Husbandry Guidelines for:

Kultarr

Antechinomys laniger

Mammalia: Dasyuridae

(Egerton, 2005)

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DISCLAIMER

This document is intended to be specifically treated as **guidelines** and a ‘work in progress’ in the care and husbandry of the kultarr (*Antechinomys laniger*). Any incident resulting from the misuse of this document will not be recognised as the responsibility of the author. Please use at the participants discretion. Any enhancements to this document to increase animal care standards and husbandry techniques are appreciated.

OCCUPATIONAL HEALTH AND SAFETY RISKS

The kultarr is an innocuous species. Although they are capable of biting when stressed, it is unlikely they have the potential to break the skin. It is the carer's responsibility to minimise stress to the animal when possible by limiting exposure to excess noise and predators, avoid invading the animals fright zone, providing adequate privacy and facilitating for natural behaviours.

Potential occupational health and safety risks to the animal include the use of inappropriate sterilisation agents or at incorrect dilutions, crushing risk from enclosure furniture and inadequate housing arrangements that may adversely affect the animal's health (e.g. extremes of temperature). They are ideally maintained in a controlled, secure environment of a nocturnal house where their behaviours and health can be monitored at minimal disturbance.

Carers are advised to wear disposable gloves when cleaning enclosures and handling chemical products to minimise risk and to maintain high standards of hygiene. Material Safety Data Sheets (MSDS) must be located within 3 m of all cleaning agents. Instructions must be read and followed prior to use.

Hands are to be washed thoroughly with a recommended anti-bacterial soap agent prior and after performing husbandry duties and particularly following the preparation of any meat products. Any manual handling involved should done so following the correct lifting procedures and with the assistance of a team member where required.

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Husbandry Routine

FREQUENCY	TASK			
	Cleaning duties	**Breeding Program**	**Health monitoring**	**Record keeping**
Daily	●Spot clean substrate (dispose of contaminated substrate and replace with fresh substrate). ●Remove faeces from exterior walls and lid of nest box. ●Clean water and food dishes with disinfectant and rinse. Allow to air dry or dry with paper towel if immediate use is required.	● Observe individuals for signs of reproductive behaviour if currently paired for breeding. (e.g. one chasing the other, whether or not they are sharing a nest box etc).	● Daily distant examinations noting any abnormal health related observations (e.g. ataxia, lethargy, alopecic).	●Recording of general condition of animals, identification number of animals sighted and any further notable behavioural information.
Weekly	●Remove and clean nest box. Dispose of bedding material and introduce fresh bedding material. ●Wash any rocks or other furniture that require cleaning. ●Remove native branches and introduce fresh branches into the enclosure (e.g *Eucalyptus spp*., *Acacia spp*., *Casuarina spp*).	●Pouch checks of females during breeding season.	●Weighing individuals.	●Record data on pouch checks and body mass.
Monthly	●Remove all substrate. Disinfect enclosure and apply fresh substrate.			

1 Introduction

The kultarr is a member of the Family Dasyuridae. More than 50 species of these carnivorous marsupials inhabit Australia (Egerton, 2005). They are categorised into four subfamilies:

- Dasyurinae; Tasmanian devil and quolls,
- Phascogalinae; the phascogales and antechinuses,
- Sminthopsinae; Dunnarts and kultarr, inappropriately referred to as 'marsupial mice',
- Planigalinae; planigales and ningauis.

Carnivorous marsupials range in size, from the minute long-tailed planigale at 4-5 g, to the renowned Tasmanian devil, whose bulk can reach 14 kg (Strahan & Van Dyck, 2008). However, all to some extent share common physical attributes. It is possible that these features are advantageous to succeed as a carnivorous marsupial; perfecting the need to seek and hunt prey.

Dasyurid dentition is adept at cutting and biting; with highly developed canine teeth, four upper and three lower pairs of sharp incisors, up to three pairs of upper and lower premolars and four pairs of sheer, pointed molars, both upper and lower (Strahan & Van Dyck, 2008) – Safe to say, *I wouldn't want to stick my fingers in that jaw!*

The larger dasyurids such as the Tasmanian devil and quolls have a predominately flesh-eating diet (Strahan & Van Dyck, 2008). Comparatively, small species including the kultarr are predominately insectivorous. In some cases, this provides a unique opportunity for survival in arid regions as invertebrates may be composed of up to 80% water, potentially enough to sustain a small dasyurid (Egerton, 2005).

Alongside the dentition of a predator, dasyurids for the most part, share a common paw structure, with five clawed toes extending from both forefeet and virtually rounded palms (Egerton [ed], 2005, Strahan & Van Dyck, 2008). Differences in paw structure are evident in comparison of arboreal and terrestrial species, with the former having a large, manoeuvrable toe and padded or wide palms, and the latter having long hind feet lacking in a big toe, or having a minimised version (Egerton, 2005). The kultarr is a model of a true extreme, with elongated hind legs and a galloping method of locomotion (Egerton, 2005; Strahan & Van Dyck, 2008).

The history of carnivorous marsupials in captivity spans back prior 1807, a time when the Tasmanian devil was maintained in Hobart (Jackson, 2003). In the past, the species was misinterpreted greatly as a vicious beast-like animal (Jackson, 2003). Now in current times, efforts to protect this species, with thoroughly planned breeding programs to combat the fatal tumour disease suggest zoological institutions have the potential to play a beneficial role in conserving wildlife.

This demonstrates a growth of zoological institutions towards the welfare of captive animals and conservation as opposed to human entertainment and wealth. Human-associated factors that have threatened wildlife such as habitat destruction and introduced species have been a focus of concern, with education and awareness being primary to environmental protection.

True success in exhibiting small carnivorous marsupials has been speculative across the boards of zoological institutions. In general, without the necessary facilities to stimulate natural behaviours in a safe, controlled environment (e.g. nocturnal house), small dasyurids are maintained in less than adequate species-specific conditions (Jackson, 2003). In terms of the kultarr specifically, difficulty in determining reproductive triggers, their flighty nature and being highly susceptible to stress has resulted in them being not ideal for a display environment. Nevertheless, exhibiting the lesser known carnivorous marsupials provides an opportunity to gain awareness towards conservation measures and promote a greater appreciation for the natural environment.

1.1 ASMP Category

ASMP Monotreme and Marsupial TAG (ASMP, 2009).

Not Evaluated; Management Level 3 (ASMP, 2009).

1.2 IUCN Category

Least Concern
(International Union for Conservation of Nature and Natural Resources).

1.3 EA Category

N/A

1.4 NZ and PNG Categories and Legislation

N/A

1.5 Wild Population Management

The Kultarr (*Antechinomys laniger*) Recovery Plan (2002) provides the founding steps towards preserving wild kultarr populations. The kultarr is categorised as endangered in NSW by the *Threatened Species Conservation Act*, 1995. The focus populations are located in NSW. The recovery plan objectives are to avoid further decline and to implement management strategies to support population growth (NSW National Parks and Wildlife Service, 2002).

The following are statements of the specific objectives:

1. Determine the distribution and habitat requirements of the species in NSW from existing sources;
2. Locate populations in known and potential habitat, particularly in the stronghold of the species around Cobar;
3. Identify known and potential threats;
4. Identify primary habitat areas for the Kultarr;
5. Identify and implement strategies for alleviating threatening processes and protecting remaining populations; and
6. Increase awareness in the wider community of the plight of the Kultarr.

(Directly from: NSW National Parks and Wildlife Service, 2002)

See Kultarr (Antechinomys laniger) Recovery Plan (2002) for full details on species wild population management.

1.6 Species Coordinator

None listed.

1.7 Studbook Holder

None listed.

2 Taxonomy

Since wild-caught kultarr were first studied, the classification of the species into an appropriate taxonomic grouping has been an issue. Gould classified the kultarr as *Phascogale lanigera*, having a shallow knowledge regarding their anatomy, biology and behaviour. The kultarr was eventually, categorised into its own, appropriate genus of *Antechinomys* by Krefft in 1867. During 1888, Thomas modified the name of the species to *Antechinomys laniger* (NSW National Parks and Wildlife Service, 2002).

Until Archer's theory was recognised, *Antechinomys laniger* was believed to be a distinct species to *Antechinomys spenceri*, referred commonly in the past as the wuhl wuhl (NSW National Parks and Wildlife Service, 2002; Ride, 1980).

Presently, both are categorised as subspecies of the kultarr, with scientific names of *Antechinomys laniger laniger*, referring to the 'original' kultarr, located in the eastern regions of Australia and *Antechinomys laniger speceri*, (previously the wuhl wuhl) in the western and central regions of Australia (Strahan & Van Dyck, 2008).

The sub species are distinguished predominantly by their geographic distribution, having similar behavioural and anatomical features. However, *Antechinomys laniger spenceri* has subtle paler colouration and slightly greater mass than *Antechinomys laniger laniger* (Ride, 1980).

Archer believed that *Antechinomys* should be categorised as a sub-genus to *Sminthopsis*. However, Baverstock's genetic and biological research, confirmed by later studies demonstrated that although related, *Antechinomys* should remain individual to *Sminthopsis* (NSW National Parks and Wildlife Service, 2002).

Figure 2.1: *Antechinomys laniger*
(Egerton [ed.], 2005)

2.1 Nomenclature

Class: Mammalia
Order: Dasyuromorphia (*Antechinomys laniger* (Gould, 1856), 2008)
Family: Dasyuridae
Subfamily: Sminthopsinae
Genus Species: *Antechinomys laniger*

2.2 Subspecies

Antechinomys laniger laniger
Antechinomys laniger spenceri

2.3 Recent Synonyms

Antechinomys laniger
Sminthopsis laniger

2.4 Other Common Names

Jerboa, Jerboa-marsupial, Jerboa Marsupial mouse, Jerboa Pouched-mouse, Pitchi-pitchi, Yurndu
(NSW National Parks and Wildlife Service, 2002; Strahan & Van Dyck, 2008)

3 Natural History

The kultarr is a solitary carnivorous marsupial (Strahan & Van Dyck, 2008; Egerton, 2005). They are endemic to Australia and have adapted the ability to survive in semi-arid and arid environments. This in part can be attributed to their small size (20 – 30g), agility to evade predators and nocturnal behaviour.

Sir Thomas Mitchell provided insight into the diversity and uniqueness of native Australian wildlife by catching wild specimens of kultarr throughout Victoria and New South Wales (Troughton, 1973; NSW National Parks and Wildlife Service, 2002). Nevertheless, this species has been the target of many misconceptions and assumptions.

In 1856, John Gould drew a portrayal of the kultarr that provoked the misconception it was arboreal rather than terrestrial species (Strahan & Van Dyck, 2008; Ride, 1980; Troughton, 1973). The observation that the kultarrs brush-tipped tail had a similar appearance to that of the arboreal red-tailed phascogale contributed to these assumptions (Ride, 1980).

Alston, an anatomist and Troughton (1973) suggested that due to the elongated, slender hind legs of kultarr, they were adapted to a bipedal, hopping style of movement, alike with *Notomys spp.*, the native hopping mice. Thus kultarr were referred to as 'Jerboa-like Marsupials' (Ride, 1980). Ride (1980) from the Western Australian Museum corrected these assumptions through Basil Marlow's techniques of studying footprints and innovative high-speed photography.

This demonstrated that the kultarr's method of locomotion "… is a graceful gallop in which the animal springs from its hind feet, lands on its fore feet, and then, bringing its hind feet around the outside of its fore feet… it springs off again with its hind feet" (Ride, 1980). This highlights the predominantly quadrapedal method of locomotion of the kultarr, with the ability to perform swift, bounding motions (Strahan & Van Dyck, 2008).

In 1865, Krefft of the Australian Museum, studied wild-caught individuals inhabiting the region of Gol Gol Creek. This included a female with seven pouch young (Troughton, 1973). The native inhabitants accurately understood the kultarr to be a nocturnal species and Krefft noted their carnivorous diet (Troughton, 1973).

The kultarr has a short gestation period of 12 days and reach sexual maturity at 11.5 months (Egerton, 2005). Photo-period has been identified as a reproductive trigger although breeding successes in captivity have been limited (Strahan & Van Dyck, 2008). Wild populations are highly susceptible to seasonal fluctuation but are nevertheless, widely dispersed (NSW National Parks and Wildlife Service, 2002). However, they are sparse throughout areas of their distribution (NSW National Parks and Wildlife Service, 2002).

The focus on conserving kultarr lies in part with perfecting wild trapping to track the abundance of the species, studying changes in habitat in terms of contributing factors (e.g. flooding and excess cattle grazing) and developing a greater understanding of home range, ideal environments and dietary needs (International Union for Conservation of Nature and Natural Resources).

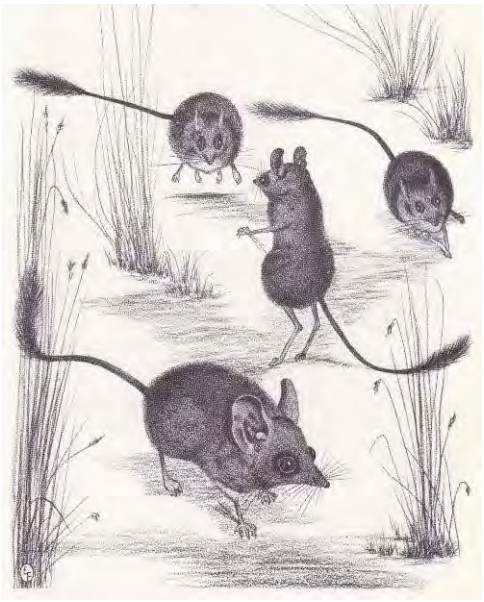


Figure 1.1: Drawings highlighting *Antechinomys laniger spenceri* method of locomotion

Figure 3.2: Gould's inaccurate depiction of the kultarr as an arboreal species.

(Rawlinson, Accurso & Walker from Museum Victoria).

3.1 Morphometrics/Diagnostic features

The small size (20-30g) and prominent eyes and ears of the kultarr have resulted in them mistakenly being referred to as marsupial mice. Their most identifiable characteristics are elongated hind legs and a long brush-tipped tail. In terms of colouration, they are sandy-brown with a pale underbelly (Cole & Woinarski, 2002; Dyck & Stephan, 2008).

3.1.1 Mass And Basic Body Measurements

Table 3.1: Measurements of length and body mass of the kultarr (*Antechinomys laniger*)

	Head to body length (mm)		**Tail length (mm)**		**Body mass (g)**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Min- max	80 – 100	70 – 95	100 -150	100 - 140	20-30	20-30
Average	85	85	130	120	30	20

(Adapted from: Strahan & Van Dyck, 2008; Jones, 2003)

3.1.2 Sexual Dimorphism

Kultarr have minimal sexual dimorphism, although males may be slightly larger than females. There is no obvious characteristic to distinguish between sexes from a distant examination. The development of a pouch approaching when receptive to mating is a solely female characteristic.

3.1.3 *Distinguishing Features*

Kultarrs superficially resemble species of the Genus *Notomys*. Specifically, they share the colouration and prominent features of *Notomys alexis*, the Spinifex hopping-mice as well as inhabit the same desert regions. However, upon closer examination and becoming familiarised with the species enable them to be easily distinguished (*see* ***Table 3.2***).

Comparison of the kultarrs predominantly quadrapedal method of locomotion to the Spinifex hopping-mice bipedal locomotion is a further distinguishing factor. Furthermore, kultarr specimens have only four digits on their hind limbs (NSW National Parks and Wildlife Service, 1999).

Dentition of dasyurids in contrast to the rodent dentition of Muridae, with either side of the jaw containing three pairs of molars, and one pair of upper and lower incisors is a further means of identification (Cronin, 2000). Kultarrs also lack in the throat pouch common to male and female Spinifex hopping mice.

In terms of distinguishing kultarr from other dasyurids, the observations of Morton, Dickman and Fletcher (1989) serve as an accurate summary;

"Because of the overall uniformity of body shape among Dasyurids, identification of species from external characteristics relies on size, hind foot morphology, tail length and colour patterns" while research by Hyett and Shaw (1981) reveal their shared dentistry.

Nevertheless, the kultarr is unique among dasyurids, due to their long brush-tipped tail, approximately 1.5 times their body length and elongated hind legs (Strahan & Van Dyck, 2008; Strahan, 1995).

