Biology, life history, and captive management of the kultarr (Antechinomys laniger): Kultarr Captive Management

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RESEARCH REVIEW

Biology, Life History, and Captive Management of the Kultarr (*Antechinomys laniger*)

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The kultarr (*Antechinomys laniger*) is a small marsupial that inhabits arid and semi-arid areas of central Australia. The kultarr is the only species within its genus and is morphologically unique from other dasyurids. Like many Australian marsupials, the kultarr has undergone significant population declines and although it is listed as "least concern" on the IUCN red list little is known of their ecology in the wild. A lack of knowledge on their biology can be attributed to their cryptic nature and sparse population densities. Recent studies of kultarrs have increased knowledge of the biology and captive management, with current data predominately coming from captive colonies. Captive studies of the kultarr have provided data on reproduction, diet choice, nutrition, health, and disease. Kultarrs are polyestrous seasonal breeders and are believed to be mostly insectivorous. Diseases noted in captive individuals provide some insight into those that may influence animals in the wild. Further research is required on both wild and captive populations to increase the knowledge base and determine appropriate management techniques for both wild and captive populations. Zoo Biol. XX:XX–XX, 2014.

Keywords: conservation; dasyuid; diet; endangered species; marsupial; reproduction

INTRODUCTION

Marsupials in Australia have been negatively influenced by human settlement [Maxwell et al., 1996; Johnson, 2006]. The introduction of exotic predators, agricultural land-use, and clearing of habitat has contributed to the mass decline of species across the Australian continent [Johnson, 2006]. The kultarr (*Antechinomys laniger*) is one example of a dasyurid species that has been negatively influenced by agricultural land-use, predators, and habitat clearing in Australia. Members of the Dasyuridae family are carnivorous; however, most are insectivorous, marsupials [Van Dyck and Strahan, 2008]. In this family 10 species are listed as "endangered" and 8 as "vulnerable" under federal legislation [Van Dyck and Strahan, 2008].

The kultarr is the only species in its genus and is morphologically unique from other Dasyurids and its conservation status varies across its distribution. It is under threat from introduced predators, changed fire regimes, and agricultural land-use. Lidicker and Marlow [1970] reviewed the allopatric species variation, habitat requirements, morphology, and life history phenomena of the kultarr. They stated at that time little research had been conducted on the kultarr [Lidicker and Marlow, 1970] and since that review 44 years ago further data have become available on kultarr biology. A subsequent review in 1977 by Archer looked at dentition, morphology, habitat, and reproduction in the allopatric forms.

This manuscript aims to summarize all current data on the kultarr to ensure appropriate captive management techniques are utilized. Data were collected from published and unpublished sources as well as personal observations of a captive colony. Provided here also is a review of data available on their ecology in the wild as much of these data is not published. Maintenance and breeding of captive kultarr colonies could be used for re-introduction and translocation programs in the future to boost wild population numbers. In

Conflicts of interest: None.

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addition, the information provided here can be used as a guide for other small dasyurids that can often be difficult to rear in captivity.

GENERAL DESCRIPTION

The kultarr is a small brown, fawn to sandy colored marsupial with a white belly [Valente, 2008]. They have large ears, protruding eyes, and a long tail with a brush-like tip (Fig. 1). Their hind legs are elongated with four toes similar to macropods [Van Dyck and Strahan, 2008]. Males grow to between 80 and 100 mm long and weigh 17–30 g and females are smaller, growing to 70–95 mm long and weigh 14–29 g [Lidicker and Marlow, 1970; Woolley, 1984; Valente, 2008]. The lifespan of wild kultarrs is not known but they can live up to 5.5 years in captivity [Stannard and Old, 2010].

There are two sub-species or allopatric forms (*A. laniger laniger* and *A. laniger spenceri*) of kultarr that are recognized by their differing geographic ranges across Australia, in addition to morphological differences (seven external features such as body length, tail length, number of mammary glands, and 10 cranial measurements, see Table 1) [Lidicker and Marlow, 1970]. *A. l. spenceri* were determined to have three pairs of mammary glands and *A. l. laniger* has four pairs of mammary glands [Lidicker and Marlow, 1970]. Both subspecies have very similar characteristics and they are generally recognized as one species [National Parks and Wildlife Service, 2002].

