Husbandry Guidelines
for
Southern Bettong
Bettongia gaimardi

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RUV30204 Captive Animals – Cert III Online
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OCCUPATIONAL HEALTH AND SAFETY

OH&S RATING: LOW RISK

There is a possibility that during capture this animal may cause harm, either through biting or kicking. Correct handling and restraint techniques should be employed.

When working with this animal there is a potential for zoonotic diseases to be transferred from the animal to people.

The potential zoonotic diseases include:

- Toxoplasmosis
- Salmonellosis
- Coccidiosis
- Helminthosis

Some of these diseases may be contracted from touching bodily discharge (faeces, urine or vomit), being bitten by the animal, equipment that has been in contact with the animal, including needles or microchip injectors, or during medical procedures, eg from blood or bodily fluids. To prevent these zoonotic diseases ensure to maintain high levels of personal and workplace hygiene. Personal protective equipment should also be worn when capturing and handling animals.

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1.0 Introduction

The southern bettong is one of four members of the genus *Bettongia.* It is the largest of the four members, and the third largest of the Family Potoroidae, which consists of ten species occurring in Australia. All members of the Potoroidae family have reduced in numbers and suffered reductions in range since European settlement. Two of these species are presumed to be extinct, the Desert Rat-kangaroo, *Caloprymnus campestris*, and the Broad-faced potoroo, *Potorous platyops* (Claridge *et al*, 2007).

There are records from London zoo that Southern bettongs were held there as early as 1853 (Jackson, 2003). Southern bettongs can do very well in captivity, and make a great display animal, especially in parks that cater for night tours. They are a good example for the public of what an introduced species, such as a fox, may do to a native species. The southern bettongs housed at Moonlit Sanctuary have shown good temperaments and show an apparent lack of fear of humans, happily eating out of visitor's hands.

Rat-kangaroos have retained relatively 'primitive' characteristics compared to kangaroos and wallabies; they have a prehensile tail which enables them to grasp grasses and sticks (Claridge *et al*, 2007). The tails of the bettong species are strong, prehensile and furred, with the southern bettong having a distinct white tip on the end.

2.0 Taxonomy

2.1 Nomenclature and systematics

Class:	Mammalia
Infraclass:	Marsupialia
Order:	Diprotodontia
Family:	Potoroidae
Genus:	*Bettongia*
Species:	*gaimardi*

The genus name *Bettongia* is the aboriginal word for rat kangaroo, according to the Victorian Museum.

2.2 Subspecies

- *Bettongia gaimardi gaimardi* – presumed extinct around 1920's
- *Bettongia gaimardi cuniculus* – still widespread in eastern Tasmania

2.3 Recent Synonyms

There are no recent synonyms, but there are a number of older synonyms; *cuniculus, formosus, hunteri, lepturus, minimus, phillippi, setosa, white* and *whitei*.

2.4 Other common names

- Eastern Bettong
- Tasmanian Bettong
- Tasmanian Rat Kangaroo
- Wallaby-rat

3.0 Natural History

The marsupial family Potoroidae, includes bettongs, potoroos and two of the rat-kangaroos. There are four living species of bettongs (*B. gaimardi, B. lesueur, B. penicillata* & *B. tropica*) and one extinct species(*B. pusilla)*. The Southern bettong appears to be the most common and secure member of its genus. There is very little published information about this small marsupial (Rose, 1986). Previously it was found on both the mainland of Australia and on Tasmanian, it can now only be found in the north eastern parts of Tasmania, with populations on Bruny Island and Maria Island. The decline and subsequent extinction of the mainland population was related to the European man bringing in foxes and rabbits (Rose, 1986). No systematic survey of the population distribution has been done and there is not much literature about the past distribution, but Rose (1986) suggests that the population distribution is much patchier than it has been in the past.

3.1 Morphometrics

Rat-kangaroos have retained relatively 'primitive' characteristics compared to kangaroos and wallabies. They have a prehensile tail which enables them to grasp grasses and sticks, they have a simpler stomach, the forelimbs and hind limbs are closer in size, and they have different dentition (Claridge *et al*., 2007). Rat-kangaroos have well developed upper canines. This is not present in either kangaroos or wallabies. The second and third incisors are smaller than the first. They also have a large blade-like premolar, and there is no forward movement of the molar row.

3.1.1 Mass and basic body measurements

The Southern bettong has a combined head and body length of 315-332mm, the average measurement being 323mm. The tail length varies from 288-345mm, with the average being 326mm (Claridge *et al*., 2007).