Table 3.2: Visual Comparison of Physical Characteristics of Families Dasyuridae and Muridae

a) Kultarr (*Antechinomys laniger*)  Family: Dasyuridae	b) Fat-tailed Dunnart (*Sminthopsis crassicaudata*)  Family: Dasyuridae	c) Stripe-faced Dunnart (*Sminthopsis macroura*)  Family: Dasyuridae	d) Southern Ningaui (*Ningaui yvonneae*)  Family: Dasyuridae
e) Red-tailed phascogale (*Phascogale calura*)  Family: Dasyuridae	f) Spinifex Hopping-mouse *Notomys alexis*  Family: Muridae	**g)** Mitchell's Hopping-mouse *Notomys mitchellii*  Family: Muridae	

(Adapted from: Strahan & Van Dyck, 2008)

3.2 Distribution and Habitat

The anatomical characteristics of the kultarr support its lifestyle in the arduous, desert environment of Australia. The species habitats include the open landscape of semi-arid regions, *acacia* woodlands, outcrops of rocky and sandy plains in regions vegetated sparsely with endemic grass and shrubbery, with foliage offering minimal shelter (Strahan & Van Dyck, 2008; Egerton, 2005; Cole and Woinarski, 2002).

The locations of subspecies vary, with *Antechinomys laniger spenceri* populations primarily inhabiting Western and Central Australia, while the *Antechinomys laniger laniger* populations are situated primarily in Eastern Australia (Egerton, 2005). Subspecies favour particular environments, with *Antechinomys laniger spenceri* often located in claypans within *Acacia* woodlands of seldom vegetation cover. Alternatively, *Antechinomys laniger laniger* are evident more so in habitats of rocky outcrops, amongst growths of *Cassia*, *Acacia* and *Ermophila* (Strahan & Van Dyck, 2008).

Records regarding the distribution of the kultarr throughout Australia indicate they are dispersed widely within arid regions, but nevertheless, their population is dwindling (NSW National Parks and Wildlife Service, 2002). The Kultarr (*Antechinomys laniger*) Recovery Plan (2002) indicates reductions in populations throughout Queensland, South Australia and NSW; however, they remain considerably stable in Northern Territory and Western Australia.

Populations of kultarr in Cedar Bay of Queensland are now presumed to be extinct (Egerton, 2005). The population in Queensland at Sandringham Station also may have suffered to this extent, as well as those in Victoria, the southern region of New South Wales and the south east region of South Australia. Kultarr populations throughout New South Wales still present are believed to be of crucial scarcity (NSW National Parks and Wildlife Service, 2002). However, kultarrs continue to inhabit the land in proximity to Roper River, in the Northern Territory (Egerton, 2005; NSW National Parks and Wildlife Service, 2002).

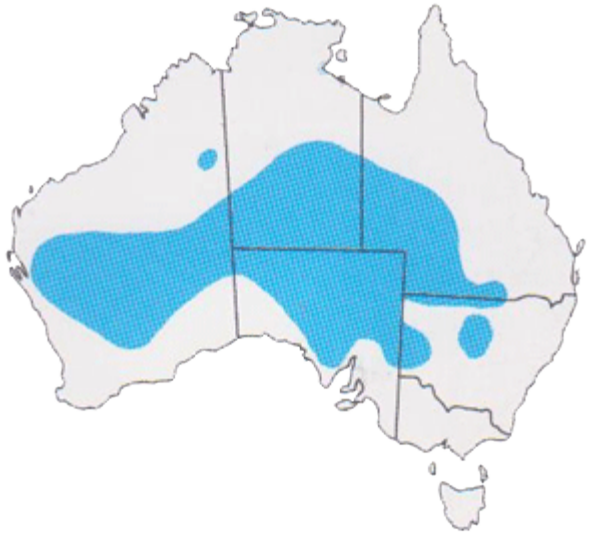


Figure 3.3: Current distribution of kultarr (*Antechinomys laniger*). Populations are sparse within specified area.

(Strahan & Van Dyck, 2008)

The following factors have contributed to the population decline of wild kultarr:

- Farming establishments and the impacts of livestock

- Introduced predators such as foxes, feral and domestic cats.

- Use of insecticides in Australia to eliminate locust species.
  (e.g. the insecticide Fenitrothion may be responsible for secondary poisoning of small dasyurids. The use of insecticides in areas of kultarr habituation also reduces quantities of prey available).

- Seasonal changes involving floods and fires responsible for drowning and decrease in available natural shelters.
  (e.g. Floods of 1989 and 1990 at Nyngan and Kinchega National Park (NSW) and conditions of high rain at Sandringham Station at southern Queensland from 1966 to 1977).

(Kultarr – profile [online], 2005; NSW National Parks and Wildlife Service, 2002; Cole and Woinarski, 2002; Strahan & Van Dyck, 2008; Dickman, Whish and Pressey, 2002)

3.3 Conservation Status

Kultarr are categorised as a species of Least Concern in terms of the IUCN Red List (International Union for Conservation of Nature and Natural Resources). Their present rate of population decline alongside their widespread population does not highlight a need for them to be listed as a species under greater threat (International Union for Conservation of Nature and Natural Resources).

3.4 Longevity

The longevity of kultarr is an area of data deficient evidence, likely due to the rarity of the species, with populations dispersed thinly throughout Australia's arid and semi-arid regions. Nevertheless, records by Woolley (1984), when performing research regarding the reproduction of *Antechinomys laniger*, documented the longevity of particular specimens (*see **3.4.1** & **3.4.2***).

However, this limited study does not accurately present an average, or maximum longevity of kultarrs. Nevertheless, one may assume that the longevity of captive kultarrs is greater than that of wild specimens, due to the elimination of factors such as predation, competition for food, as well as dangers from environmental conditions.

3.4.1 In the Wild

Wild-caught males have been maintained in laboratory conditions for 6, 11 and 18 months until death (Woolley, 1984). A wild-caught female alternatively was maintained for 15 months until death (Woolley, 1984).

3.4.2 In Captivity

One male kultarr raised in captivity survived 11 months, and three others had a lifespan of 7 months (Woolley, 1984). Two females, raised in laboratory conditions had longevity of 40 months, the longest lifespan of kultarr during Woolley's (1984) research.

3.4.3 *Techniques Used to Determine Age in Adults*

Inadequate data available.

4 Housing Requirements

4.1 Exhibit/Enclosure Design

The kultarr is a small, flighty species that are capable of agile and swift movements (pers obs). Thus it is recommended they be maintained in entirely sealed holding area or exhibit, as with other small dasyurids to prevent the escape of specimens (Jackson, 2003). However, it must be ensured that adequate ventilation is provided.

Kultarrs are prone to stress and may vocalise or tremble when their fright, flight, fight distance has been invaded (pers. obs.). Therefore, among the most effective ways of monitoring this species within the enclosure is by the use of infrared video surveillance. This is particularly valuable in regards to observing reproductive behaviours within the nest box to limit disturbance.

Nocturnal houses with a reverse day/night cycle are an ideal housing arrangement. This enables the public to view exhibited specimens when they are at the peak level of activity while enabling kultarrs to remain at rest and undisturbed during stages of inactivity. It also enables temperature control, minimises exposure to elements and allows maintenance of natural photo-period by artificial means.

Overall, a captive environment must adequately facilitate for natural behaviours to take place. This is a key factor influencing the welfare of exhibited animals. It is the responsibility of animal carers to monitor and adjust conditions within a controlled environment for the health and psychological wellbeing of animals. Exhibits should be aesthetically pleasing by the inclusion of natural features, which also serve to stimulate animals and thus, decrease stress. Exhibits must also enable animals to be easily monitored and accessed for evaluations of health and reproductive status to maintain high standards of animal care.

Figure 4.1: Western Plains Rat Exhibit
Sydney Wildlife World

The Western Plains Rat (*Pseudomys australis*) exhibit of Sydney Wildlife World, featured inside a nocturnal house, is suitable to use as the foundations of displayed kultarr housing (*see* ***Figure 4.1***). A tunnelling system is provided against the side of the enclosure glass, enabling clear viewing of the animals while simulating the security of being 'underground'. The circular design of the enclosure allows the animals and their representative natural habitat to be viewed from all angles, maintaining public interest with natural browse also present.

4.2 Holding Area Design

Holding areas of kultarrs can be of a basic construct and must accommodate their essential physical requirements. As they are a terrestrial species, there is no need to facilitate for the behavioural needs of a red-tailed phascogale for example, which is highly arboreal (Dyck & Strahan, 2008). Woolley's (1982) housing design for small Dasyuridae species, are particularly notable, created for research purposes, with the need for easy access to the animal a dominant concern. Stainless steel materials allow a hygienic environment to be maintained. This aspect is particularly significant when considering a specimen that has been removed from public display due to a potential illness.

A glass front enables clear observation of the animal, allowing distant examinations to be performed, and accounts for the possibility of escape, with the holding area entirely sealed. The two exterior nest boxes (*see* ***Figure 4.2*** & ***Figure 4.3***), enable the animals to be captured and restrained, when the animal, as a nocturnal species, is residing inside. This limits the stress response of having to directly capture the animal, while active, through the use of a cloth bag. Furthermore, exterior nest boxes allows for a greater surface area to be available in the interior, enabling natural behaviours and the kultarrs bounding locomotion to take place.

Woolley (1982) describes a further use of the design;

"The twin-unit cages were especially useful for segregating a male from one or more females during the mating period so that the male could be allowed access to female(s) and observed, without prior handling, by raising the centre partition".

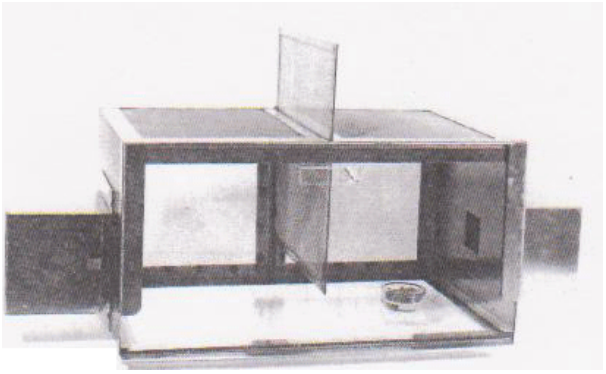


Figure 4.2: Stainless steel holding area design, with external nest boxes and ability to convert into an enclosure with two segments. Appropriate for the temporary housing of small dasyurid species.

Dimensions
Enclosure: 50 x 31 x 25 cm
Nest box: 12 x 12 x 12 cm

(Woolley, 1982)

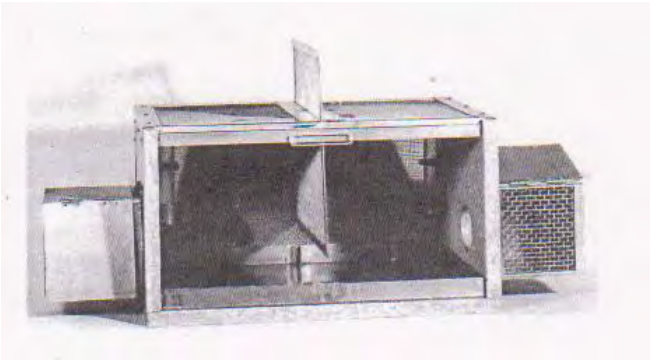


Figure 4.3: Wooden and stainless steel cage design. Floor tray is removable, enabling thorough cleaning to take place. The nest boxes can be disconnected from the enclosure walls for easy access to enclosed animal.

Dimensions
Enclosure: 45 x 30 x 25 cm
Nest box: 12 x 12 x 12 cm

(Woolley, 1982)

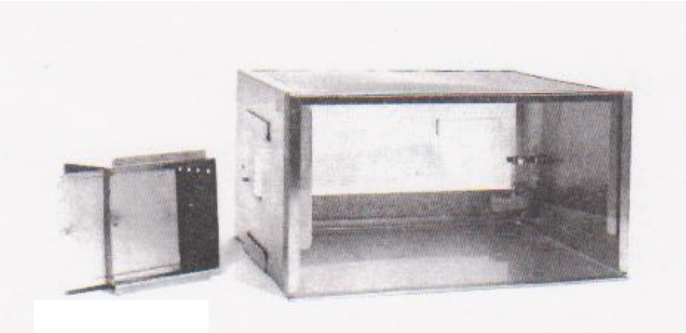


Figure 4.4: Holding facility design with singular compartment, for the solitary housing of small dasyurid specimen.

Dimensions
Enclosure: 42 x 31 x 23 cm
Nest box: 12 x 12 x 12 cm

(Woolley, 1982)

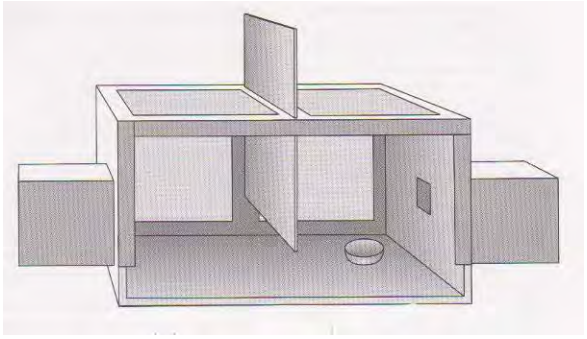


Figure 4.5: Standard enclosure for housing small dasyurid species.

(Jackson, 2003)

4.3 Spatial Requirements

The spatial requirements provided to an animal must facilitate the need for natural behaviours to take place, such as foraging, exploratory and locomotion. A specimen's interaction with their environment is dictated partially by the extent of the area they are confined in, alongside the scents, appearance and tactile features of the enclosure contents.

Table 4.1 According to the ARAZPA Australian Exhibition Standards, 1986 and Jackson (2005), a pair of kultarrs should be housed in an enclosure of the following minimum measurements:

Scientific name	**Minimum Surface Area (m^2)**	**Minimum Height (cm)**	**Minimum Length (cm)**	**Minimum Breadth (cm)**	**Area for each additional specimen (m)**
Antechinomys laniger	0.25	40	50	50	0.25 x 0.25

(Adapted from: NSW Department of Primary Industries, 2005; Jackson, 2003)

4.4 Position of Enclosures

An indoor nocturnal house with a reverse day-night cycle is particularly suitable for holding kultarrs. The dark lighting of a nocturnal house encourages nocturnal behaviours to take place, as night is the peak period of kultarr activity. Foraging behaviours, for example, are stimulated in this artificial night environment. This enables visitors to experience a close encounter with nocturnal species during the normal opening hours of zoological or native fauna parks, where as otherwise, the kultarr would typically remain in the nest box throughout this time, unless roused by feeding. If intending to breed specimens, it may be necessary to have an alternative facility to house them, ensuring access to regular day/night hours as factors that influence the kultarrs reproductive state.

Positive factors of indoor enclosures include allowing animals to be monitored and observed from close range and to be located without excessive difficulty. Furthermore, the enclosure should be fully enclosed to minimise risk of this swift and small species escaping, preventing a highly stressful situation for the specimens. Attempts made by the public to come into contact with the animals that may provoke flight and fright responses are also inhibited in this manner as well as access of potential predators.

4.5 Weather Protection

An indoor enclosure is required to minimise exposure to the elements. Kultarrs are sensitive to temperature fluctuations and change as a factor that may influence or stimulate torpor (pers. obs.). Therefore, an indoor enclosure serves to protect them from environmental factors, such as rain and wind that may adversely affect their health. Torrential winds have the ability to shift branches, or other enclosure furnishings, presenting a possible crushing risk to this small species. Therefore, outdoor enclosures are not recommended. However, Jackson (2003) highlights the benefits of natural light, as for breeding purposes. Photoperiod in particular, may influence a kultarrs breeding status (Strahan & Van Dyck, 2008).

4.6 Temperature Requirements

As a species that is sensitive to climate change, and is prone to “Spontaneous torpor” at or below a body temperature of 19^{o}C, a thermostat is required to regulate and monitor temperature (Geiser, 1986). Ideally, the temperature of a kultarr enclosure should be maintained at approximately 22^{o}C. Studies by Geiser (1986) have demonstrated the relationship between temperature to torpor in the kultarr, and his journal articles can be reviewed for further information.

A basking lamp is recommended in the housing of the majority of small dasyurid species to facilitate basking behaviours (Jackson, 2003; Woolley, 1982). According to the Australian Mammal Exhibition Standards 1986, providing either natural or artificial means to bask, is an essential requirement.