TAXONOMY AND PHYLOGENY

The kultarr was first described as *Phascogale lanigera* [Gould, 1856], and in 1867 was placed in a new genus, *Antechinomys* [Krefft, 1866]. The sub-species *spenceri* was first described in 1906 [Thomas, 1906]. The kultarr was considered to be a member of the *Sminthopsis* tribe [Archer, 1981]; however, more recent genetic studies indicate that while the kultarr and dunnarts (*Sminthopsis* spp.) have a number of similar morphological characteristics, they are classified in separate clades [Blacket et al., 1999; Krajewski et al., 2012]. Based on nuclear and mitochondrial DNA the kultarr is in a sister clade to the dunnarts of the *Sminthopsis* spp. genus and it is likely they shared a common ancestor [Blacket et al., 1999].

Fig. 1. A photograph of a male, 3.5-year-old kultarr.

ANATOMY AND PHYSIOLOGY

The most distinctive morphological feature of the kultarr that separates it from other dasyurids is its elongated hind limbs. This feature is very similar to eutherian hopping-mice (*Notomys* spp.) and a number of comparisons have been made [Ride, 1965; Marlow, 1969; Baudinette et al., 1976a,b]. These studies described kultarrs as quadruped, while hopping-mice are bipedal [Ride, 1965; Marlow, 1969; Baudinette et al., 1976a,b]. Kultarrs and hopping-mice have similar running speeds of 13.8 and 13.1 $km\,h^{-1}$, respectively [Garland et al., 1988], however, while traveling at high speeds the kultarr had higher oxygen consumption rates than their eutherian counterparts [Baudinette et al., 1976a,b]. The morphological similarity exhibited between these species is likely an example of evolutionary convergence that may have occurred to cope with the arid environment inhabited by both species. It may also be an adaptation for fast movement to escape predators or to conserve energy while moving long distances to find food.

Another adaptive feature likely used to cope with the arid habitat, characterized by a variable rainfall and fluctuating temperatures, is the use of torpor. The kultarr, like a number of other Dasyurids, uses torpor to conserve energy [Geiser, 1986]. It regularly uses torpor (lasting between 2 and 16 h) spontaneously even when food is available, but torpor is more frequent when food is withheld and temperatures are low. They are able to reduce their body temperature to 11°C during a torpor bout [Geiser, 1986].

Investigation of internal anatomy of the kultarr has been focused on the digestive tract. The kultarr has a simple digestive tract without a cecum [Beddard, 1908; Schultz, 1967; Stannard and Old, 2011a]. The intestine is relatively uniform along the tract and there are no macroscopic differences between the small and large intestine. Passage time for meal elimination through the kultarr digestive tract is rapid, lasting only 3.9 h [Stannard and Old, 2011a].

HABITAT AND GEOGRAPHIC DISTRIBUTION

Kultarrs inhabit arid and semi-arid zones of south and central Australia. They use logs, stumps, spinifex tussock (*Triodia* spp.) and burrows of other animals for nesting [Lidicker and Marlow, 1970; Valente, 2008]. The sub-species laniger inhabits semi-arid savannah zones vegetated with *Acacia* spp. in New South Wales and southern Queensland, whereas *spenceri* are found in deserts in Western Australia, Northern Territory, western Queensland, and South Australia vegetated with *Acacia*, *Eremophila*, and *Cassia* spp. [Lidicker and Marlow, 1970; Strong and Low, 1986]. Population declines have occurred, with the disappearance

TABLE 1. Morphological measurements of the two sub-species of kultarr, *A. l. spenceri* and *A. l. laniger* [Lidicker and Marlow, 1970]

	A. l. spenceri	*A. l. laniger*
External features		
Body length		
n	20	10
Av.	89.5 mm	81.4 mm
Total length		
n	18	10
Av.	202.8 mm	194.8 mm
Tail length		
n	22	16
Av.	116.8 mm	104.5 mm
Cranial features		
Condylobasilar length		
n	19	6
Av.	26.8 mm	24.0 mm
Cranial breadth		
n	20	9
Av.	11.7 mm	11.1 mm
Cranial height		
n	7	7
Av.	11.0 mm	9.9 mm
Rostral length		
n	20	8
Av.	10.6 mm	9.2 mm
Rostral width		
n	20	7
Av.	3.6 mm	3.3 mm
Bullar length		
n	19	7
Av.	7.7 mm	6.1 mm
Least inter-orbital breath		
n	22	8
Av.	5.6 mm	5.3 mm
Maxillary toothrow length		
n	21	8
Av.	5.6 mm	5.1 mm
Nasal length		
n	23	5
Av.	10.3 mm	8.9 mm
Mandibular length		
n	22	7
Av.	17.4 mm	15.5 mm

of the kultarr from Victoria, southern New South Wales, south-eastern South Australia, and Sandringham Station in Queensland [Maxwell et al., 1996; National Parks and Wildlife Service, 2002]. The last known sighting of the kultarr in north-west Victoria was recorded in 1857 [Atlas of Living Australia, 2013].