Southern bettongs weigh within the range of 1200-2240grams, the average being 1660 grams (Claridge *et al*., 2007). At birth the average weight is 0.307 grams and average weaning weight is 789 grams.

3.1.2 Sexual Dimorphism

There are no significant differences between female and male head lengths or weights from birth up to maturity. Apart from the presence of a pouch or scrotum, the southern bettong males and females are not easily distinguished (Rose, 1989). The only differences in the adults are the foot length and the canine length, which are slightly longer in males. Rose (1989) states this as being unusual as the Darwinian theory suggests that most males are larger than females as a result of males competing with males for females, thus the more polygynous the species the larger the males.

3.1.3 Distinguishing Features

All of the rat-kangaroos are small with similar features which include variously elongated muzzles, short rounded ears, short muscular forearms with small paws that have forward pointing spade-like claws that they use for digging and manipulating food. The hind legs are muscular and well developed with elongated feet. The tails of the bettong species are strong, prehensile and furred. Short dense hair covers most of the body, with the exception of the nose which is naked. The tail and feet are covered in hair but it is very short (Claridge *et al.*, 2007). Bettongs differ from the remainder of the rat-kangaroos by having short, broad skulls that are characterised by a very large auditory bullae, large posterior palatal foramina and large blade like premolars with 7-11 fine vertical ridges present. Southern bettongs have a distinctive white tip on their tail.

3.2 Distribution and Habitat

Southern bettongs are found in open dry sclerophyll forests, mainly in the eastern and central regions of Tasmania ranging from sea level to 1000m. They are present on Bruny Island and between 1967-1971 were introduced onto Maria Island. (Claridge *et al.*, 2007). The southern bettong is not found on the larger Bass Strait islands, such as Flinders and King Islands. Rose (1986) and Claridge (2007) presume that the habitat was not suitable until clearing began with European settlement. The under storey is normally low, from 0 to 1 meter in height. These forests are normally located on infertile dolerite soils and sometimes they are found on sandstone or granite (Rose, 1986). The habitat of the southern bettong includes a number of grass species, including wallaby grass *Danthonia sp*., tussock grass *Poa sp.* and browntop *Agrostis sp.* The most common species found in this habitat is the *Lomandra longifolia.* Other species include everlasting daisy, guitar plant, cutting grass and sedges. In recently burnt areas the bracken *Pteridium sp.* is found as well (Rose, 1986). This bettong is found in warmer parts of Tasmania with low rainfall levels (50-75mm per annum), with the exception of the central highlands area which may become covered in snow (Rose, 1986).

The Southern bettong is only found in Tasmania, Australia.