Woolley's (1982) successful management of kultarrs in captivity in relation to temperature requirements can be applied to an exhibited animal situation, to fulfil a behavioural need.

Woolley (1982) describes;

"In the laboratory infrared lamps (15O W) were suspended above the cages were switched on for 1-2 hours during the day, 5 days a week. Each lamp was 20-50 cm above the floor of the cage and the temperature at floor level was 35-48^{o}C. Soon after the lamps were switched on, animals emerged from their nest boxes…. They flattened their bodies against the floor and turned their hind legs backward alongside the tail".

Nevertheless, the ability to overheat the animals must be considered and thus, the basking light must be isolated to a particular section of the enclosure, ensuring there is available space for the animal to retreat from the extremes of heat. A constant source of fresh water must also be accessible to the animal to avoid dehydration.

4.7 Substrate

At the University of Western Sydney Hawkesbury native mammal research facilities, Breeder's Choice Animal Bedding (cat litter) is currently used as a substrate for kultarrs (*see **Appendix** for supplier details*). This enables regular spot cleaning to take place, by removing the isolated areas of faeces and replacing with fresh bedding. Digging behaviours of the kultarr are also enabled (pers. obs.). However, this substrate by no means reflects the animal's natural environment.

Among the purposes of a zoological park is public education and entertainment. Exhibit design should therefore, mirror the animal's natural habitat. In the case of the kultarr, this is predominantly Australian semi-arid desert regions (Strahan & Dyck, 2008). Therefore, sand, is a substrate I personally recommend. Jackson (2003) supports this opinion, stating "Several species, such as the kowari and kultarr, appear to keep their fur clean and scent mark by sand bathing, so the provision of fine sand is recommended". Furthermore, sand facilitates digging, a behaviour of the kultarr related to the foraging of insects (pers. obs.). Thus, a soft sand substrate is preferred.

Jackson's (2003) other suggestions regarding substrate for small dasyurid species include "…. soil, paper, cardboard or sawdust". Among these, soil is the most appropriate in a permanent housing facility, as a substrate encountered naturally in the environment and does not present a risk of damaging the kultarr's feet, as concrete would for example. However, caution must be taken to ensure the soil is animal-safe and does not harbour disease.

In off-display holding facilities, paper is likely to be an acceptable temporary substrate. The entire piece can be removed and disposed of easily when soiled and fresh paper applied, enabling sanitary conditions to be maintained. Ideally, the animal should be sealed in the nest box throughout this process, rather than doing so at a time when it is active, and requires direct capture techniques.

4.8 Nestboxes and/or Bedding Material

Nest boxes are essential furniture for dasyurids, excluding the marsupial mole (Jackson, 2003). Not only do they facilitate behavioural needs for the kultarr as a nocturnal species, but also provide shelter and privacy for the animal. Furthermore, they provide a means of capture for the carer that minimises the animal's stress response.

Nest boxes with dimensions of 22cm width, 24cm height (including lid) and approximately 24.5cm breadth, with a circular opening of 6cm in diameter have been used successfully at the University of Western Sydney Hawkesbury native mammal facilities (*see* ***Figure 4.6***). As a terrestrial species, the nest box should remain level to the ground. Nest box designs that support a sliding panel, to seal the entrance are particularly useful in the process of capture.

Timber is a standard material used to construct nest boxes, with Jackson (2003) in particular suggesting the use of "thin plywood for small species". It should be ensured that the timber is smooth and free of splinters, for the safety of the kultarr.

Straw has been used as a successful bedding material for kultarr specimens at the University of Western Sydney Hawkesbury native mammal facilities (pers. obs.). Stringy bark or grasses are further alternatives, providing the means for nesting (Jackson, 2003). Furthermore, it must be ensured the nest box lid is properly and securely closed to limit the crushing risk to the animal.

Figure 4.6: A standard timber nest box, providing shelter and privacy within a kultarr enclosure.

Dimensions: 22 x 24 x 24.5 cm

Opening: 6 cm diameter

4.9 Enclosure Furnishings

Furniture is fundamental to environmental enrichment, introducing a range of scents into the enclosure, as well as stimulating the animal's tactile senses. It is the primary method of preventing "stereotypic behaviour" (Jackson, 2003). Jackson (2003) suggests the use of "rocks, hollow logs, climbing branches, pieces of bark, PVC pipes (off display only)…. for small species". Natural furniture in particular, assists in reflecting the animal's habitat, encouraging natural behaviours alongside educating the public. Nevertheless, cardboard rolls are suitable in off-display enclosures, as an inexpensive substitute to natural shelters, having been used with success at the University of Western Sydney Hawkesbury native mammal facilities. They should be disposed of regularly, once contaminated with faeces, and fresh rolls can be introduced into enclosure (*see* ***Figure 4.7***).

Branches in the enclosure, if possible, should be changed on a weekly basis, to introduce new scents in the enclosure, and stimulate investigatory behaviour within an altered environment. Particularly, native Australian flora, such as *Eucalyptus spp*., *Acacia spp*., *Casuarina spp*. or Spinifex and saltbush tussocks, is suitable for this species, in mirroring their natural habitat *(see* ***Figure 4.7*** *&* ***Figure 4.8***). A constant water source is also required. Natural-appearing shallow bowls are suitable for this purpose. Furthermore, smooth rather than jagged rocks are suitable, as they decrease the risk of injury to the animal and are less difficult to clean, to maintain a hygienic environment.

Nevertheless, consistency in regard to enclosure furniture is necessary to some extent, to avoid the heightening of stress. Therefore, ensuring some factors remain familiar to the animal, such as the presence of the nest box, as an essential furnishing for this species, is appropriate (Woolley, 1982). Caution must be taken to ensure furniture is stable, and poses no risk of crushing this small animal.

Figure 4.7: Off-display kultarr enclosure, featuring nest box, native branches, cardboard rolls and a water bowl. A security lock and key mechanism is also included.

Figure 4.8: Cardboard rolls and native branches provide means of environmental enrichment for the captive kultarr.

5 General Husbandry

5.1 Hygiene and Cleaning

5.1.1 Substrate

Substrate should be spot cleaned on a daily basis, preferably when the animal is within the nest box to reduce stress. Moist areas from water spillage, or areas contaminated with faeces must be disposed of appropriately and fresh substrate applied. A small hand-shovel is appropriate to remove the bulk of substrate, with a dust pan and brush used to collect the remaining debris.

Complete substrate change of fine sand or Breeder's Choice Animal Bedding typically occurs monthly or as required. However, in terms of paper or cardboard substrate used within temporary holding facilities, this should be removed every second or third day (Woolley, 1982). Be observant – if substrate develops mouldy odour, an immediate removal is required.

5.1.2 Enclosure walls and floor

The animal must be captured and removed from the enclosure prior to a full clean. After contaminated substrate is disposed of, the enclosure wall and floor can be wiped down with a paper towel, ensuring all organic matter is removed to allow disinfectant products to function to their full potential. Spray bottles are particularly convenient to apply the cleaning agent, with the area wiped down once again with a paper towel. Depending on the product, rinsing may not be required.

5.1.3 Nest boxes

On a daily basis, faeces should be removed from the lid and outer walls of the nest box using a paper towel or similar and disposed of. If the animal is not in an active reproductive status, the nest box material can be removed and replaced with fresh nesting material on a monthly basis. The interior and external timber of the nest box should be cleaned monthly, with the use of a damp paper towel, as well as disinfectant if appropriate. Cleaning of the nest box is also a measure to prevent and control the prevalence of endoparasites (Jackson, 2003; Woolley, 1982). It is recommended that the cleaning of the nest box occurs on an alternative day to the substrate, to ensure the enclosure retains an element of familiarity for the animal (Woolley, 1982).

5.1.4 Chemical cleaning products

Ensure instructions are read prior to use and followed, with the recommended dilution obtained and the MSDS of the product within 3 m range in case of emergency (*see **Appendix** for MSDS*). Ensure the product is not harmful to animals. I personally recommend F10 SC Veterinary Disinfectant or Viraclean as animal-safe and biodegradable agents, effective in destroying a range of pathogens (*see **Table 5.1** in*

Appendix) (Chemical Essentials; Whitley Medical). Bleaches should be avoided, as they tend to be corrosive, with fumes potentially harmful to small species.

5.1.5 Furniture

Fresh native branches, including *Eucalyptus spp.*, *Acacia spp.* or *Casuarina spp.*, should be introduced into the enclosure on a weekly basis, with decaying old branches removed. Faeces should be wiped off from hollow logs, rocks, etc on a daily basis, and cleaned thoroughly weekly with water and appropriate animal-safe disinfectant. Cardboard rolls can be disposed of weekly or when required, with fresh rolls introduced in an off-display enclosure as a temporary, inexpensive furnishing. Do not clean all furniture on the same day unless necessary, to enable familiar scents to remain and thus, keep the animals stress to a minimum.

5.1.6 Food and water dishes

Food and water dishes should be free of grime, mould, rust etc. Cleaning on a daily basis, using disinfectant, ensures hygienic conditions are maintained. Animal-safe dishwashing liquid is appropriate for this purpose. Organic matter is firstly removed and disposed of using a paper towel. The dishes or bowls are then rinsed, with the disinfectant applied, scrubbed and then rinsed again thoroughly. The bowls or dishes are allowed to air dry or are dried with a paper towel if required immediately. Stainless steel water dishes are suitable in off-display holding facilities, as they are generally easy to clean and to maintain in a sterile condition.

5.1.7 Potential pests

Mites, such as *Austrochirus sp*. may be introduced into an enclosure if rodents used for feeding are infected (Woolley, 1982). Therefore, it is recommended that laboratory-bred rodents are examined thoroughly prior to feeding, and not used in the case of contamination. Disposing of bedding material and introducing fresh material on a frequent basis is also necessary for successful pest control.

5.2 Record Keeping

Maintaining legible records is a required element of working within the animal care industry. Records serve as a working document, with four main purposes:

1) Gathering an accurate history of specimens, enabling carers to backtrack where necessary.

2) Allowing the flow of communication between staff, and to remain updated on current animal-related events (e.g. births, deaths, acquisitions).

3) Monitoring the health and behaviour of specimens.

4) Enable successes (such as in regard to breeding programs and the optimum conditions for breeding a specific species) to be replicated and repeated.

On a daily basis, events noted in regard to kultarr care and husbandry includes:

- What was fed and the quantity.
- The identification number of animals sighted from each enclosure.
- Any notable health or behavioural related observations.

Pouch checks and weighing should be performed and recorded on a weekly basis if possible unless there is a need to limit disturbances due to reproductive condition of animals.

Veterinary checks or treatment must be recorded as they occur.

5.3 Methods of Identification

Kultarr specimens may have subtle differences in physical attributes in regards to measurements of body-to-tail length, tail length and body mass between the sexes. However, identifying individuals is a challenging task when relying solely on visual characteristics.

Identification methods for captive small dasyurids should:

• Be permanent: to minimise stress by their being no need to reapply the identification device. (**Note:** Marking with paint is appropriate for short-term research of wild animals but does not fulfil the long-term requirements of the zoo keeper or animal attendant).

•Minimise injury: e.g. Ear tagging with metal identification device is not recommended, as they may rip the flesh and result in injury and subsequent infection (Jackson, 2003).

•Not adversely affect behaviour or locomotion.

Ear notching has been performed on related species to the kultarr such as dunnarts and ningaui with success (Jackson, 2003). However, this method alongside, ear tags damage the 'natural' atmosphere of exhibits and may provoke public complaint.

Therefore, microchip transponders are the recommended identification device for captive marsupial species, as they are permanent, unseen to the public eye, reliable and can be applied to animals of ranging body mass. Therefore, the expense of obtaining a microchip reader does not outweigh the advantages.

A negative aspect of this form of identification is the need of the keeper or animal attendant to capture and restrain the animal, to gain a reading of the transponder. However, this can be performed alongside the regular pouch checks and weighing of specimens that take place, without provoking additional stress to the animal.

Also, it must be noted that in small dasyurids such as the kultarr, the presence of the microchip transponder beneath the flesh of the shoulder blades, may alter the body mass readings significantly.

5.4 Routine Data Collection

Routine data collection is essential in producing working records of the history of a particular specimen.

Maintaining records of pouch checks of kultarrs is valuable towards the success of breeding programs, in noting whether females are receptive to breeding. The pouch enlarges within the breeding season, and decreases at its finale (Strahan & Van Dyck, 2008).

Records regarding the absence or development of the pouch can be performed on a weekly basis. This should occur alongside the monitoring of weight, to determine whether an increase or decrease in feeding is required and as a further method to confirm reproductive status.

Males can be introduced in an exhibit with a female when the pouch is prominent, to allow copulation to take place, with an increased level of success at this particular period. Observations of notable pair reproductive behaviours or interactions are to be included in routine data collection. This may determine the level of pair compatibility.

These observations can be assisted greatly by the use of an infrared video camera installed in the nest box

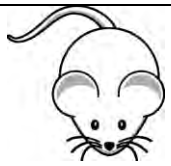
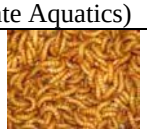
6 Feeding Requirements

6.1 Diet in the Wild

The kultarr is a highly insectivorous marsupial species. Their wild diet consists primarily of invertebrates including crickets, cockroaches and spiders (Menkhorst and Knight, 2004; Dyck & Strahan, 2008). Hyett and Shaw (1981) suggest kultarrs consume small lizards if they are encountered. However, Ride's (1970) recordings contradict this, as when lizards were offered to wild-caught specimens, they "were left untouched". Feeding and foraging behaviour of the kultarr, as a nocturnal species, typically occurs during the night (Strahan & Van Dyck, 2008).

6.2 Captive Diet

Table 6.1: The captive diet of kultarr at Alice Springs Desert Park:

DAY	FOOD ITEM	GRAPHIC
Monday	Crickets	 (Swarm Supplies, 2008)
Tuesday	Adult mouse (1cm x 1cm) (dusted with calcium powder)	 (Ultimate Aquatics)
Wednesday	Mealworms	 (Feeder Worms, 2008)
Thursday	Pinkies (dusted with calcium powder)	
Friday	Mealworms	 (Feeder Worms, 2008)
Saturday	'Starve day' – Not fed	
Sunday	Wood roaches	 (Keeping and Breeding Woodies, 2008)

Note: On a typical maintenance diet, animals are fed **6g** of the designated food item per day (excluding 'starve day' – Saturday).

Alternatively commercially available substitutes to live insects include the Small Carnivore Food by Wombaroo. This was trialled at the research native mammal facilities of University of Western Sydney, Hawkesbury campus. The kultarrs readily accepted the Wombaroo Small Carnivore Food.

Table 6.2: Nutritional content of Wombaroo Small Carnivore Food

Min Crude Protein	34 %
Min Crude Fat	10 %
Max Fibre	5%
Max Salt	0.8 %

*(See **Appendix** for supplier details).*

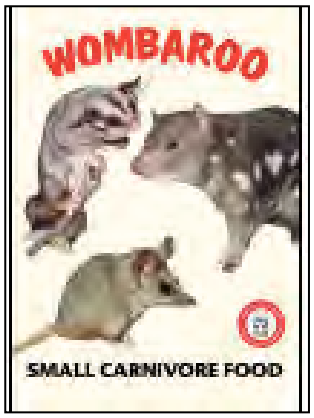


Figure 6.1: Wombaroo Small Carnivore Food

(**Table 6.2** and **Figure 6.1** directly from Wombaroo: Small Carnivore Food)

The average weight of a kultarr is 20-30g, with males slightly larger than females (Strahan & Van Dyck, 2008). Weekly weighing and recording of this information may indicate a need to increase or decrease daily quantities provided to individuals. This should be adjusted by small increments as required until the animal is an ideal body mass and in a healthy condition.

Similarly, additional food must be provided to females with pouch young, to accommodate for their increased energy requirements while lactating.

Water is provided *ad libitum* in a shallow natural-appearing bowl. Ensure moist substrate is removed on a daily basis in the case of spillage.

Alternatively, stainless steel bowls can be used off-display, as these are maintained in a hygienic condition with little difficulty.

6.3 Supplements

Feeder rodents should be dusted with calcium (e.g Rep-cal) and Vitamin E powder prior to feeding, as to offer kultarrs a nutritional balance within the captive diet.
These products are available from a range of pet shops, or reptile supply stores.
(*See **Appendix** for further details*).