ECOLOGY AND RECORDED SIGHTINGS

Kultarrs are not often seen in the wild by field researchers. Populations are believed to migrate to other locations possibly accounting for fluctuations in population densities within an area (P. Withers, pers. comm.). Populations are known to fluctuate seasonally in response to rainfall and drought conditions which is common with arid zone mammals [Office of Environment and Heritage, 2012]. Kultarrs seem to be more active in drier conditions as opposed to after heavy rains like rodents (C. Dickman and D. Fisher, pers. comm.). They appear to prefer hunting for food on open plains over dense vegetation and they sleep in shallow burrows, often partially exposed, in areas of dense vegetation (D. Fisher, pers. comm.).

There are 1,164 records of kultarrs in the wild that includes observations, captures, and museum voucher specimens. These records included deceased kultarrs captured and brought home by domestic cats, run over by cars, or from bones in owl pellets [Office of Environment and Heritage, 2012; Atlas of Living Australia, 2013]. In New South Wales, there have been 100 recorded sightings or captures of kultarrs (from 1788 to 2010), 264 in Northern Territory (1901–2011), 148 in Western Australia (1958–2008), 612 in South Australia (1950–2011), and 1 in Victoria (in 1857) [Atlas of Living Australia, 2013]. In Queensland, 177 kultarrs sightings or captures have been recorded within Local Government Areas [Department of Environment and Heritage Protection, 2011]. Records from Queensland date from 1892 to the most recent record in 2011 from the Quilpie Local Government Area [Department of Environment and Heritage Protection, 2011]. Many of the museum voucher specimens come from unknown locations [Atlas of Living Australia, 2013]. A number of kultarrs were caught at various locations in WA by biological survey teams and used for a laboratory experiment prior to being released (P. Withers, pers. comm.). A single kultarr was caught during mammal surveys at the Little Sandy Desert, WA in an insect trap suggesting insect traps may be the appropriate size for capturing kultarrs [Start et al., 2013]. Recent sightings of kultarrs have included one animal at Noonbah Station, QLD in 2009, one animal at Woodgreen Station, NT in 2009 (E. Ritchie, pers. comm.), one animal at Ledknapper Nature Reserve, NSW in 2008 (S. O'Sullivan, pers. comm.), and one animal at Quanda Nature Reserve, NSW in 2008 [Garden, 2012]. Six kultarrs were successfully trapped and radio collared during 2009 and 2010 in Idalia National Park and Diamantina National Park, Queensland (D. Fisher, pers. comm.).

Successful trappings have led to the establishment of a captive colony of kultarrs. The colony was established in 2002 when two males and one female with three pouch young were caught and taken to Alice Springs Desert Park, NT [Caton, 2006]. Further trappings in 2003 and 2004 added a further two females, each with six pouch young, and one male to the captive population [Caton, 2006]. This population still exists today in low numbers due to limited breeding success of kultarrs in captivity. In 2007, animals from this population were taken to establish a breeding and research colony at the University of Western Sydney, Hawkesbury Campus. In the 6 years since that colony was established, four litters have been born, totaling 20 pouch young. Nineteen out of the 20 pouch young were successfully raised to weaning by their mothers.

THREATS TO WILD KULTARR POPULATIONS

Kultarrs are most affected by habitat degradation, introduced predators, natural flooding events, fire, and pesticides [Maxwell et al., 1996; National Parks and Wildlife Service, 2002]. Degradation of kultarr habitat is caused by rabbits (*Oryctolagus cuniculus*), sheep (*Ovis aries*), and cattle (*Bos taurus*) grazing, as well as flooding and fires [Lidicker and Marlow, 1970; Woolley, 1984; Strong and Low, 1986; National Parks and Wildlife Service, 2002]. Floods and insecticides used in agriculture influence arthropod abundance, thus influencing food available for kultarrs, and they can be poisonous to kultarrs and may cause death [Strong and Low, 1986; National Parks and Wildlife Service, 2002]. The impact of habitat degradation, flooding, fire, and pesticides may cause mortality of an individual or population and contribute to poor body condition through reducing food availability.