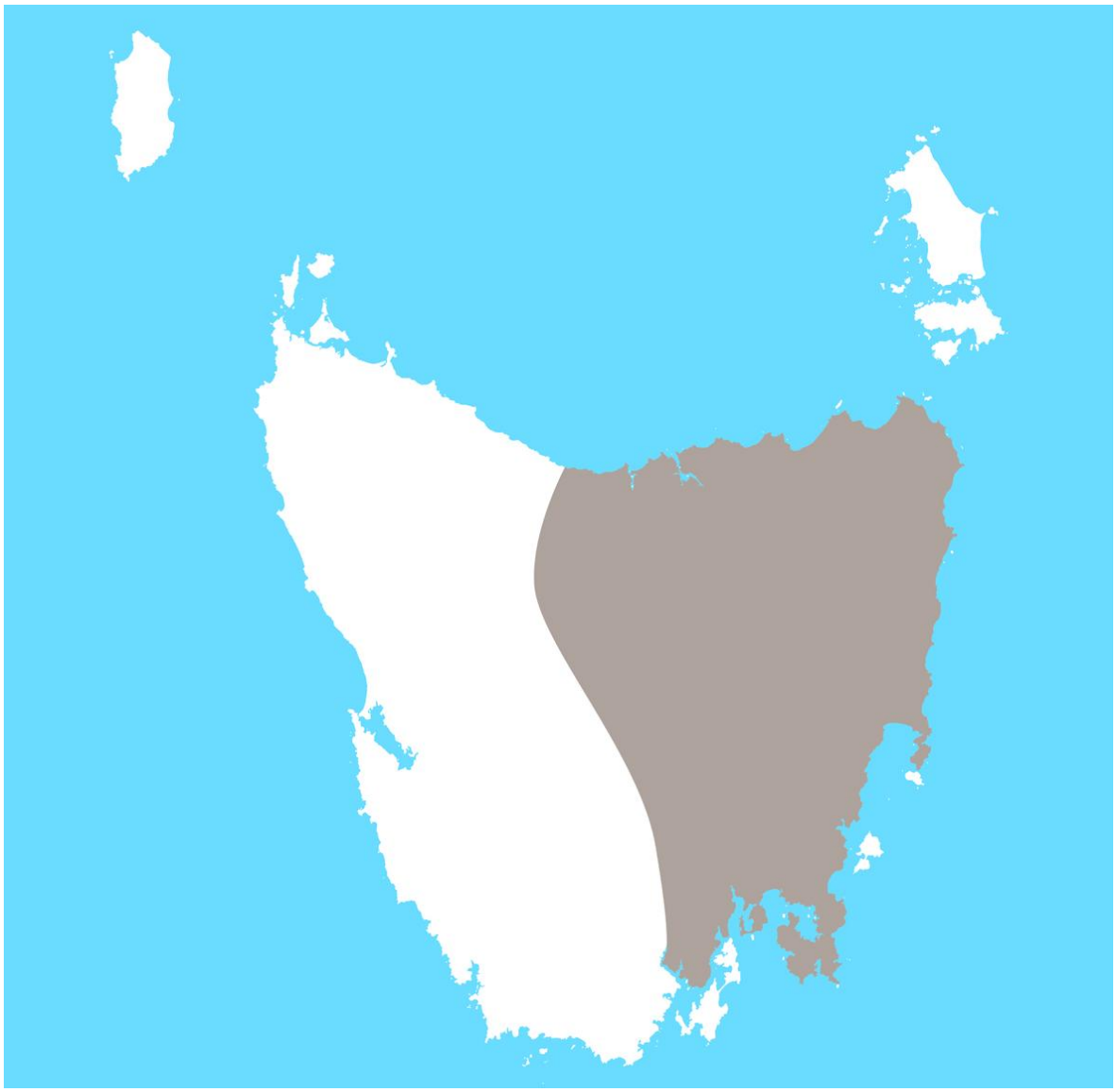

Figure 1. Distribution of the *Bettongia gaimardi*. Map based on information from Claridge *et al* (2007).

3.3 Conservation Status

Southern bettongs are a protected species in Australia and are classified as Near Threatened on the IUCN red list. This was last assessed in 2008. The range of this species has reduced by nearly 50% since European settlement due to habitat destruction in the form of land clearing and grazing (Claridge *et al*, 2007). Repeated 1080 poisoning which was intended to target wallabies by private land owners has also had adverse effects on the species (www.iucnredlist.org). Altered fire regimes have also played a role in affecting the abundance and availability of the southern bettong's staple food, hypogenous fungi (Claridge *et al*, 2007).

Although it may be considered common in Tasmania the recent introduction of the red fox potentially will change that, as southern bettongs are thought to have been eliminated from mainland Australia due to fox predation. If fox control is not successful in Tasmania the decline in numbers of this species could be significant, possibly qualifying it as Vulnerable (www.iucnredlist.org).

The recommended actions for the species include:

- reserve suitable sclerophyll habitats
- maintain open habitat through appropriate fire regimes
- monitor selected sites throughout the species range
- identify populations vulnerable to 1080 poisoning and implement measures to reduce its use in those areas
- education of land owners in regards to land clearing and 1080 baiting

3.4 Longevity

3.4.1 In the wild

Not much is known about the longevity of these animals. The Parks and Wildlife Services state that they live between 3-5 years in the wild.

3.4.2 In captivity

There are differing records of the ages of southern bettongs in captivity. Weigl (2005) states that the record is held by a male that reached 8.3 years. There is some suggestion that one animal made it to 11.8 years. This is possible but unverified.

3.4.3 Techniques used to determine the age of adults

There are a number of techniques that may be used to determine the age of southern bettongs. They include measuring the body parameters of the animal, including the head, foot and tail length, although this is only in maturing animals (Rose, 1989). Other methods include molar eruption and wear. For more information on this, please refer to Rose's (1989) article "*Age Estimation of the Tasmanian Bettong* (*Bettongia gaimardi*) (Marsupialia:Potoroidae)".

4. Housing Requirements

4.1 Exhibit/Enclosure Design

Enclosures for southern bettongs need to be built with the knowledge that they are good diggers and can jump. The enclosure design may be simple, a large area with the fence-line being free of any obstacles and no corners. The corners of the enclosure should be designed so that there are no 90 degree angles. This is because macropods often run along fence-lines when frightened and can cause themselves serious injury if they are moving at speed into a corner. Poles should also be on the outside of the enclosure due to the same reason. The height of the fence may be approximately 1.2m. Bettong enclosures require either rooves or a 45 degree overhang which is 50cm in length into the enclosure so that they cannot climb out.