Figure 6.2: Rep-cal calcium supplement is dusted onto adult mice and pinkies prior to being fed to kultarr specimens.

(Prewett)

6.4 Food Preparation

At the University of Western Sydney Hawkesbury native mammal facilities, insects are fed live to stimulate activity and natural foraging behaviours as a form of food-related environmental enrichment. The required quantity is weighed on a scale. It is recommended that FLON AD1 is applied around the weighing container rim, to prevent invertebrate escapes. In the case of mealworms, sifting through the bran housing the colony is the most efficient method of capturing them.

Euthanised feeder rodents must remain in a frozen state for a minimum of 4 weeks prior to feeding to captive specimen. This is to ensure the elimination of potentially harmful bacteria. The feeder rodents should be inspected for mites and if present, the rodent must not be fed to kultarr. This is to prevent introducing the parasites into the enclosure, presenting a health risk to the captive specimen. Furthermore, the feeding of rodents that displayed signs of illness prior to death, or died from unknown causes must be avoided where possible.

Adult mice and pinkies can be allowed to thaw partially prior to food preparation, so they may be cut into portions more easily. The recommended method of thawing to avoid the proliferation of bacteria is to allow rodents to defrost in a refrigerator if possible. Thawing in warm or hot water is not advised, nor at any stage the use of a microwave.

Adult mice are cut into 1 cm x 1 cm cubes, to accommodate the small size of the kultarr. Pinkies generally can be cut into halves or thirds, depending on their size. Occasionally,

larger portions of rodent or whole pinkies can be provided for environmental enrichment purposes. Ensure nest boxes are checked for uneaten rodent as required and dispose of accordingly.

6.5 Presentation of Food

Wood roaches and crickets are fed live, scattered in the enclosure to promote natural foraging behaviours (*See **Figure 6.3***). Generally, the feeding of live invertebrates is not a cause of concern for the public and observing the kultarrs responses may provide an enlightening experience, as kultarrs dig for and catch prey.

Alternatively, feeding pieces of adult mouse and pinkies may receive negative reactions from the public. To avoid this, food dishes can be disguised behind furniture. Alternatively, informative signage educating on the carnivorous nature of the species may be included beside the exhibit.

Rodent food items are to be placed on a flat natural-appearing food dish, to minimise contact with substrate and provide the kultarr with easy access. If preferred, a food dish with curved edges is acceptable when offering mealworms, to limit their escape as they tend to burrow beneath substrate when given the opportunity. Although this may prevent immediate kultarr access to the food item, it may also be perceived as beneficial, stimulating digging behaviours (pers. obs.).

A mealworm dispenser is a possible food-related environmental enrichment device and is relatively inexpensive to construct. Small holes can be drilled into narrow PVC tubing, with sealable openings. Suspended from the enclosure wall, mealworms will fall and irregular intervals, providing an element of spontaneity within the typical regular routine of a captive environment.

Figure 6.3 & 6.4: Captive kultarr feeding behaviours.

7 Handling and Transport

7.1 Timing of Capture and Handling

As a nocturnal species, captive kultarr remain within the nest box throughout the daylight hours, with activity roused when feeding, or due to the disturbance of the keeper's presence. This provides opportunities for capturing the animal, as to perform pouch checks and record weights. Also, as the morning is the coolest period of the day, the animals are less susceptible to heat stress at this time.

Stress is reduced by placing a wooden panel over the opening of the nest box, as opposed to attempting capture while the animal is in an active state, susceptible to fright and flight reactions. Also, the difficulty presented by the capture of these typically, flighty and swift animals as well as the possibility of escape is minimised. The potential to cause harm to this small and delicate species during capture is reduced by doing so when they are inactive.

Jackson (2003) states "Carnivorous marsupials are best caught during the day while they are asleep in the nest box. If held in a nocturnal house they can often be caught first thing in the morning before the lights go out". Morning capture and release, enables the animals to be monitored throughout the day, to ensure they have recovered from the incident. The peak heat of the day is also avoided, as another potential stress and health risk to these small carnivorous marsupials.

7.2 Catching Bags

Figure 7.1: Standard catching bag for small dasyurid species. Labelled on the bag is the specimen's body mass (prior to transport) and identification number.

Catching bags facilitate keeper needs to perform close examinations; pouch checks and weighing of small dasyurids (*see* ***Figure 7.1***). Cloth is an appropriate, non-abrasive material for the construction of capture bags. The seams are to be located on the outside of the bag to avoid the animal's claws becoming caught in them, increasing the stress response and potential injury. Jackson (2003) alternatively suggests the use of "…. calico or click seal bags (with small air holes) for very small species for short periods during weighing".

Preferably, the catching bags should be a dark colour. A dark environment generally has a calming effect on animals, shielding them from further stress. The bag itself acts as a visual barrier. As West, Heard and Caulkett (2007) state, "Animals in bags tend to relax as outside stimuli and visual threats are removed".

7.3 Capture and Restraint Techniques

Figure 7.2: Catching net for small dasyurids, used while the animal is in an active state.

Nest boxes of dasyurid species can be designed to accommodate a wooden panel, which is slid over the entrance. This functions to seal the kultarr temporary inside. Alternatively, the panel can be held over the nest box opening by the carer, for the purpose of capture.

Jackson (2003) suggests "….the best way to catch them [small species of Dasyurid] is by tipping them into a nest box and into a cloth bag". However, the nesting material inside the nest box, such as straw, must be taken into account.

The animal alternatively can be accessed through removing the lid of the nest box and, with a cloth bag, inverted over one's hand; they can be caught directly, with the opening of the bag positioned over the animal. If active and located outside the nest box, this same approach can be adopted, with the animal firstly being isolated in the corner of the enclosure (Jackson, 2003).

Nesting material is disposed of where necessary, with the draw string pulled tightly and tied securely to restrain the animal. When not handling or weighing the animal, the capture bag can be placed inside a nest box, to ensure the safety of the animal until it is attended to.

Catching nets with pole handles are a necessary in the instance of escape, or if kultarr are housed in a large nocturnal enclosure, for the purpose of capture (*See* ***Figure 7.2***). Caution must be taken to prevent accidently crushing this small species. The net is placed directly over the animal, securing it within the circular mesh frame of the catching pole. The net can be twisted closed by the pole handle and manipulated to access the animal as required (Jackson, 2003). Caution must be taken to avoid the animal entangling in the mesh to prevent injury.

Chemical restraint is not advised for the kultarr, due to the psychological and bodily stress to the animal. Nevertheless, if chemical restraint is deemed necessary, special caution must be taken to ensure the correct dosage of anaesthetic is injected. Staff must be aware of the kultarr's reaction to the particular anaesthesia to respond accordingly. A veterinarian with native mammal experience should be contacted to perform the task.

The dominant safety concern to the carer in the capture of kultarrs is the ability of the animal to bite through the capture bag. Although harm to the keeper is minimal, gloves that enable the manoeuvrability of hands and fingers can be used as a precaution to prevent damage to skin. Also, the bag is to be held out of the reach of the animal inside where able.

7.4 Weighing and Examination

Securing the animal in a capture bag after removal from the nest box, enables weights, pouch checks and a close examination to be performed. Stress is reduced by keeping noise to a minimum. A spring balance provides an accurate reading of weight, in comparison to a standard scale, in which the reading may fluctuate due to the animal's movements. The draw string of the cloth capture bag, tied securely, is suspended over the hook of the spring scale. The weight of the bag is then recorded prior to the animals capture. The process is repeated once the animal is restrained in the cloth bag, to gain a reading of the total weight of the specimen and bag. The former weight reading is deducted from the latter, to determine the weight of the specimen.

The handling of the animal occurs primarily through the capture bag (Jackson, 2003). Relying on tactile senses, the keeper can cup their hand gently over the front half of the kultarr through the cloth of the bag (Woolley, 1982). When the animal is secure and supported appropriately, the bag can be untied. Allow only the lower body of the animal to be exposed, with the head concealed in the bag to reduce stress (Woolley, 1982). At this stage, the pouch development of the specimen can be examined in the case of females and a close examination of the animal's condition can be performed. Scrotum measurements of males can also be undertaken (Woolley, 1982).

Daily observations of animal behaviour and health can be performed readily when animals exit the nest box during feeding time. This, alongside removing the animal from the enclosure for cleaning, provides the opportunity to note the quality of the coat, examine the animal for dischargers, lameness and other injury, note food consumption or lack of and the quantity and state of faeces (Jackson, 2003). If residing in the nest box, the lid can be removed to ensure the animal is in a good physical state of health.

7.5 Release

Kultarr can be returned directly into their captive environment on the completion of transporting the animal, examining, pouch checks, recording weights or implanting identification. The draw string bag is untied and opened inside the enclosure. Holding it horizontally against the ground, the lower half of the bag can be raised slightly to encourage the animal to exit.

Alternatively, if the kultarr was restrained solely in the nest box, the nest box can be returned to the enclosure, with the animal contained inside. The wooden panel blocking the opening of the nest box is removed to enable the animal's release. The animal's condition can be monitored throughout the day, particularly in relation to signs of stress, such as trembling, vocalisation and flight responses.

7.6 Transport Requirements

7.6.1 Box Design

Box design is a high concern in regards to limiting stress and dangers to animals during travel, as well as in facilitating for their physical needs. Furniture is a dominant consideration. However, the potential for it to cause harm to an animal must be noted, with branches, for example, presenting a possible crushing risk for kultarrs.

A timber transport box is suitable, as recommended by the IATA (*see* ***Figure 7.7***) (Jackson, 2003). This functions to protect kultarrs from exposure to the elements, throughout transport box handling and during transport. The available space within the transport box must accommodate the size of the animal and ideally, enable the ability to stand and move for comfort purposes. Jackson (2003) suggests that "For smaller species [of dasyurid]…. the box can be divided into two or more compartments for easy convenience". Wooden panels are suitable to separate the compartments (*see* ***Figure 7.5*** & ***Figure 7.6***). A 'Live Animal' label is essential on the box to ensure correct handling (*see* ***Figure 7.4***).

Standard dimensions for the size of an individual compartment are length of 12 cm, width of 6 cm and height of 17 cm. A minimum of two air holes per compartment (diameter of 1.5 cm) are required as well as mesh for ventilation.

Figure 7.3. Standard timber transport box for kultarrs.

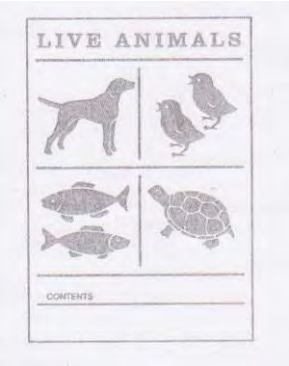


Figure 7.4. Essential label on live animal transport boxes.

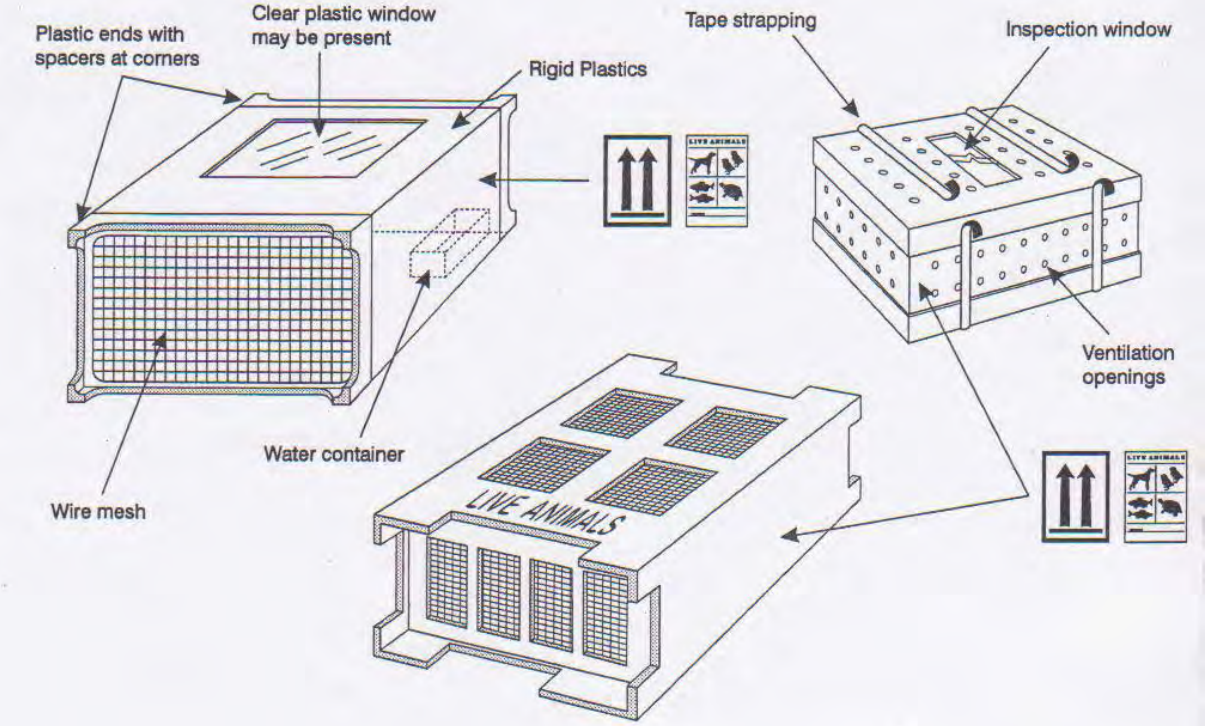
Dimensions (min): 10 x 15 cm

Font size (min): 2.5 cm in height

Figure 7.5: Photograph from above displaying the four separate compartments of a kultarr transport box.

Figure7.6: Photograph demonstrating the use of air holes, ventilation mesh and arrow signage (this way up) to ensure the transport box is handled appropriately.

Figure 7.7: IATA Live Animal Regulations, 2000 - Container Requirement
According to the IATA Live Animal Regulations, the following box design is appropriate for the transport of Jerboa marsupials:



(IATA Live Animal Regulations, 2000)

7.6.3 Water and Food

Water and food is inappropriate to provide during travel, with water likely causing spillage and further stressing the animal. Feeding live invertebrates during transport is impractical, with foraging behaviour restricted by being constrained in a cloth bag. Ideally, the animal should be kept in a calm state. Feeding, therefore, is likely to stimulate behaviours that may put the animal at risk inadvertently.

7.6.4 Animals per Box

Kultarrs should remain in a small cloth bag, which is located inside an individual compartment of the transport box (Jackson, 2003). Only one animal should be transported in each individual compartment for safety purposes. Also, this is to limit stress which otherwise, could be heightened through the presence of another animal. Furthermore, Jackson (2003) notes, “Females with pouch young should not be transferred unless only recently born and still attached to the teat. Although, even then there is some risk that a stressed female will remove her young”.

7.6.5 Timing of Transportation

From personal experience, kultarrs tend to be the least active during the morning period, and generally reside in the nest box until disturbed. Therefore, this is a suitable time for transport. However, depending on the length of travel, the peak heat of the day as a potential stress and health factor of these animals must be considered.

7.6.6 *Release from Box*

Once the transport box has been opened and access to kultarrs in the cloth bags is enabled, it is necessary to examine their condition and ensure they are in a healthy state. The animals can then be released directly into the enclosure. The tie of the cloth bag is undone, with the bag supported on a solid surface. The end of the cloth bag is raised slightly, encouraging the animal to exit. The condition of the animals is monitored throughout the remainder of the day for signs of stress.

8 Health Requirements

8.1 Daily Health Checks

Feeding time provides a vital opportunity to observe kultarr health. Despite their typically nocturnal nature, many specimens are lured outside the nest box once food is provided.

According to Jackson (2003), key elements that should be noted in regards to kultarr health include:

- Secretions from mucous membranes or cloaca.
- Any cuts, abrasions or other injury
- Quantity and condition of faeces (e.g. diarrhoea)
- Atypical behaviours.
- Lameness or ataxic movement. (Animals should stand upright and have the ability to perform agile, swift movements as when catching prey insects).