Kultarrs are prey for larger animals such as introduced feral cats and foxes (*Vulpes vulpes*) and native owls (*Ninox* spp.) and snakes (*Oxyuranus* spp.) [Morton et al., 1977; Shine and Covacevich, 1983; National Parks and Wildlife Service, 2002]. Regurgitated bones found in barn owl (*Tyto alba*) pellets at Mt. Chambers, South Australia, indicate barn owls prey on kultarrs [Morton et al., 1977]. It is important that threats such as agricultural land-use, feral predators, and habitat degradation are managed to aid in conservation of the kultarr and prevent further population declines.

DIET AND NUTRITION

The kultarr diet in the wild is currently based on anecdotal observations with no detailed studies published to date. They prey on insects including crickets, spiders, and cockroaches [Lidicker and Marlow, 1970; Valente, 1984]. Their diet of arthropods including cockroaches, beetles, and arachnids is similar to that of other small (<60 g) dasyurids in the wild [Fox and Archer, 1984; Woolnough and Carthew, 1996; Gilfillan, 2001; Bos and Carthew, 2007].

Diets formulated for captive kultarrs have included minced sheep meat, insects, canned cat food, dog biscuits, and mice (*Mus musculus*) [Lidicker and Marlow, 1970; Woolley, 1984; Geiser, 1986] (Table 2). Valente [1984] noted that captive male kultarrs consumed 7.5–12.5 g and females 5–7.5 g of food per night, and Woolley [1982] fed 3–7 g of food per animal per day. Stannard and Old [2011b] found that kultarrs consumed 2.7–3.6 g/day on a dry matter basis. As part of these nutritional trials kultarrs were fed cockroaches (*Panesthia australis*), mealworms (*Tenebrio molitor*), crickets (*Acheta domesticus*), black rats (*Rattus rattus*), and Wombaroo small carnivore food [Stannard and Old, 2011b]. Kultarrs unlike red-tailed phascogales (*Phascogale calura*) readily accepted Wombaroo as a substitute meal. The live insect food items provided stimulation and encourage kultarrs to exhibit natural behaviors including digging, chasing, hunting and prey capture (pers. obs.). The nutritional studies found kultarrs daily maintenance energy requirement was $695\,kJ\,kg^{0.75}\,day^{-1}$ in captivity, when held at $22 \pm 3°C$ and under natural photocycles [Stannard and Old, 2011b]. Water is provided ad libitum, un-supplemented in a shallow bowl, with kultarrs occasionally observed drinking (pers. obs.).

REPRODUCTION

The kultarr has a long breeding season which varies across its distribution [Woolley, 1984; Valente, 2008]. Photoperiod is believed to be a controlling factor, with kultarrs generally breeding in the second half of the year after the winter solstice (note: July/August is winter in the southern hemisphere) [Woolley, 1984]. Kultarrs in Queensland breed from July to February and in Western Australia from August to January [Woolley, 1984; Valente, 2008]. Male kultarrs become sexually mature at 9–10 months and females at 11–12 months of age [Valente, 1984; Woolley, 1984]. Females are polyestrous and can enter estrus up to six times in one season. Both males and females are capable of breeding more than once in their lifetime [Woolley, 1984; Stannard and Old, 2010].

Female kultarrs have a pouch consisting of small folds of skin on the abdomen with six to eight teats [Lidicker and Marlow, 1970; Valente, 1984; Woolley, 1984]. Lidicker and Marlow [1970] suggested that the two sub-species of kultarr can be differentiated by teat number; *A. l. laniger* eight and *A. l. spenceri* six. Although it has been found that teat number varies among individuals within a sub-species, Woolley [1984] had three females (*A. l. spenceri*) carrying six pouch young in a captive population, and it was recorded that six females had six teats, one had five and two had four teats. Another study recorded a female (*A. l. spenceri*) carrying four pouch young [Happold, 1972]. Recent captive observations have shown *A. l. spenceri* are capable of rearing up to six pouch young [Stannard and Old, 2010]. Archer [1977] found female *A. l. laniger* had four, six, eight, or ten teats (with the latter only being observed in one individual). Based on the findings from these studies teat number varies within each sub-species and thus it is not a reliable indicator of sub-species.

