked neck females showed a lower proportion of abnormal embryos than normally feathered females, which had the highest proportion of chimeras at 31 $^{o}$C. This effect of the Naked Neck was not seen, as the temperatures during rearing were 26$^{o}$ C.

The variation in fertility over time could be explained by the fertility of the cocks. Over time the cocks their fertility could have been affected by the type of feed, which has been formulated for egg production. The breeder feed was not easily accessible. Replacing the cocks could have solved these, but the genetic variation would have been introduced. The flock sizes were also too small to put several cocks into the flock.

On hatchability, the normal had the highest, the dwarf and the Frizzle being intermediate. The Naked neck had the lowest hatchability among the four phenotypes.
This is in agreement with other findings, which associated both the Naked Neck and the Frizzle with poor hatchability.

Merat, (1990) documented that the Naked Neck gene was found to be associated with an increased embryonic mortality, which was up to 10%. This occurred during the last stages before hatching. He suggested that the reduced hatchability seems due to malpositions of embryos, perhaps due to few feathers on the neck allowing the head to assume faulty positions. Landauer in1932, maintained that the hatchability of eggs laid by heterozygous frizzles is subnormal and that it is still lower in eggs from homozygotes (Somes, 1990).

## VII. Chick Weights and Growth rates

The crosses between the local cock and Isa brown had the highest chick weights. This was expected, as the Isa Brown is a well-developed breed. The farmers involved in the smallholder poultry project in the District were using these Crosses. The high ADG means that the birds can achieve a higher body weight in a shorter time than the local birds. However, if the Crosses will be used for reproduction, there will be a loss of heterosis as the Isa Brown is a hybrid meant for egg production. It can therefore be used only in the short-run and the farmers will have to buy more birds as parent stock.

The Naked Necks, the Frizzles and the Normals had similar growth patterns. Their weights were significantly different with the Crosses and the Dwarf throughout the five weeks. Towards the fifth week, the Naked Neck showed an increasing ADG more than the Frizzle and the Normal. The Dwarf had a significantly lower growth rate as expected. This was in relation to the final body weight.

Growth rate is an important trait that should be considered in the local poultry, as the main objective of keeping the birds is for meat production as compared to egg production. Therefore there are benefits in crossing the local breeds with early maturing birds in order to obtain a faster early growth.

## VIII. Behavioural Observations: Feather Pecking

Feather pecking, defined as pecking at and pulling out of feathers of another birds, was predominantly observed on frizzle-feathered birds (growers) only. The susceptibility of the frizzles to be pecked can be explained by the extreme body exposure of these birds. These birds were hatched from both the frizzle cocks and hens, and therefore there were some that were homozygotes. Homozygotes frizzles are known to have extremely recurved rachis and barbs in all feathers, which are easily broken (Somes, 1990). McAdie and Keeling (2000), showed that birds with damaged feathers are more susceptible to feather pecking and injurious pecking. They found out that damaged feathers received significantly more severe feather pecks than undamaged feathers. The body areas that had been manipulated and received severe feather pecks were the tail and rump feathers. Damaged feathers increased feather pecking by becoming an attractive target.

Other factors could have as well contributed to this behaviour of feather pecking. The behaviour was observed in the fourth week of age when all the phenotypes were reared together in one room without being fed grass. Bestman and Wagenaar (2002), showed that feather pecking behaviour was low in flocks using the outdoors run and recommended including a vegetative cover to the run and keeping the flock size at around 500 birds.

Though the frizzle feathered could have an advantage in heat dissipation, incorporating it in flocks reared in hot and humid climates might promote feather pecking and hence cannibalism. More studies are needed to assess the effects of this gene on feather pecking in a purely frizzled feathered flock and in a mixed flock e.g. with normal feathered birds.

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## 6. Appendix: Analysis Of Variance Tables

*Dependent Variable: Body weight (Model 1)*

| ***Source*** | ***DF*** | ***F-Value*** | ***Pr > F*** |
|---|---|---|---|
| **Sex** | 1 | 29.90 | <. 0001 |
| **Source** | 3 | 5.83 | 0.0011 |
| **Genotype** | 3 | 4.95 | 0.0031 |
| ***R-Square:*** 0.42 | ***CV:*** 21.42 | ***Root MSE:*** 0.29 | ***Body weight Mean:*** 1.3 |

*Dependent Variable: Mortality (Model 2)*

| ***Source*** | ***DF*** | ***F-Value*** | ***Pr > F*** |
|---|---|---|---|
| **Source** | 3 | 2.53 | 0.0619 |
| **Genotype** | 3 | 2.02 | 0.1171 |
| ***R-Square:*** 0.14 | ***CV:*** 30.30 | ***Root MSE:*** 0.48 | ***Mortality Mean:*** 57.0% |

*Dependent Variable: Egg weight (Model 3)*

| ***Source*** | ***DF*** | ***F-Value*** | ***Pr > F*** |
|---|---|---|---|
| **Phenotype** | 3 | 37.35 | <. 0001 |
| **Month** | 5 | 3.59 | 0.0036 |
| **Phenotype*Month** | 15 | 1.57 | 0.0804 |
| ***R-Square:*** 0.39 | ***CV:*** 9.36 | ***Root MSE:*** 3.99 | ***Egg wt Mean:*** 42.7 |

*Dependent Variable: Fertility (Model 4)*

| ***Source*** | ***DF*** | ***F-Value*** | ***Pr > F*** |
|---|---|---|---|
| **Phenotype** | 3 | 1.30 | 0.2742 |
| **Lot** | 3 | 8.34 | <. 0001 |
| ***R-Square:*** 0.04 | ***CV:*** 86.70 | ***Root MSE:*** 48.75 | ***Fertility Mean:*** 56.3 |

*Dependent Variable: Hatchability (Model 4)*

| ***Source*** | ***DF*** | ***F-Value*** | ***Pr > F*** |
|---|---|---|---|
| **Phenotype** | 3 | 1.46 | 0.2246 |
| **Lot** | 3 | 0.63 | 0.5936 |
| ***R-Square:*** 0.02 | ***CV:*** 59.1 | ***Root MSE:*** 43.80 | **Hatchability Mean:** 74.1 |