It is recommended that animals be sighted at least every second day, and thus it may be necessary to check inside the nest box. However, when paired for breeding it is necessary to minimise disturbances and therefore the animals may not be checked as frequently (with an exception of the first few days of being introduced, to observe and monitor potential aggressive behaviour). However, checking the nest boxes may be a cause of stress to kultarrs as indicated by vocalisation as a defensive behaviour.

Trembling may also be observed as an indicator of intolerance to cold temperatures and the need produce heat (Vogelnest & Woods, 2008). To conserve energy, periods of torpor may ensue, with the kultarrs temperature decreasing to 11^{o}C (Vogelnest & Woods, 2008). For the efficient monitoring of small dasyurids, it is necessary to be aware of this thermoregulation method and adjust temperatures accordingly throughout the summer and winter months.

Furthermore, if the animal is not observed eating, the food offered can be examined the following day to determine whether the specimen has fed overnight, when they are the most active.

8.2 Detailed Physical Examination

8.2.1 Chemical Restraint

8.2.1.1 Anaesthesia by inhalation

The preferred method of administering anaesthesia to dasyurid species is via inhalation (Vogelnest & Woods, 2008). The animal will require to be physically restrained in a catching bag for the anaesthesia to be introduced (Vogelnest & Woods, 2008). The animal's head can be manoeuvred into the bags opening, allowing a mask to be positioned over the head (Vogelnest and Woods, 2008).

The lowest risk method of administering general anaesthesia is through a non-rebreathing circuit such as an Ayre's T-piece (Vogelnest & Woods, 2008; Holz). Emphasis must be placed on minimising stress of the animal by maintaining it in a quiet environment, as well as reducing any visual disturbances (e.g. it may be necessary to limit the number of people present).

To induce anaesthesia via inhalation, 5% isoflurane at a rate of 200 mL/kg/min is appropriate for dasyurid species (Vogelnest & Woods, 2008; Holz). It may be necessary for 2% isoflurane to be administered to maintain the animal in this condition (Vogelnest & Woods, 2008; Holz). The task should be performed by an experienced native mammal veterinarian.

8.2.1.2 Anaesthesia by injection

Successful general anaesthesia of a dasyurid can be achieved with tiletamine/zolazepam (a combination referred to as zoletil) at a rate of 7-10 mg/kg injected intramuscularly (Vogelnest & Woods, 2008; Holz). This anaesthesia acts quickly with only small dosages required (Vogelnest & Woods, 2008, Holz). Alternatively, for a light anaesthesia a combination of xylazine at 4mg/kg and ketamine at 20 mg/kg is administered intramuscularly (Vogelnest & Woods, 2008; Holz). This enables the muscles to remain in a relaxed state comparatively (Vogelnest & Woods, 2008; Holz).

Woolley (1982) recommends the use of sodium amytal at 0.08g mg/g of body weight for the anaesthesia of small dasyurid species. A solution consisting of "10 mg of sodium amytal per 1 mL of sterile distilled water" was developed, with half administered into the animal's left and right thighs (Woolley, 1982). The anaesthesia took effect within a 30 minute period (Woolley, 1982). Further injection of the solution at a quarter of the first volume was sometimes necessary to maintain the animal under sufficient anaesthetic (Woolley, 1982). This level of anaesthesia provides a maximum time of 45 minutes in which surgery could be performed (Woolley, 1982). Woolley (1982) discarded the use of ether as an anaesthetic due to its potential to induce vomiting, and thus it presented a high choking risk.

8.2.1.3 General concerns

The level and type of anaesthesia required will be dictated to an extent by the risk of the procedures to be performed (e.g. blood collection will not require as strong a dosage as a surgical procedure).

It is recommended that dasyurids be fasted 6-8 hours prior to the administration of anaesthetics (Vogelnest & Woods, 2008). Although regurgitation is not typically common, this is a suitable precaution (Vogelnest & Woods, 2008).

Veterinarians and native mammal keepers must be aware of the potential stresses and risks of anaesthesia. As physical restraint is required for successful administration, this in

itself provides the opportunity for blood collection, micro-chipping and other such minor procedures without the need to actually anaesthetise the animal. Therefore, the animal can be returned into familiar environment more rapidly, without undergoing greater distress. In either case, it should be monitored following the stressful experience and therefore, such procedures are best performed in the early morning.

Due to the fast metabolism and small body mass of the kultarr (< 35g) it is essential that the anaesthetic agent is measured correctly and administered in the appropriate dosage. There is minimal margin for error, with the potential for mortality if the procedure is not done so correctly.

8.2.2 Physical Examination

Blood collection: Although Vogelnest & Woods (2008) suggest anaesthesia is typically necessary for taking blood samples from dasyurids, this is not always the case in smaller species. Successful venipuncture may be achieved on the kultarr, by restraining the upper half of the body in the catching bag. Limiting visual stresses in this manner generally has a calming effect.

The animal can be gently held in place in a state of dorsal recumbancy, while a veterinarian performs the procedure (Vogelnest & Woods, 2008). The jugular vein in particular can be used for blood collection in all species of dasyurid (Vogelnest & Woods, 2008). Caution must be taken to avoid retrieving any more than 10% of the animal's total blood (this is equivalent to about 1% of body weight).

Body mass/weighing: Due to the fast metabolic rate of small dasyurid species, it is recommended that kultarrs be weighed on a weekly basis (Jackson, 2003). Weights should be recorded to provide a working history of the animal's physical condition, allowing comparison to previous dates. Food quantity provided should be adjusted accordingly in the case of an underweight or overweight animal and feeding behaviour monitored. Providing additional environmental enrichment may result in increased activity to encourage a decrease in body weight if required (Vogelnest & Woods, 2008).

Body condition: Observe for any lacerations, abrasions or further injury (Jackson, 2003). This physical detailed examination can be performed under physical restraint, to minimise the use of chemical agents as well as the health risk to the animal.

Eyes: The eyes should be clear, free of discharge and display the appropriate response to light sensitivity (Jackson, 2003). Also, the corneal reflex can be tested alongside observations of whether the eyes appear alert and devoid of any cloudiness (Jackson, 2003).

Nose: The nasal orifice should be clear and free of secretions (Jackson, 2003).

Cloaca: The cloaca should be observed for the presence of faeces as a possible indication of diarrhoea. The cloaca is generally clean in a healthy animal (Jackson, 2003).

Fur condition: Healthy animals should have full, clean coat of fur (Jackson, 2003). Fur should be examined for potential ectoparasites (Jackson, 2003). A scruffy appearance may suggest lack of grooming, indicating a behavioural change reflective of a greater problem. Alternatively, dishevelled appearance may be result of kultarr pair interactions.

Females – pouch checks: Pouch checks enable observations of pouch development as a potential indicator of reproductive state. Young may also be examined and their estimated age determined through physical restraint of females (Jackson, 2003).

Males – scrotum measurements: Scrotum measurements can be performed to keep track of male reproductive status (Jackson, 2003; Woolley, 1983). Scrotum of an animal in good condition is ideally firm (Jackson, 2003).

Pulse and respiration rate: An animal under anaesthesia provides the opportunity for accurate data on pulse and respiration rates to be obtained, as these may heighten with the stress of capture and restraint (Jackson, 2003).

Body temperature: Measurements of body temperature can be taken through the rectum if absolutely necessary (Jackson, 2003). Special caution must be taken to avoid injury to this small and delicate dasyurid.

Trembling is a sign of insufficient warmth. However, this may also be a stress related response. Self-licking and panting is a mechanism of "evaporative cooling" in dasyurids, indicating overheating (Vogelnest & Woods, 2008).

8.3 Routine Treatments

8.3.1 Worming

Routine treatment with anthelmintics may assist in the prevention of endoparasitic worms (Jackson, 2003). Droncit specifically is effective in the control of tapeworms (Jackson, 2003).

8.3.2 Vaccination

There is little information available regarding vaccinations for the common ailments of small dasyurids. Many captive animal diseases are present in collections due to failure to meet preventative measures (e.g. poor preparation of sheep mince responsible for toxoplasmosis or metabolic bone disease as a consequence of not supplementing calcium in the diet).

8.4 Known Health Problems

8.4.1 Ectoparasites

Cause: Species of fleas including *Echidnophaga* and *Uropsylla* as well as mite species such as *Demodex* and tick species such as *Ixodes sp.* may have adverse impacts to dasyurid health (Jackson. 2003). Species of mite from the genus *Austrochirus sp*. have been introduced into captive populations by being present on rodents used as a food source for dasyurids (Woolley, 1982).

Signs: Infected animals may display excessive scratching behaviour and subsequent hair loss (Jackson, 2003). The flea species, *Echidnophaga* and *Uropsylla* may result in great discomfort, aggravating areas such as the face, ears and scrotum (Jackson, 2003). This has been noted in larger dasyurid such as species of quoll and Tasmanian devils (Jackson, 2003).

When Brown Antechinus (*Antechinus stuartii*) and Yellow-footed Antechinus (*Antechinus flavipes*) were infected with the mite species, *Austrochirus sp*. the specimens suffered a dramatic decline in the health of the fur and skin (Woolley, 1982). Kultarr may suffer to the same degree.

Treatment: Particular caution must be taken when attempting treatment of ectoparasites in small dasyurid species. Woolley's (1982) attempts to eliminate ectoparasites from Brown Antechinus and Yellow-footed Antechinus resulted in fatality in some instances, with the method being to dust the specimens with 0.1% Gammexane. Those restricted in a capture bag following the treatment generally had a lower survival rate (Woolley, 1982).

Treatment of small dasyurids of mites may involve bathing the animals in a Telmosol dilution of 1:15 with water. A light dose of anaesthetic was administered to enable easier submersion of the specimens (Jackson, 2003; Woolley 1982). This method was successful in eliminating the parasites, but nevertheless 3 out of the 12 specimens did not survive the treatment (Jackson, 2003; Woolley, 1982).

Jackson (2005) suggests management of ectoparasites by subcutaneous injection (200 mcg/kg) of carbaryl or ivermectin.

Prevention: To avoid introducing ectoparasites into a dasyurid enclosure, the feeding of infected rodents is not recommended (Jackson, 2003; Woolley, 1982). Maintaining hygienic conditions in captive institutions reduces the prevalence of naturally present parasites such as those infecting wild specimens (Woolley, 1982). Regular cleaning and disinfection of enclosures and nest boxes, alongside the disposing of old nest box material and the introduction of fresh material is recommended (Woolley, 1982). These hygienic practices are particularly relevant during the 2 to 3 weeks following a wild specimen's introduction into a captive environment (Woolley, 1982).

8.4.2 Endoparasitic worms

Cause: Dasyuridae have the potential to become infected with parasitic worms such as nematode or hookworm species (including Ascarids, *Mackerra* s*trongylus spp*, *Cylicospirura* and *Trichinella spiralis)* and cestode or tapeworm species (including *Anoplotaenia* and *Taenia ovis)* (Jackson, 2003; Colville & Berryhill, 2007).

Signs: Signs are generally not apparent, although evidence of worms may be present in faeces through diagnosis. (Jackson 2003).

Diagnosis: Diagnosis is achieved through faecal floatation, determining the infestation of worms in the faeces via detection of eggs and proglottids (segments of the worm body) (Jackson, 2003).

Treatment: Treatment of tapeworms involves the use of anthelmintics (e.g. Droncit) for the elimination of the endoparasites (Jackson, 2003). See specific drug treatment instructions for details.

Prevention: Maintaining enclosures in a high standard of hygiene through daily disposal of faeces is a simple preventative measure (Jackson, 2003). Regular treatment with anthelmintics is a further precaution (Jackson, 2003).

8.4.3 Toxoplasmosis

Cause: Toxoplasmosis, resulting from the protozoan, *toxoplasma gondii* has been reported in kultarrs and has caused fatalities in captive specimens (Jackson, 2003). It is introduced into captive populations primarily through the feeding of infected raw minced meat (Woolley, 1982; Vogelnest & Woods, 2008). Specifically, the feeding of minced sheep was connected with the prevalence of toxoplasmosis (Woolley, 1982). However, contact with contaminated cat faeces, as the definitive host of the disease, or water and food sources that have been contaminated with cat faeces is a further mode of infection (Vogelnest & Woods, 2008).

Signs: Signs of infection include lack of coordination or ataxia, atypical behaviour, sight impairment, anorexia, paralysis and neurological disorders (Jackson, 2003; Vogelnest & Woods, 2008).

Diagnosis: A range of diagnostic procedures are available for the identification of toxoplasmosis (Vogelnest & Woods, 2008; Jackson, 2003). Detection of the disease in a living specimen can be performed through the direct agglutination test (DAT), latex agglutination test and modified agglutination test (MAT) (Vogelnest & Woods, 2008). The direct agglutination test “measures levels of IgG and IgM”, with the level of “titres” increasing within 7 to 10 days following contraction of the disease (Vogelnest & Woods, 2008). Seek consultation from a native mammal veterinarian.

Post-mortem examination may reveal inflammation of vital organs including the brain, liver and lungs. Muscles of the bladder gut and neck region as well as lymph nodes may also be affected (Jackson, 2003).

Treatment: Treatment of dasyurid species for toxoplasmosis involves administering clindamycin at 10 mg/kg throughout a 4 week period (Woods and Vogelnest, 2008). Alternatively, atovaquone at 100 mg/kg or trimethoprim-sulphonamide at 15 mg/kg can be administered for a minimum of 30 days (Woods and Vogelnest, 2008). However, it must be noted that attempts to treat for toxoplasmosis generally fails and therefore, prevention must be the main focus (Woods and Vogelnest, 2008).

Prevention: Freezing meat for a minimum of 4 weeks prior to feeding enables the *Toxoplasma* cysts to be disabled (Woolley, 1982). Alternatively, meat can be cooked to a minimum of 66^{o}C prior to feeding (Woods and Vogelnest, 2008).

Furthermore, meat from beef in preference to sheep mince can be used, as the toxoplasmosis is less prevalent in cattle (Woolley, 1982). Therefore, there is the potential for minced meat to be fed in small portions to assist substituting the insectivorous wild diet to an extent (Woolley, 1982).

Autoclaving apparatus assists in maintaining sterile captive conditions free of disease (Vogelnest & Woods, 2008). The access of cats to enclosures and animal food and water sources must be avoided (Jackson, 2003).

8.4.4 Calcium deficiency

Cause: Predominantly meat diets have low calcium (13 mg/100g) and high phosphorous (200 mg/100g) content (Woolley, 1982). Thus, in regards to the nutritional value of the diet, there is insufficient calcium to phosphorous ratio (according to Woolley's (1982) research, calcium to phosphorous ratio of 2:1 – 1:1 is necessary for the body to remain in a healthy condition).

Signs: Signs of metabolic bone disease include deformed growth, lameness of limbs, poor posture and awkward gait (Jackson, 2003). Furthermore, the bones constructing the skull may be abnormally soft and fragile and to an extent, transparent (Woolley, 1982).

Diagnosis: Fragility of bones can be detected through radiography of the pelvic bone and spine (Jackson, 2003).

Treatment: Early diagnosis may be achieved through radiography for the identification of poor skeletal density of the pelvic and vertebral bones (Jackson, 2003). Treatment through a diet with high calcium and vitamin D3 content as well as keeping activity to a minimum may have positive results (Jackson, 2003).

Prevention: Calcium supplementation is a necessary preventative measure (Jackson, 2003). Products such as RepCal that are readily available at the majority of pet or reptile supply stores are adequate for this purpose (*See **Appendix** for supplier details*).

8.4.5 Pancreatitis

Cause: Lesions of the pancreas have been identified in dasyurid species including the kultarr (Attwood & Woolley, 1980; Vogelnest & Woods, 2008). These may be associated with necrosis or the prevalence of toxoplasmosis cysts (Vogelnest & Woods, 2008; Attwood & Woolley, 1980).

Signs: Diagnosis is required to identify presence of disease.

Diagnosis: Woolley and Attwood's (1980) studies involved removing the pancreas and holding it in "formol acetic alcohol" for a minimum of 24 hours, and then maintaining it in a solution of 70% alcohol and noting recordable observations. 2 of the 8 pancreas of kultarrs studied contained lesions (Attwood & Woolley, 1980).

Treatment: Inadequate data is available.

Prevention: Inadequate data is available.