There has been limited success breeding the kultarr in captivity, most likely due to the solitary nature of the species; it is not well adapted to the captive environment and there is a lack of detailed biological information available to wildlife managers. One successful breeding regime utilized urine samples to determine the onset of the breeding season, by assessing the epithelial cell and spermatozoa content every second day from May onwards [Caton, 2006]. Once the onset of the breeding season had begun, males were placed with a female for 7 days then removed for 7 days then placed with another female for 7 days. Pouch checks were conducted every 2 weeks following mate introduction. The breeding regime had a 40% success rate [Caton, 2006]. Females can

TABLE 2. Captive feeding regimes provided to kultarr populations

Author	Diet
Happold [1972]	Minced beef or mutton, milk, insects, and spiders
Collins [1973]	A heap teaspoon of meat mixture supplemented with mealworms, crickets, and mouse pinkies
Aslin [1982]	Day 1: egg, brains, and baby food. Days 2, 4, and 6: raw minced mutton with dried dog food. Day 3: dry dog food, brains, and baby food. Day 5: minced mutton with baby cereal. Day 7: starve day
Woolley [1982]	2–5 g of mince mix daily (beef heart, liver, eggs, calcium carbonate, and cat food). Supplemented with insects: mealworms, cricket, or maggots at 1–2 g daily when available
Geiser [1986]	Wet cat food, dried dog food given ad libitum. Mealworms and egg gelatine given once per fortnight
Stannard and Old [2011b]	Mealworms, crickets, cockroaches, adult mice, and pinkie mice (supplemented with calcium carbonate), fed in rotation. Diet adapted from Alice Spring Desert Park captive diet designed by Wes Caton

enter estrus up to six times in a breeding season with each cycle 30–40 days apart, and estrus lasting 26–45 days, with cycle length decreasing as the breeding season progresses [Woolley, 1984]. Gestation is between 12 and 17 days [Woolley, 1984; Caton, 2006; Stannard and Old, 2010]. Woolley [1984] found that "older" (2- and 3-year old) females entered estrus, however they did not produce young [Woolley, 1984]. Stannard and Old [2010] however, found that second and third year females successfully produce and raise pouch young to weaning in captivity. The University of Western Sydney (UWS) colony had a weaning success rate of 95%, from four litters, with all but one pouch young surviving till weaning. In comparison with other Dasyurids, the UWS population of kultarrs had more successful weaning rates however total numbers of pouch young were relatively low. Captive red-tailed phascogales had a 68% weaning success rate, with 87% ($n = 127$ females) of breeding females producing young [Foster et al., 2008]. Over 4 years of captive breeding, dibblers (*Parantechinus apicalis*) had a 71% weaning success rate from 17 litters, with most pouch young lost to cannibalism [Lambert and Mills, 2006]. Captive stripe-faced dunnarts (*Sminthopsis macroura*) had an 89% weaning success rate from 68 litters, and of that 89%, 98% of female pouch young survived to reach sexual maturity [Woolley, 1990].

Once the young are born they attach themselves to the teats for 30–48 days before being left in the nest while the mother forages [Valente, 2008]. Kultarrs, like other metatherians are very immature and under developed at the time of birth, compared to eutherians. Most of their anatomical development occurs after parturition while the young are attached to the teat (Table 3), and thus the majority of maternal investment in reproduction is post-parturition. Juveniles are weaned at 80–90 days after which they become independent solitary animals [Happold, 1972; Woolley, 1984; Caton, 2006].

CAPTIVE HOUSING

Captive housing for kultarrs has consisted of $90 \times 40 \times 45\,cm^3$ enclosures with Perspex fronts [Happold, 1972], $60\,cm^2$ wooden enclosures with glass fronts [Stannard and Old, 2011a], plastic containers with a mesh lid, and wooden box cages [Woolley, 1984]. Substrates used include sand, rocks, bark [Happold, 1972], wood shavings [Geiser, 1986], and kitty litter [Stannard and Old, 2010] and wooden boxes or cardboard cylinders provided as nest boxes [Woolley, 1984; Geiser, 1986]. Captive kultarrs have been kept under natural photoperiods and supplied with temperatures between 19 and 25°C with the lower temperature being used in autumn and winter [Happold, 1972; Woolley, 1984; Geiser, 1986; Stannard and Old, 2011a]. The lower temperatures are more suitable than higher temperatures when holding these animals in captivity. Natural photoperiods were supplied through glass windows and a skylight [Stannard and Old, 2011a].

Generally kultarrs are housed as individuals as they are solitary in the wild [Valente, 2008]. However, keeping animals together in same sex family groups (3–4 animals) from birth has proved successful, with no fighting or injuries observed (pers. obs.).