8.5 Quarantine Requirements

8.5.1 Maintaining hygiene standards

For all species, quarantine conditions must be maintained at an acceptable standard of hygiene to minimise disease prevalence. Personal protective equipment of staff is of optimum importance, particularly when disposing of potentially contaminated faeces. Products such as F10SC Veterinary Disinfectant assist in maintaining enclosures in a sterile state, for the elimination of pathogens. Also, separate cleaning tools and food preparation equipment is necessary, to isolate any potential infectious disease from the bulk of the captive population. Animal care duties of specimens in quarantine should occur after all other animals have been tended to, to avoid healthy animals from becoming infected.

8.5.2 Quarantine housing

Hospitalised kultarrs or small terrestrial dasyurids in quarantine can be housed in a stainless steel enclosure with clear, glass panelling, enabling the animal to be visible to carers (*see **Figure 4.2** & **Figure 4.3***). An external nest box connected to the bulk of the enclosure provides easy access to the animal at minimum stress, enabling capture and close examination to take place. The small surface area of the enclosure (as opposed to a nocturnal house for instance) allows for the easier collection of faeces, to perform faecal flotation. Also, with the animal isolated, there is no concern regarding the faeces being that of an alternative animal. Stainless steel water and food dishes can be used, as they are easy to maintain in a hygienic state, in comparison to potential alternatives.

8.5.3 AQIS Quarantine regulations

According to the Australian Quarantine Inspection Service, a monotreme or marsupial must be maintained in post-arrival quarantine (PAQ) for a minimum of 30 days prior to admittance into another collection (Banks, 1999). However, if the intention is to import a dasyurid species from a country or region that has not been identified as a rabies-free zone by AQIS, they must remain in quarantine for four months. This must occur in a Government Quarantine Station or the facilities of a zoo recognized as an AQIS registered institution (Banks, 1999).

Medical procedures and general examinations conducted throughout quarantine include:
1) Treatment with parasiticide, particularly for the elimination of ticks.

2) Examinations of the animal that affirm it is in a healthy condition, performed by a recognised wildlife veterinarian, or the quarantine stations official veterinarian. The animal must be announced to have no infestation of endoparasites and be in a state suitable for transport.

3) Any further recommended testing or treatment as deemed necessary by the Director.

8.5.4 Disease concerns

According to Woodford (2000) "The purpose of quarantine is to allow the detection of those animals which may be incubating a disease with a short incubation period and also to detect the clinical signs of diseases with a longer incubation period". Therefore, knowledge of disease incubation and transmission is necessary for successful quarantine practices to be put in place.

Toxoplasmosis: It should be noted that occysts of toxoplasmosis may remain viable in the external environment for an 18 month period, with infected flies, cockroaches and earthworms presenting a means of transmission (Woods and Vogelnest, 2008). Cysts have the potential to never be discarded from the infected animal (Colville and Berryhill, 2007). Stevenson (1988) suggests the incubation period may be between a matter of days and four weeks. In regards to potential human infection, it is essential that any open skin be covered, to avoid possible transmission of the disease into the blood while performing food preparation (Shakespeare, 2002).

9 Behaviour

9.1 Activity

Alike with the majority of small dasyurid species, the kultarr is nocturnal and thus the majority of its activity occurs after dark (Cronin, 2000; Jackson, 2003). The nocturnal nature of the kultarr is particularly significant as an adaption to desert environments (Egerton, 2005). This, in part, is to avoid being exposed to the peak heat of the day. The most notable of the kultarrs nocturnal activities is foraging/hunting behaviour. Observations of this on captive specimens can be achieved by the use of infrared video surveillance cameras, included in an exhibit (*see* ***Figure 9.1*** *&* ***Figure 9.2***).

Figure 9.1: Infrared camera suspended in kultarr enclosure for the monitoring of nocturnal behaviours. Video images can be recorded and displayed on a television monitor.

Figure 9.2: Photograph from perspective of infrared camera within a kultarr enclosure.

During the day, wild kultarr may seek shade and protection in cracks in the soil beneath species of *Acacia* and *Eremophilia*, in tussocks of saltbush and Spinifex, in hollow logs, tree stumps or underneath rocks (Cronin, 2000; Strahan & Van Dyck, 2008). They may also inhabit the abandoned burrows of species such as hopping-mice, trapdoor spiders, goannas and lizards of the family, Agamid (Cronin, 2000; Strahan & Van Dyck, 2008). Despite observations of captive kultarr constructing shallow burrows and concealing the opening with grasses, it is uncertain whether wild animals display such behaviours (Strahan & Van Dyck, 2008; Cronin, 2000).

The kultarr is a terrestrial species, with a quadrapedal method of locomotion (Cronin, 2000; Dyck & Strahan, 2008). They are capable of great manoeuvrability, shifting from the hind legs to forefeet to spring itself forward in a ‘gallop’ motion (Strahan & Van Dyck, 2008; Cronin, 2000; Ride, 1970). Thus, their gait accommodates rapid movements, as well as a pivoting motion of the forefeet enabling a swift change in direction (Strahan & Van Dyck, 2008; Egerton, 2005; Cronin, 2000). Thus, they are able to evade predators or prevent being bitten by risky prey invertebrates such as centipedes and spiders

(Strahan & Van Dyck, 2008; Cronin, 2000; Egerton, 2005). Furthermore, they have the ability to stand bipedal upon the back legs as a response to disturbances or to evaluate their surroundings (*see* ***Figure 9.4***) (Cronin, 2000). This behaviour may be used also to gain a visual perspective above the underground burrow shelter (Ride, 1970).

Kultarrs may spontaneously enter a torpid state (Cronin, 2000; NPWS, 2002). This is a method of surviving periods of food and water shortage as well as to conserve energy (Cronin, 2000; NPWS, 2002). This means of thermoregulation enables greater longevity of the kultarr in unpredictable arid environments (Geiser, 1986; NPWS, 2002). In a laboratory situation, the greatest duration of torpor was between 2 and 16 hours at temperatures between 13 and 20^{o}C (Geiser, 1986). In situations where food was not provided, the onset of torpor occurred at temperatures below 27^{o}C (Geiser, 1986).

Figure 9.3: As kultarrs are a species susceptible to environmental fluctuations, it is necessary to monitor temperature of the enclosures, and respond accordingly. This may assist in identifying the cause of observed behaviours.

Figure 9.4: A wild kultarr standing upright upon its hind legs, examining its surroundings with eyes alert and tail erect.

9.2 Social Behaviour

Kultarrs are typically a solitary species excluding during the breeding season when they interact for the purpose of mating (Cronin, 2000).

9.3 Reproductive Behaviour

There is minimal data available regarding kultarr courtship behaviours. There has been difficulty stimulating mating behaviours of captive kultarrs, with the presumption they require specific conditions, and to be maintained in the photo-period of their natural environments (Woolley; 1982 Aslin, 1984). Nevertheless, wild-caught females, either pregnant or carry pouch young have successfully raised the young to the stage of weaning (Woolley, 1984; Aslin, 1982).

Kultarrs typically mate between the months of July and October (Jackson, 2003). Young remain in the protection of the mother's pouch until 30 days after birth (Cronin, 2000; Strahan & Van Dyck, 2008). After this point they may remain in the safety of a nesting site or upon the mothers back while she forages. Vocal recognition between mother and young is particularly significant to locate young in instances where they have fallen from the mothers back, or have strayed from the nesting site (Strahan & Van Dyck, 2008). Young are weaned between 80 and 90 days of age, and will disperse hereafter (Cronin 2000; Strahan & Van Dyck, 2008; Woolley 1984, Jackson, 2005).

9.4 Bathing

Observations of wild-caught kultarrs have demonstrated sand bathing behaviour for the purpose of maintaining fur in a good, clean condition (Woolley, 1982). However, this behaviour was only stimulated when provided fine textured sand sampled from their natural habitat as opposed to kiln-dried sand of a courser texture (Woolley, 1982). Thus, the animals have demonstrated a preference for sand texture, with fine sand specifically encouraging natural behaviours.

9.5 Behavioural Problems

Captive kultarrs do not appear to be prone to stereotypical behaviours as are other dasyurid species. For example, red-tailed phascogales and dibblers have been observed jumping from the nest box, to the roof or wall of the enclosure in a relatively unbroken cycle (pers. obs; Jackson, 2003). Furthermore, Tasmanian devils and fat-tailed dunnarts pace or run continuously on a specific path or route, potentially associated with awaiting feeding time, or for the requirement of a mate (Jackson, 2003) .

9.6 Signs of Stress

Kultarrs are typically a flighty species, and react negatively to circumstances of close-human contact (pers. obs; Ride, 1970). When approached, they may respond by immediately seeking shelter in the nest box. Alternatively, they may remain in a stationary state, alert to the target of threat with staring, focused eyes, and then respond rapidly by seeking shelter when the flight distance has been invaded. Some individuals may rapidly bite the source of the threat (typically being the hand of the keeper) as opposed to retreating. However, it is not confirmed whether this is associated as a stress response, or an eagerness to be fed, however the former appears more likely.

Trembling is among the first signs of stress displayed (pers. obs). Severer forms of stress can be identified by vocalisation as a means of defence. Vocalisation appears to be a response isolated to instances of stress, directed towards conspecifics or humans or alternatively for mother-young recognition (Strahan & Van Dyck, 2008; pers. obs).
Signs of chronic stress in dasyurid species may include lethargy and alopecia (fur loss).

In summary, the predominant signs of stress in the captive kultarr include:

- Trembling
- Retreating into the nest box
- Distressed vocalisation
- Biting

Nevertheless, some captive specimens have displayed inquisitive behaviours, and may approach their carer with presumable interest and excitement associated with feeding time (*See **Figure 9.5, 9.6 & 9.7***). In such instances, particular caution must be taken to prevent the animals escape when accessing the enclosure (e.g. position a wooden panel over the entrance of the nest box, to temporary restrain the animal inside).

Figure 9.5, 9.6 & 9.7: Kultarrs are typically timid and flighty. However, captive specimens may be highly responsive to a keeper's presence by approaching the enclosure glass with eyes alert and ears erect. This is presumably associated with eagerness towards feeding time and inquisitive behaviours in general.

Photographs by: Sam Ridden

9.7 Behavioural Enrichment

There is a variety of methods to enhance a kultarrs captive environment and stimulate the senses. Natural behaviours can be facilitated by:

• ***Providing native branches –*** Including species of *eucalypt*, *wattle* and *acacia* (*see **Figure 9.8***). Ideally, the branches should have a thick, leafy arrangement and positioned laterally to provide adequate shelter areas for the kultarr. Alternating between species serves to introduce new, stimulating scents and textures into the enclosure. This is to occur on a weekly or fortnightly basis.

Safety considerations: Branches present a potential crushing risk to this small dasyurid species. Caution must be taken to ensure the branches are relatively secure and stable in the enclosure as a preventative measure. Furthermore, as fresh branches are retrieved from the natural environment, there is potential disease risk and inadequate hygiene if contaminated with the faeces or urine of other animals.

Also, they may be the source of potentially dangerous invertebrates such as spiders, and thus they should be examined prior to including into the enclosure

Figure 9.8: Thick, leafy eucalypt branches, toilet rolls and egg cartons have the potential to enrich the captive environment through providing shelter areas and stimulating the senses. Breeder's choice animal bedding also facilitates digging behaviour when foraging for live invertebrates.

• ***Sand pit –*** Access to fine grain sand facilitates the natural behaviour of sand bathing and scent marking (Woolley, 1982; Jackson, 2005). This enables high quality coat condition and the cleanliness of fur to be maintained, while serving as an engaging enrichment device (*see **9.4 Bathing** for further details*). The sand pit can be isolated to a section or corner of the enclosure for easy removal and disinfection when necessary. It may also serve to stimulate digging behaviour of the kultarr.

Safety considerations: It is not recommended that food items (e.g. mealworms) be provided concealed within a sand pit. Although this may stimulate increased foraging behaviours, the ingestion of sand may be a potential cause of illness to the kultarr.

•***Cardboard tubes:*** Cardboard tubes serve multiple functions. Some kultarr specimens may select the shelter of the cardboard tubes for resting and sleeping behaviours as opposed to that provided of the nest box (pers. obs.). Furthermore, an individual has been sighted running through cardboard rolls while engaged in foraging behaviour, as among the times of greatest activity (pers. obs.).

Cardboard rolls can be used to conceal pieces of rodent included in the routine diet schedule to increase foraging times. Alternatively, insects can also be provided in this manner, or insects may seek refuge inside when being fed live to encourage foraging behaviours of the kultarr (Jackson, 2003)

Safety considerations: Cardboard rolls should be disposed of on a fortnightly basis or when required and fresh rolls provided. This is to avoid the accumulation of faeces and urine on this temporary furniture as a potential disease risk and source of poor hygiene.

•***Mouse/Rat wheel:*** Providing mouse/rat wheels encourages exercise of small dasyurids, despite being artificially constructed and not particularly aesthetically pleasing (i.e. only suitable for off-display exhibits) (Jackson, 2003). Thus, it may assist to control the animal's weight and prevent obesity (Jackson, 2003).

Safety considerations: It must be ensured that the mouse/rat wheel remains secured to the ground to prevent crushing risk to the kultarr.

•***Basking lamp –*** Small captive dasyurid species respond positively when basking behaviours are facilitated (Woolley, 1982; Jackson, 2005). In Woolley's studies (1982), species including the kultarr were observed leaving the nest box to bask, flattening and stretching their bodies against the ground to absorb warmth. Thus, this facilitates both a behavioural need and provided an adequate thermal gradient within an enclosure (Jackson, 2003; Woolley, 1982). Woolley (1982) used 150W infrared lamps for this purpose, suspended above the flooring of the enclosure at 20 – 50cm. These lamps were turned on five days per week for intervals between one and two hours on these designated days (Woolley, 1982; Jackson, 2003).

•***Rat/mouse scent smears:*** Smearing the scent of a dead rat pup or mouse on the branches and furniture included in the exhibit may stimulate activity of the kultarr. There is a potential for other scents of deceased animals to be used as an alternative such as dead chicks.

•***Mealworm dispenser:*** On days included in the feeding roster designated for mealworm feeding, the specified quantity of mealworms provided (typically 6g per individual) can be done so within a mealworm dispenser. This may simply be designed from a cardboard roll, with a small opening large enough for mealworms to fall out at sporadic intervals.

The sides must be sealed when provided, but be able to open to fill with invertebrates when required. This provides an element of unpredictability for the kultarr due to the random rate mealworms fall.

•***Provision of live insects:*** All insects should be provided live where possible. The active movement of wood roaches and crickets in particular may stimulate a high response from the kultarr, which may eagerly chase the invertebrates (pers. obs.). Although mealworms do not have the capacity to move quickly, they nevertheless encourage digging behaviours when located in substrate (i.e. Breeder's Choice Animal Bedding) and are consumed eagerly (pers. obs.). It is recommended kultarr be fed in the late evening to encourage natural nocturnal foraging behaviours.

•**Nest boxes:** Nest boxes are an essential furniture requirement for the majority of dasyurid species (*see* ***Figure 9.10***). Not only do they facilitate the nocturnal behaviours of the species, providing adequate shelter, privacy and warmth, but also are required for breeding behaviours. Jackson (2003) suggests the use of nest boxes constructed from thin plywood materials for small dasyurids. The inclusion of straw, stringy bark or native grasses as nesting materials fulfils both physical and behavioural needs. Nest boxes are to be located on the enclosure floor to accommodate the kultarrs terrestrial behaviours.

Safety considerations: Nest boxes may present a crushing risk to this small dasyurid species and thus must be placed securely on the enclosure floor as a preventative measure.

Figure 9.9: Although unusual, there may be evidence of female kultarr removing straw from the nest box to construct alternative nesting site.

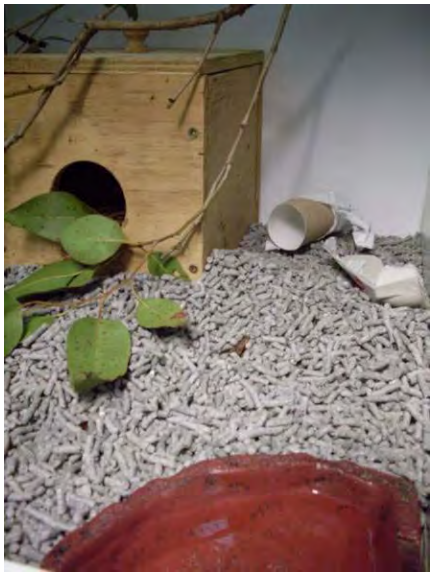


Figure 9.10: Enclosure featuring typical furniture included in a kultarr captive environment including shallow water bowl, nest box, toilet roll and native branches.