HANDLING AND CLEANING REGIMES

Kultarrs should be handled in the early morning hours or during cool parts of the day to avoid the possibility of heat related stress and possible death. Kultarrs can be trapped in the corner of a nest box and using a catching bag inverted the around the handlers hand (so that their hand is inside the bag with the seam side facing outwards) and picking the animal up and reverting the bag back around the animal and tying it securely. Kultarrs can be restrained by positioning the animals head in between the index and middle fingers, with their body held between the thumb and rest of the hand [Jackson, 2003]. Kultarrs should be examined externally for any health issues and weighed in a catching bag with hand

TABLE 3. Major developmental milestones of kultarr pouch young (from UWS captive kultarrs and Caton [2006])

Age (days)	Milestone
0	Weight $\leq$5 g, naked, well-developed forelimbs
13	Ears free from skull
15	Able to determine gender
34	Eyes open, covered in fur
30–48	Detach from teat
57	Trying to eat solid food
85	Weaning begins
91	Competing with mother and siblings for food
80–110	Independent (weight 15–20 g)

held scales. While restraining a female kultarr in the hand using one finger to move fur and open the pouch, the pouch can be checked for cleanliness and presence of young. After examination animals can be gently placed back in the enclosure, either directly into the nest box or onto the ground [Jackson, 2003]. If animals escape, a net or a baited Elliot trap can be used to re-capture, and then once caught they can be emptied carefully into a catching bag.

Cleaning is recommended at least monthly, depending on the size of the enclosure, smaller enclosures may require more frequent cleaning. A full clean consists of removing substrate and nest material followed by a wipe down with F10 veterinary disinfectant, 70% ethanol or eucalyptus disinfectant. Substrate and nest material should be replaced with clean materials and the animal returned to the enclosure immediately.

HEALTH AND DISEASE

Little has been recorded regarding the diseases and parasites kultarrs can contract. Individuals have been noted to be infected with toxoplasmosis, a protozoan disease caused by *Toxoplasma gondii* that generally causes death [Attwood and Woolley, 1970, 1980; Jackson, 2003]. Toxoplasmosis can be transmitted from other species such as cats (*Felis catus*) or through food, in particular raw red meat diets. Freezing meat for 4 weeks reduces the chance of spreading toxoplasmosis [Jackson, 2003]. Interstitial pancreatitis has been associated with toxoplasmosis in one animal [Attwood and Woolley, 1980].

Trematodes and mites have been identified in the kultarr. A trematode, *Coelomotrema antechinomes*, was identified in a kultarr that died from a pneumonia-hepatitis infection [Angel, 1970]. Mites have been observed in a small number of kultarrs maintained in a facility that housed native rodent species (plains rats *Pseudomys australis* and spinifex hopping-mice *Notomys alexis*) (pers. obs.). Mite infestations lead to fur loss and excess scratching often causing wounds and scabs to form on affected areas. A recommended treatment is 20 μL of 10% Ivermectin in glycerol applied to the skin between shoulder blades.

In 2012, two 4.5-year-old kultarrs from the captive colony at the University of Western Sydney were euthanized due to illness. As stated earlier, the lifespan of wild kultarrs is not known, however, they have lived as long as 5.5 years in captivity [Stannard and Old, 2010]. The male had small lumps on its ears and feet (Fig. 2a,b) that were determined to be vasculitis and cutaneous squamous cell carcinomas, respectively (Fig. 3a,b). Internally, the kultarr had an