•**Introducing scents of conspecifics:** By transferring disposable furniture such as toilet rolls or native branches between kultarr exhibits (particular of different sexes), additional activity may be stimulated, specifically in regards to the olfactory sense. This is particularly significant throughout the breeding season.

Safety considerations: There is a potential disease risk of re-using furniture between enclosures of different specimens if contaminated with urine and faeces.

9.8 Introductions and Removals

It is recommended that specimens are given the opportunity to observe and interact with one another through a mesh patrician prior to enabling physical contact (Jackson, 2003; Woolley, 1982). They are able to familiarise with their potential pair through auditory means, as well as sighting them visually and becoming associated with their scent (Jackson, 2003; Woolley, 1982). Woolley's (1982) cage designs facilitate this means of introducing small dasyurid species. Glass fronting enables keepers or attendants to identify any potential aggressive behaviours (e.g. distressed vocalisation) prior to enabling the animals to share an enclosure. Thus, it is ensured that safety risk is minimal and that the animals are compatible mates (*see **Figures 4.2 & 4.3***).

9.9 Intraspecific Compatibility

The kultarr is a solitary species, and thus, they should only be housed in pairs during the mating season, with males introduced to females in a period of oestrous (Cronin, 2000; Jackson, 2003). Ideally, this should only be attempted after following the precautions described in **9.8 Introductions and Removals**. The aftermath of a pair compatibility issue has been observed, with the least dominant individual injured severely by its mate to the point of death as well as being partially consumed (pers. obs.).

9.10 Interspecific Compatibility

Typically, as dasyurids are carnivorous, they should not be housed with other species due to the potential of consuming those of similar or smaller size (Jackson, 2003). Due to this, as well as their solitary nature, kultarrs should not be housed in mixed-species enclosures.

9.11 Suitability to Captivity

Due to their small size, solitary and nocturnal nature as well as timid behaviours and being susceptible to stress, kultarrs are generally not an ideal species for displaying to the public. If intended for public display for the purpose of education, the species would ideally be maintained in an isolated section of a nocturnal house that other individuals or species do not have access to. Nevertheless, they have been maintained successfully at Alice Springs Desert Park, as well as the native animal research facilities at the Hawkesbury University of Western Sydney, with limited or rare and controlled public access.

10 Breeding

10.1 Mating System

Kultarrs are polyoestrous in their reproductive strategy (Woolley, 1984). Females may endure oestrus up to six times within a single breeding season, occurring throughout mid-summer and mid-winter (Woolley, 1984). The oestrus cycle decreases in length throughout the time of the relatively long breeding season (Woolley, 1984).

10.2 Reproductive history

The breeding season of kultarr populations differs depending on geographic location (Strahan & Van Dyck, 2008; Cronin, 2000). The females of the south-western Queensland population undergo oestrous throughout the period of July to February (Strahan & Van Dyck, 2008). In comparison, the Western Australian females experience oestrous from August until January (Strahan & Van Dyck, 2008). Photo-period is the influencing factor that triggers the breeding season (Strahan & Van Dyck, 2008; Woolley, 1984).

The pouch functions to shelter the young while receiving the first bouts of nourishment, suckling on one of the mothers 6-8 teats (Cronin, 2000; Strahan & Van Dyck, 2008). They remain in the protection of the pouch until 30 days old at which stage they are approximately 25 mm in length (Cronin, 2000; Strahan & Van Dyck, 2008). The young may remain in the nest or alternatively, stay on the mother's back while she hunts (Cronin, 2000; Strahan & Van Dyck, 2008).

Vocalisation is used between mother and young, to identify one another's location (Strahan & Van Dyck, 2008). This is particularly significant in instances where young have ventured from the nesting site or have fallen from the mother's back (Strahan & Van Dyck, 2008).

10.3 Ease of Breeding

According to Aslin (1982), kultarrs must be maintained within particular conditions for captive breeding to take place, although these conditions are yet to be determined or confirmed. Despite the presence of a pouch in females, and the spermatorrhea (that is, the ejection of semen) by males, none of Aslin's (1982) specimens reproduced. Jackson (2003) also notes the difficulty of breeding kultarrs in captivity, with further research required. Woolley (1984) maintained animals at a temperature of 21^{o}C, with 45% humidity throughout his breeding studies; however, no successful captive copulation occurred.

10.4 Reproductive Condition

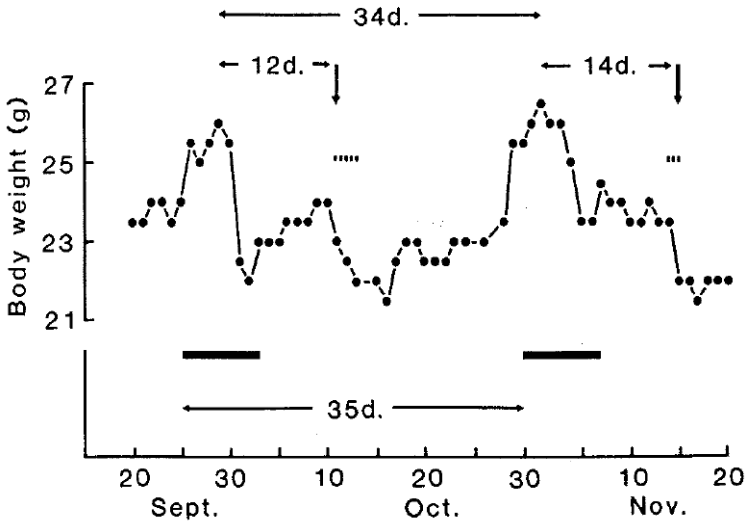
10.4.1 *Females*

The reproductive status of a kultarr female is signified by the development of a pouch, a skin fold with a rear-facing opening (Cronin, 2000; Strahan & Van Dyck, 2008). This forms during the breeding season and diminishes at its conclusion (Cronin, 2000; Strahan & Van Dyck, 2008). Pouch checks can be performed by restraining the animal in a small inverted catching bag, and exposing its lower region (Jackson, 2003; Woolley, 1984) (*see **7.3 Capture and Restraint Techniques** for further details*).

Table 10.1: Determining reproductive status of female kultarrs

Reproductive status	Definition	Identification
Non-parous	Females that have not reproduced	Undeveloped pouch, with no marginal folds present and minute teats. Pale, short hairs present on pouch region.
Parous	Females that have reproduced in the past but are not breeding currently	Teats are marginally elongated. Pouch is small but distinguishable.
Pregnant	Females currently in period of gestation.	Pouch may have pinkish colouration and skin folds visible.
With pouch young	Females that have produced young that are currently sheltered in the pouch and is entirely dependent on the mother.	Pouch young are minute in size but are visible attached to the teat.
Lactating	Young no longer held in the pouch, but continue to suckle from mother producing milk.	Elongated teats and developed pouch area.
Post lactation	Period following weaning of young.	Teats may produce clear liquid and decrease in size.

Figure 10.1 Relationship of epithelial cells in urine, pouch secretions and body weight in female kultarr



Changes in body weight (●) and the occurrence of epithelial cells in the urine (solid bars), and clear secretion in the pouch (broken bars) of female 4 over the third and fourth oestrous periods and pseudopregnancies in 1973. The arrows indicate the end of pseudopregnancy.

(Directly from Woolley, 1984)

10.4.2 *Males*

During the breeding season, the testes of males may enlarge (Jackson, 2003; Woolley, 1984). Measurements of scrotum width can be conducted by one individual restraining the animal in a small catching bag, with its lower portion exposed while another performs the measurements (Jackson 2003; Woolley, 1984). Measurements must be recorded as a unit of millimetres (Jackson, 2003). Scrotum measurements can also be used to determine whether specimen is juvenile or adult (Woolley, 1984). Furthermore, spermatorrhea may be identified in male kultarr. This can occur regularly for up to a period of 6 months at a time and typically is observed from May to January (Woolley, 1984). However, as the testes only fully develop 6 to 8 weeks following the initial spermatorrhea, it is questionable whether kultarr males are able to reproduce prior to July (Woolley, 1984).

10.5 Techniques Used to Control Breeding

Dasyurids are typically solitary species and as such, they should be housed singly unless breeding is intended (Jackson, 2003). To increase the potential for reproductive success, males and females are to be segregated until the breeding season. The reproductive status of females should be monitored through pouch checks approaching this time. If male and female are maintained in shared housing throughout the year, pair familiarity may consequently diminish breeding behaviours. Thus, they are only introduced towards the breeding season (*see **10.2 Captive Reproduction** for further information*) (Jackson, 2003).

10.6 Occurrence of Hybrids

N/A

10.7 Timing of Breeding

According to Jackson (2003), kultarrs typically mate between the months of July and October, with birthing predominantly occurring throughout August and November.

10.8 Age at First Breeding and Last Breeding

Sexual maturity is reached between 8 and 11.5 months of age (Cronin, 2000; Woolley, 1984). Both males and females are capable of breeding up to 24 months of age (Jackson, 2003).

10.9 Ability to Breed Every Year

Both sexes of kultarr have the ability to reproduce in multiple breeding seasons in a captive environment (Woolley, 1984). Thus, unlike wild male antechinus and phascogales, male kultarrs do not die as a consequence related to copulation and reproductive stresses (Jackson, 2005; Woolley, 1984). However, it is uncertain whether wild kultarr generally have a survival rate beyond one breeding season (Woolley, 1984).

10.10 Ability to Breed More than Once Per Year

Kultarr have the potential of producing two litters each breeding season (Jones & Parish, 2006). Their ability to produce multiple litters per year is increased by good conditions and availability of resources (Cronin, 2008).

10.11 Nesting, Hollow or Other Requirements

A wooden nest box must be provided to facilitate breeding behaviours and provide adequate privacy to the kultarr pair or mother and young (*see* ***Figure 10.2 & 10.3***) (Jackson, 2003). Jackson (2003) specifically suggests the use of "thin plywood for small species". Dimensions of 22 cm width, 24 cm height (including lid) and approximately 24.5 breadth, with a circular opening with the diameter of 6 cm have been used successfully at the University of Western Sydney Hawkesbury native mammal facilities. The nest box is to be located securely on the ground of the enclosure, to accommodate the terrestrial behaviours of kultarr and limit crushing risk.

Figure10.2: Kultarr remaining in shelter of nest box, displaying typical nocturnal behaviours

Straw has been successfully used at the University of Western Sydney mammal facilities as a nesting material, providing adequate warmth and comfort to kultarr specimens. Further alternatives include stringy bark or grasses (Jackson, 2003). Despite evidence of a kultarr removing from a nest box to construct a nest-like structure in the corner of the enclosure, it is unlikely this was related specifically to breeding behaviours, based on time of year and being housed singly (*see* ***Figure 9.9***).

Wild kultarrs may nest in hollow logs or the abandoned burrows of species such as goannas, Spinifex hopping mice or trapdoor spiders (Egerton, 2005; Strahan & Van Dyck, 2008). However, it has not been confirmed whether kultarrs may construct their own nest in the wild. Nevertheless, captive specimens have been recorded digging burrows and concealing their openings with grasses (Strahan & Van Dyck, 2008),

10.12 Breeding Diet

Additional food should be provided to female kultarr to fulfil increased energy requirements while reproductively active. This includes the period of pregnancy and lactation. The additional quantity provided should be based on the animal's increased weight and whether it is producing milk for young.

10.13 Oestrous Cycle and Gestation Period

Woolley's (1984) studies have determined that the gestation period of the kultarr is up to 12 days in length. This research also established that the oestrus cycle of the kultarr is approximately 35 days in length (Woolley, 1984). Oestrus cycles are first identified 2 to 4 weeks following the winter solstice, in July (Woolley, 1984). They conclude 2 to 5 weeks following the summer solstice, in January (Woolley, 1984). This indicates photo-period as a factor influencing the occurrence of the breeding season (Woolley, 1984).

10.14 Litter Size

Kultarr females may produce between 5 and 8 young in a single litter each breeding season (Cronin, 2000; Jackson, 2003).

10.15 Age at Weaning

Kultarrs are independent at 3 months of age (Cronin, 2000; Strahan & Van Dyck, 2008; Woolley, 1984). At this point both wild and captive young are weaned (Cronin 2000; Strahan & Van Dyck, 2008; Woolley 1984). The weaning process in captivity involves restraining young in catching bags and housing them in enclosures individually.

10.16 Age of Removal from Parents

As sires do not participate in the care of young, they are to be removed from their female pair once successful mating has occurred. Kultarr young are separated from dam at 3 months of age, corresponding to the weaning age.

10.17 Growth and Development

Due to difficulties in initiating the captive breeding of kultarrs, there have been minimal studies regarding the growth and development rates of young. Litters typically are detached from the teat at 30 to 48 days of age, when they are approximately 25mm in length (Jackson, 2003; Cronin, 2000; Strahan & Van Dyck, 2008). At this point they are permanently removed from the pouch (Jackson, 2003) (see **10.*2 Reproductive history*** *for further details*). Weaning occurs between 80 and 90 days of age with the young fully independent (Jackson, 2003). They disperse in the wild or are housed individually in a captive environment.

Table 10.2: Growth and development of kultarr (*Antechinomys laniger)*

Gestation period (days)	Detachment from teat (days)	Weaning (days)	Sexual maturity (months)
12	30-48	80-90	11.5

(Jackson, 2003; Cronin, 2000; Woolley, 1984)

In general, the development stages of dasyurid species include:

- Ability for sex determination
- Ear tips emerging
- Distinguishable eye lashes
- Opening of eyes
- Fur growth
- Growth of incisor tips
- Remaining on mother's back or in nesting area
- Consuming solid material
- Feeding without dame assistance
- Independence and dispersion

(Jackson, 2003)

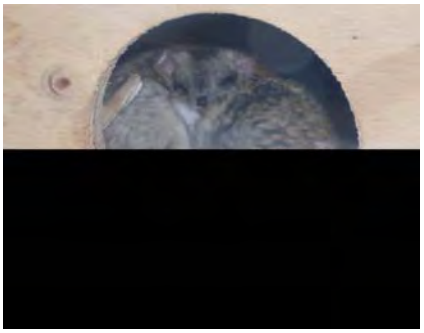


Figure 10.3: Kultarr pair provided with a singular nest box to promote shared nesting behaviours.

10.18 Captive Reproduction

Wild-caught females kultarr, either pregnant or with pouch young may perform maternal duties successfully to the weaning stage of young in captivity (Aslin, 1982). This was true in the circumstance of the two kultarr litters involved in Aslin's (1982) research, despite there being no successful mating.

Particular caution must be taken when pairing specimens for mating, with the potential for aggressive behaviour and consequential injury. Woolley's (1982) cage designs for small dasyurid species facilitates a means to introduce male and female (*see **Figure 4.2 & 4.3***). The mesh partition enables the cages to be divided in two (Woolley, 1982). Through the partition, the pair is able to view each other, and their interactions can be observed and monitored. By this segregation of the sexes, direct physical contact however is limited, to prevent the potential breeding pair causing injury to each other.

If the pair does not display aggressive behaviour after observations lasting a period of days, they may be allowed to share a singular enclosure. Only a singular nest box is provided, to encourage shared sleeping arrangements and consequently, breeding behaviour. However, it may take several days until the pair is willing to share a nest box, with the submissive partner sleeping in the corner of the enclosure, or alternative shelter provided such as cardboard rolls for a time (pers. obs.).

11 Artificial Rearing of Mammals

The artificial rearing of small carnivorous marsupials is relatively rare. This in part, is due to the attachment of young joeys to the female's teat and their delicate nature (Jackson, 2003). However it has been done so with success in species of quoll (*Dasyurus spp*.) and the Tasmanian devil (*Sarcophilus harrisii*) (Jackson, 2003). It is advised that hand rearing only occur when other potential options have failed. Parent-rearing is generally ideal, enabling the animal to learn natural social behaviours and associate with members of its own species. However, in circumstances of abandonment, inadequate maternal care or an orphaned animal, artificial rearing may be present a unique opportunity to ensure the individual's wellbeing.

There have been instances of successful fostering among carnivorous marsupials. For example, this has occurred between a litter of kowari being fostered to an alternative female, who raised both her biological and surrogate young without incident (Jackson, 2003). Similar situations have been successfully applied to Julie Creek dunnarts (*Sminthopsis douglasi*), Fat-tailed pseudantechinus (*Pseudantechinus macdonnellensis*) and particularly, brush-tailed phascogales (*Phascogale tapoatafa*) (Jackson, 2003). Tasmanian devil joeys have been raised by a domestic cat, although such mixed-species fostering is not advised due to differences in milk constitutes as well as the potential for injury to young by the substitute mother (Jackson, 2003).

Figure 11.1: Tasmanian devil joey being gently bottle fed by trained zoological staff.

(Devils in Danger Foundation Inc, 2009).

12 Acknowledgements

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Please note: Any images without references were photographed by Teresa Attard (compiler).

14 Glossary

Alopecic: Loss of fur.

Anthelmintics: Drugs for the treatment of parasitic worms.

Ataxia: Lack of coordination characterised by an abnormal gait.

Bipedal: Method of locomotion involving the use of two legs to initiate movement.

Dasyurid: Taxonomic grouping of carnivorous marsupials, of the family dasyuridae. Characteristics of species vary widely in terms of methods of locomotion and size but nevertheless similarities are evident in morphological features such as dentition and paw structure. (Egerton, 2005; Strahan & Van Dyck, 2008).

Ectoparasites: An organism that gains nourishment from a parasitic relationship to the host from the external of the body (e.g. fleas and mites).

Endoparasites: An organism that gains nourishment from inhabiting a host internally and thus adversely impacts the functioning of the host body (e.g. hookworm).

Epithelial cells: Cells that form the lining of internal tissues of the body.

Intramuscularly: In terms of veterinary application; to inject into the muscle as with a dose of anaesthesia.

Nocturnal: Active during the night.

Oestrus: Period during the reproductive cycle in which females are receptive to mating.

Photo-period: The length of light within a day-night cycle.

Polyoestrous: Reproductive strategy of female animals in which they have multiple oestrus cycles during the span of a singular breeding season. This increases reproductive potential in terms of successful copulation.

Pseudopregnancy: A condition of mammals displaying signs of apparent pregnancy without being pregnant.

Quadrapedal: Method of locomotion involving the use of all four legs to move.

Spermatorrhea: The involuntary ejection of semen, occurring not under the instance of copulation.

Venipuncture: The procedure of collecting blood from the vein.

15 Appendix

Table 5.1: Chemical product information

Product	Company contact details	Active Ingredients and there concentrations	Use	Advantages	Occupational Health and Safety Considerations
•Viraclean  (Viraclean: Hospital Grade Disinfect.)	Company: Whiteley Medical *Address:* 19-28 Laverick Avenue Tomago NSW 2322 *'Product support Hotline'*: 1800 833 566 *Website*: www.whiteley.com.au	•Benzalkonium Chloride 4.255 g/L	Recommended dilution: 1:10 •Viraclean is a general disinfectant, and is appropriate to use on a range of surfaces such as food preparation areas for sanitation purposes.	•Effective against a range of pathogens. •Highly soluble •Not corrosive •Biodegradable •Non flammable	•Avoid contact with eyes and skin. •Rinse out eyes or wash skin thoroughly in the case of contamination. •In the case of swallowing, do not stimulate vomiting and contact a doctor or Poisons information centre. •Wearing Personal Protective Equipment is an appropriate precaution: PVC gloves and goggles. •Read label or MSDS prior to using product. Follow instructions detailing the products appropriate use. •Store in a dark, cool environment.
•F10 SC Veterinary Disinfectant  (F10SC Veterinary Disinfectant)	Company: Chemical Essentials *Address:* 13 Abelia Street, Doncaster East, VIC 3111 *Telephone:* + 03 9841 9901 *Fax:* + 03 9841 9909	•54 g/L Benzalkonium Chloride •4 g/L Polyhexamethylene biguanide hypochloride	Recommended dilution: 1:500 F10SC Veterinary Disinfectant is used as a general cleaner of enclosures, to maintain a hygienic environment and reduce the growth of disease-causing agents.	•F10 SC Veterinary Disinfectant has been designed specifically for the use at captive animal or veterinary facilities. •Animal-safe (if used appropriately). •Destroys a wide range of pathogens. •Classified as a hospital grade disinfectant by the Therapeutic Goods Administration.	•Avoid contact with eyes and skin. •Rinse out eyes or wash skin thoroughly in the case of contamination. •In the case of swallowing, do not stimulate vomiting and contact a doctor or Poisons information centre. •Wearing Personal Protective Equipment is an appropriate precaution: PVC gloves and goggles. •Read label or MSDS prior to using product. Follow instructions detailing the products appropriate use. •Store in a dark, cool environment.

(Information from Chemical Essentials, Whitley Medical and Vet-N-Pet Direct)

(See Material Safety Data Sheets at end of document for further details).

Supplier Information

Product: Rep-Cal Phosphorous-Free Calcium Powder

Company: The Reptile Shop

Address: Shop 4, 6/8 Porrende St, Narellan 2567 NSW Australia.

Phone: (02) 4647 1131

Email: thereptileshop@bigpond.com

Website: www.thereptileshop.com.au

(Prewett)

Product: Live invertebrates and frozen foods

Company: Pisces Enterprises

Postal Address: PO Box 200 Kenmore QLD Australia 4069

Phone: 1800 351 839

Fax: (07) 3374 2393

Website: http://piscesenterprises.com

Email: info@piscesenterprises.com

(Pisces Enterprises)

Product: Small Carnivore Food

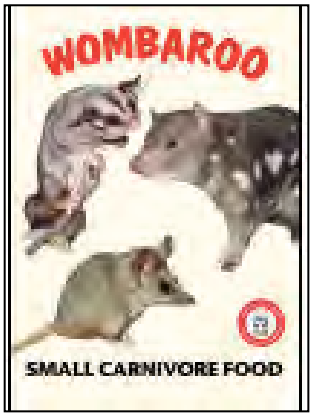
Company: Wombaroo

Postal Address: PO Box 151 Glen Osmond, SA 5064

Phone/Fax: (08) 8391 1713

Website: www.wombaroo.com.au

Email: wombaroo@adelaide.on.net



(Wombaroo)

Product: Breeder's Choice Cat Litter

Company: Fibre Cycle Pty Ltd

Phone: + 61 7 3382 0711

Fax: + 61 7 3386 1088

Website: http://www.fibrecycle.com.au/

&

Company: Pets Pantry

Address: 7 Hartley Court, Rosanna 3084 VIC Australia

Phone: 1300 30 40 34

Website: http://www.petspantry.com.au/

Email: sales@petspantry.com

(Pets Pantry)

Product: Fluon AD1

Company: Australian Entomological Supplies Pty Ltd

Postal Address: PO Box 250, Bangalow, NSW 2479, Australia

Phone: 02 6684 7650

Fax: 02 6684 7188

Website: http://www.entosupplies.com.au/

(Australian Entomological Supplies)

Product: (Natural) Reptile Sand

Company: Pet Pacific

Address: 46 David Road, Emu Plains, NSW

Phone: 02 4728 6000

MATERIAL SAFETY DATA SHEET

COMPANY DETAILS
AUSTRALIAN DISTRIBUTOR:
COMPANY: Chemical Essentials (Pty) Ltd
Address: 13 Abelia Str, Doncaster East,
Victoria 3111
Emergency Telephone number:+03 9841 9901
Fax: +03 9841 9909

MANUFACTURER:
Health and Hygiene (Pty) Ltd
P O Box 347. Sunninghill 2157,
South Africa.
Tel:+27 11 474-1668
Fax: +27 11 474-1670
e-mail: info@healthandhygiene.co.za

IDENTIFICATION

PRODUCT NAME: **F10 SUPER CONCENTRATE DISINFECTANT**

UN Number: None
D G Class: None
Hazchem code: None
Poisons Schedule: 5

HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA IN THE PACK CONCENTRATE ONLY (eyes and skin irritant)

USE: Biodegradable multi purpose Disinfectant for all hard surfaces, equipment and airspaces

PHYSICAL DESCRIPTION/PROPERTIES

Appearance:	Clear, colourless liquid, with a slight natural odour
Boiling Point:	110^{0}C
Vapour Pressure:	Not known
Specific Gravity:	1.00
Flash Point:	Not flammable
Flammability Limits:	Not flammable
Solubility in water:	Soluble

INGREDIENTS

	CAS Number	Quantity (w/w)
Benzalkonium Chloride	68424-85-1	5.4%
Biguanide	27083-27-8	0.4%
Ingredients not determined to be hazardous		to 100%

HEALTH HAZARD INFORMATION

HEALTH EFFECTS:

Acute

SWALLOWED: Low. Substantial ingestion may cause irritation to mouth, throat and digestive tract.

EYE: Low. Will cause irritation but not serious damage.

SKIN: Low. Concentrate may act as mild degreasant to sensitive skin.

INHALED: Low. No significant hazard.

Chronic

INHALED: Low. No significant hazard

FIRST AID

SWALLOWED: DO NOT induce vomiting. Give milk or water to drink. Seek medical advice where necessary.

EYE: Rinse eyes with water. Seek medical advice where necessary.

SKIN: Wash affected area with soap and water.

INHALED: Non-toxic. Avoid long term inhalation of neat liquid. Remove to fresh air.

FIRST AID FACILITIES: Contact a doctor or Poison Information Centre (phone 131126)

ADVICE TO DOCTOR: Treat symptomatically

F10 SUPER CONCENTRATE DISINFECTANT

PRECAUTIONS FOR USE

EXPOSURE LIMITS:	No data found
Engineering controls:	None required
PERSONAL PROTECTION:	Not required
FLAMMABILITY:	Not Flammable

SAFE HANDLING INFORMATION

Storage and Transport:	Store below 30^0C in dry conditions
SPILLS AND DISPOSAL:	Soak up on an inert material e.g. dry earth and dispose of in an area approved by local authority by-laws. Flush small spills with copious amounts of water
FIRE/EXPLOSION HAZARD:	The product is not flammable or explosive.
OTHER INFORMATION:	Ensure good industrial hygiene. DO NOT mix with soaps or other chemicals.

CONTACT POINT: Managing Director, +03 9841 9901
Chemical Essentials Pty Ltd

KEEP OUT OF THE REACH OF CHILDREN

Issue number: **2**

Issue Date: **August 2004**

MATERIAL SAFETY DATA SHEET

Section 1: IDENTIFICATION

VIRACLEAN

Recommended Use: Disinfectant Cleaner.
Product Code: 210556 (2x5L), 210555 (15L), 210564 (12X500mL Trigger Spray), 210574 (12X500mL Squeeze).

Whiteley Medical
A division of Whiteley Corporation Pty Ltd (A.C.N. 000 906 678)
Postal Address: P. O. Box 1076 North Sydney NSW 2059
Telephone Number: (02) 9929 9155 Facsimile: (02) 9929 9077
Emergency Telephone Number: Poisons Information Centre (National) 131126

Section 2: HAZARDS

Not classified as hazardous by the criteria of NOHSC.

Section 3: COMPOSITION INFORMATION

Ingredient	CAS No	Proportion
Benzalkonium Chloride	68424-85-1	0.426%
Proprietary Blend	Not applicable	10-30%
Ingredients deemed not to be hazardous	Not applicable	To 100%

Section 4: FIRST AID

Eye (Contact) Hold eyelids apart and flush the eye continuously with running water.

Skin (Contact) Remove contaminated clothing and flush skin and hair with running water.

Inhalation(Breathing) Remove to fresh air. The product is non volatile at room temperatures.

Ingestion (Swallowing) DO NOT induce vomiting. For advice, contact a Poisons Information Centre (Phone 131126) or a doctor.

Advice to Doctor Treat symptomatically for neutral detergent.

First Aid Facilities Ensure an eye wash is available and ready for use.

Additional Information No aggravated medical conditions are known to be caused by exposure to this product.

Section 5: FIREFIGHTING MEASURE

Suitable Extinguishing Media Solution does not burn. Use extinguishing media suited to the materials that are burning. eg. Dry chemical, CO_2 or water spray

Hazards From Combustion Products	Carbon dioxide and carbon monoxide may be produced in the case of fire or during thermal decomposition.
Precautions For Fire Fighters and Special Protective Equipment	Keep containers cool by spraying with water.
Additional Information	**Hazchem Code** – Not applicable.

Section 6: ACCIDENTAL RELEASE MEASURES

Emergency Procedure	SAA/SNZ HB76: Dangerous Goods – Initial Emergency Response Guide – Not applicable.
Spills / Clean up	Clean up personnel should wear full protective clothing. Restrict access until completion of clean up. Then ensure adequate ventilation. Stop leak if safe to do so. Contain spill with absorbent material, such as towelling, sand, vermiculite or other inert material. Prevent spill entering stormwater drains or waterways. Collect and dispose of clean up material according to local regulations. Wash away remnants with copious amounts of cold water to sewer. Clean area by working from the periphery to the centre of spill or from the edge of the room to the centre.

Section 7: HANDLING AND STORAGE

Precautions for Safe Handling	Contact Whiteley Corporation sales representative for advice when using this product for any application other than that outlined on the label or technical bulletin. Any non-intended or non-authorised use of this product may result in personal injury or damage to equipment. Store product in original container. Wash thoroughly after handling product.
Conditions for Safe Storage	Store in a cool, dry, well ventilated area. Keep container tightly sealed. Store below 30°C.

Section 8: EXPOSURE CONTROL/PERSONAL PROTECTION

National Exposure Standards – Source: National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003].

Ingredient	CAS No	ES-TWA	ES-STEL
None available			

Biological Limit Values	Not available.
Engineering Controls	Use only in a well ventilated area.
Personal Protective Equipment	Eye/face protection – Safety glasses / face shield / chemical resistant goggles should be worn to prevent eye contact. Skin protection – Use Nitrile gloves or similar to prevent skin contact. Respiratory protection – Respirator is not usually necessary but if required use a respirator suitable for organic vapours.

Section 9: PHYSICAL AND CHEMICAL PROPERTIES

Appearance Clear pink liquid

Odour Slight Lemon odour

pH 7.00-7.40

Specific Gravity 0.985-0.995

Vapour Pressure Not Available.

Vapour Density Not Available.

Boiling Point approximately 100°C

Freezing Point approximately 0°C

Solubility Soluble in water.

Flash Point Not Applicable.

Upper and Lower Flammability limits (in air) Not Applicable.

Ignition Temperature Not Applicable.

Section 10: STABILITY AND REACTIVITY

Chemical Stability Stable for period of shelf-life when stored as directed.

Conditions to avoid Avoid high temperatures (store below 30°C). Do NOT store in direct sunlight. Protect against physical damage.

Incompatible materials None known. Do not mix with other chemicals.

Hazardous decomposition products None known.

Hazardous reactions None known.

Section 11: TOXICOLOGICAL INFORMATION

HEALTH EFFECTS

Acute

Swallowed Considered an unlikely route of entry in commercial / industrial environments. May be irritating to gastro-intestinal tract.
Eye May cause irritation and reddening.
Skin May cause irritation.
Inhaled May cause irritation if aerosol inhaled.

Chronic

Swallowed No effects known.
Eye No effects known.
Skin No effects known
Inhalation No effects known.

TOXICITY DATA
Not available.

Section 12: ECOLOGICAL INFORMATION

Ecotoxicity Not available.

Persistence and degradability Not available.

Section 13: DISPOSAL CONSIDERATIONS

Disposal method Disposal to sewer is normally recommended with copious amounts of water. Refer to State/Territory Land Waste Management Authorities if applicable. Containers are recyclable and can be disposed of by a licensed waste contractor. Containers can be disposed of to general waste or rinsed thoroughly and recycled.

Special precautions Suitable for incineration by approved agent.

Section 14: TRANSPORT INFORMATION

Not classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code).

UN Number	Not applicable.
UN Proper Shipping Name	Not applicable.
Class and subsidiary risk	Not applicable.
Packing Group	Not applicable.
Special precautions for user	Not applicable.
Hazchem Code	Not applicable.

Section 15: REGULATORY INFORMATION

Poisons Schedule (SUSDP): Not applicable.

All ingredients are listed in the Australia Inventory of Chemical Substances (AICS).

Section 16: OTHER INFORMATION

Date of preparation: 19th September, 2008