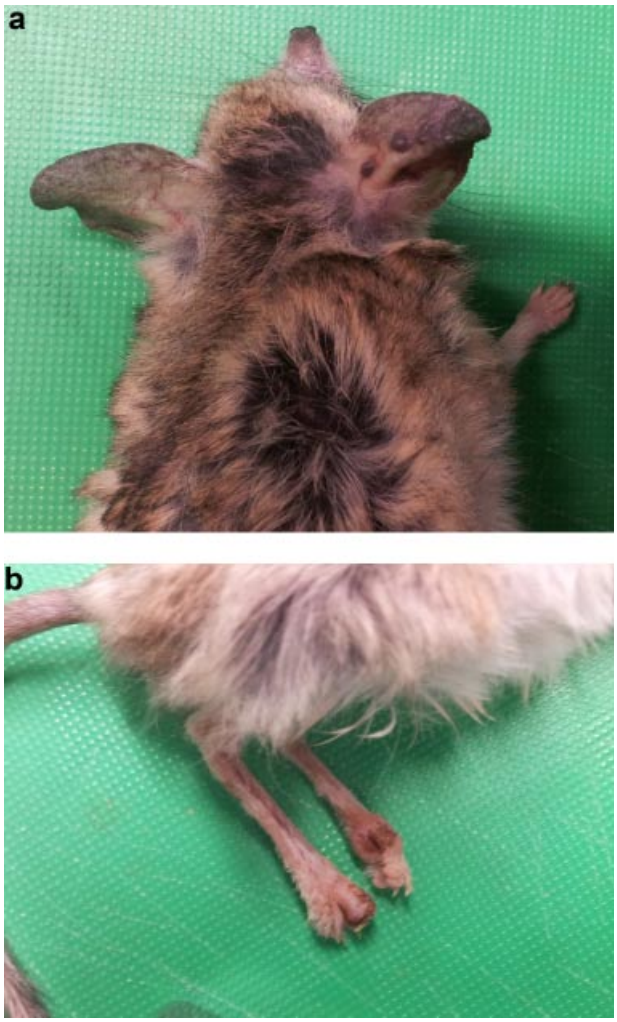

Fig. 2. **a**: External lumps on the ear of a male kultarr. **b**: External lumps on the hind foot of a male kultarr.

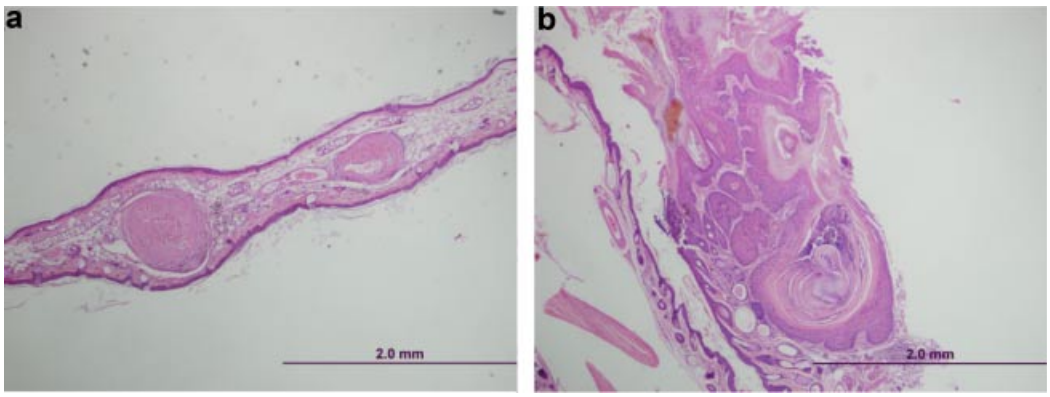

Fig. 3. **a**: Vasculitis in the ear of male kultarr. **b**: Cutaneous squamous cell carcinomas in the hind foot of male kultarr.

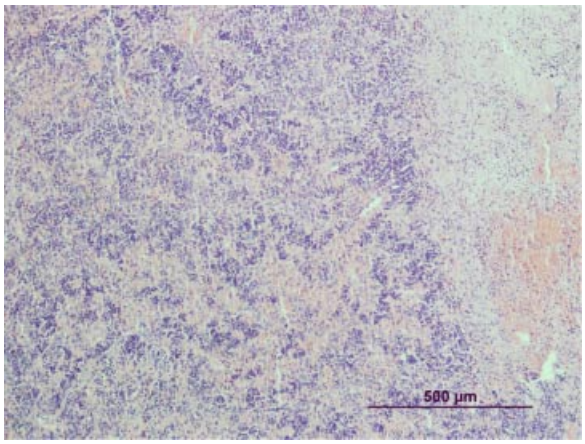

Fig. 4. Histolytic sarcoma in kidney tissue of a male kultarr.

enlarged kidney determined to be a histolytic sarcoma (Fig. 4). The female had a large growth on her dorsal side between her shoulder blades. Histological analysis showed that it was hemangiosarcoma infiltrating skeletal muscle (Fig. 5). It is unknown as to why these kultarrs grew cancerous growths, but it is likely that old age makes them susceptible. Dasyurids in general are prone to cancers and similarly cutaneous squamous cell carcinomas have been observed previously in a Tasmanian devil (*Sarcophilus harrisii*) and an eastern quoll (*Dasyurus viverrinus*) [Lombard and Witte, 1959; Straube and Callinan, 1980]. In addition, a malignant salivary tumor and a mammary carcinoma have been observed in eastern quolls, fibrosarcomata tumors, medulloblastoma, and pulmonary adenomatosis in Kowari (*Dasyuroides byrnei*), lymphocytic leukaemia in *Antechinus macdonnellensis* and *A. apicalis*, and adenocarcinoma and adrenal carcinoma in Tasmanian devils [Attwood and Woolley, 1973; Twin and Pearse, 1986; Holz and Little, 1995]. The largest dasyurid, the Tasmanian devil, is affected by a lethal infectious cancer: Tasmanian devil facial tumor disease [Pearse and Swift, 2006].

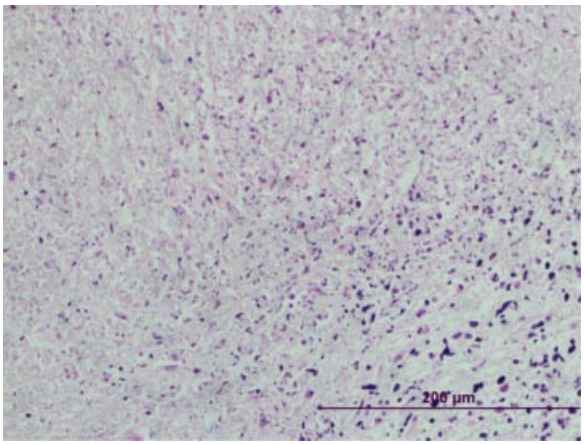

Fig. 5. Hemangiosarcoma infiltrating skeletal muscle of a female kultarr.

There are a number of other diseases and parasites that have been recorded in other small dasyurids that have not been observed, but could occur in the kultarr that have been reviewed by Holz [2008]. For example small dasyurids are prone to gastrointestinal parasites, nematodes, salmonella, Tyzzer's disease, pancreatitis, mycobacteriosis, and cryptococcosis [Holz, 2008].

CONSERVATION

At the present time there are no translocation or reintroduction programs in place for the kultarr [National Parks and Wildlife Service, 2002]. There is however, a detailed recovery plan published by NSW National Parks and Wildlife Service [2002] that provides biological and ecological information about the kultarr and provides a detailed action plan for the conservation and economic cost of ensuring the long-term management of kultarrs in the wild within NSW. However, little of the plan is actively implemented due to the cryptic nature of the species and fluctuating population densities.

In New South Wales, the kultarr is listed as "endangered" under the *Threatened Species Act* 1995. In the Northern Territory, it is listed as "near threatened" under the *Territory Parks and Wildlife Conservation Act* 1978. The kultarr is not listed as a threatened species under any other state legislation (QLD, VIC, WA, and SA). The kultarr is not listed as a threatened species under commonwealth legislation. On an international scale, prior to 2008 the kultarr was listed as "data deficient" on the International Union for the Conservation of Nature red list of threatened species [Morris et al., 2008]. Although it was up-graded to "least concern" in 2008 [Morris et al., 2008], a lack of data on wild populations means knowledge of current population stability and current threats impacting on this species in the wild is very limited.

CONCLUSION

Kultarrs inhabit areas sparsely populated by people, which has contributed to minimal data on their ecology in the wild. They are a cryptic species and population densities vary across their geographical distribution. Although this species has been kept in captivity for a number of years, captive populations are small and presumably have low genetic diversity. These captive populations have helped increase knowledge on kultarr biology in recent years. The success of these captive populations has probably occurred because managers have been persistent with breeding programs. Kultarrs readily accept a range of food items that contributes to maintaining their health and longevity in captivity.

After over 40 years since Lidicker and Marlow's review, there is still a great deal of research required to improve management and conservation of kultarrs in the wild and in captivity. A greater understanding of wild kultarr population fluctuations, current geographical ranges, habitat preferences, home ranges, and population densities is required. Studies of

dietary preference will aid appropriate diet items selection for captive animals and provide some insight into energy requirements of animals in the wild. Research into genetics to determine whether the kultarr is one species or sub-species would be helpful as some morphological features such as mammary gland number are unreliable to definitively determine sub-species. Furthermore, future research and dissemination of information to wildlife managers will ensure the appropriate and effective management of this species and the environment in which they live. Further studies on kultarr ecology would allow for a more accurate determination of its category of "threatened status."

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