Figure 2. Example of an overhang facing into bettong enclosure at Moonlit Sanctuary. Photography by L.Tuthill.

One of the greatest threats to bettongs is predation by feral animals such as foxes. This is thought to have lead them to become extinct on the mainland of Australia. The enclosure design should therefore be predator proof. At Moonlit Sanctuary we have a predator proof fence that surrounds the entire park. The bettong enclosures are within this fence. If it is a perimeter fence it may be made from a number of different materials such as, plywood, wire-mesh with holes no larger than 8cm by 4cm to avoid pest species such as rabbits and young foxes from entering, or thin sheet metal which would be an expensive alternative. There are various designs for predator proof fencing. At Moonlit Sanctuary our fence is 2 meters in height. It has two electric wires that run on the outside, one along the top of the fence and one along the centre. The fence is loose so that foxes will not climb it, and there is a 50cm apron of mesh that extends from the bottom of the fence outwards to deter animals from digging underneath. There should not be any overhanging trees or shrubs so that animals may climb into the property. There should be at least 2 meters of cleared area on the outside of the perimeter fence.

Figure 3. Example of a predator proof fence at Moonlit Sanctuary. Photography by L.Tuthill.

Walkways must be provided for keeper access and they should be kept clear of any obstacles. Feed shelters or sheds should be provided to keep food dry in wet conditions. These may be made from timber, bricks with corrugated or shingled roof (Jackson, 2003). Shelter for the animals should also be provided in the form of grass tussocks, grasses, hollow logs, shrubs, bushes and trees. These should not be planted near the fence-line.

If multiple animals are to be housed together the design should provide multiple areas where the bettongs can get away from each other. Males are territorial and should not be housed in large numbers. Overcrowding should also be avoided, for minimum requirements please see section 4.3.

As southern bettongs are nocturnal, they may be housed in nocturnal housing with reverse lighting. As these enclosures are not usually very large it is preferable to house them in outdoor enclosures. Moonlit Sanctuary runs night tours where groups get to enter the bettong enclosure carrying low wattage lanterns that do not seem to affect the behaviour of the bettongs (pers. obsv).

4.2 Holding Area Design

A holding area must be available. The size of the holding yard must not fall below one third of the minimum requirement of the display enclosure (DPI – NSW, 2006). This yard must only be for temporary holding.

4.3 Spatial Requirements

Minimum requirements for floor space for a pair of *Bettongia gaimardi* is 10 squared meters. An additional 2.5 squared meters is required for every extra adult female, and an additional 5 squared meters is required for every additional adult male. It is important to remember if designing an area where the public are able to walk through the enclosure that the animals need at least these dimensions away from the public, so the pathway is not included. This is so the bettongs can escape any unwanted attention from the visitors. They are nocturnal animals and in our experience of taking people through the outdoor enclosure at night, it is fairly easy to keep the public on the pathways, as they do not want to walk off in the dark. If this is a concern, prominent pathways should be put in place to stop people from chasing the animals (DPI-NSW, 2006).

4.4 Position of Enclosures

The enclosure should be positioned so that not all sides are accessible to the public. We have our two large bettong enclosures in an area that is off-limits to the public during the day. If people could walk up to the fence and make a lot of noise it may scare the animals and cause them stress. It does not matter which direction the enclosure faces, as long as there is appropriate cover for them to create nests out of the direct sunlight. The enclosure should be positioned to allow easy access to all aspects of enclosure maintenance and in accordance with OH&S regulations.

4.5 Weather Protection

Shelter must be provided so the animal can escape from wind, rain, extreme temperatures and direct sunlight. The shelter may be simply planting enough ground cover and shrubs to protect the animals or a wooden shelter may be constructed (DPI-NSW, 2006 & Code of Practice VIC, 2001).

Figure 4. Different types of ground cover and small trees create protection from the weather and from the public for *Bettongia gaimradi*. Photography by L.Tuthill.

4.6 Heating Requirements

No additional heating is required for the southern bettong.

4.7 Substrate

The substrate of an enclosure for southern bettongs should be natural, soil with grass tussocks growing, live and dried grasses. Southern bettongs create small burrows that they cover with grasses, leaves and sticks to create nests in which they sleep during the day. The enclosure should be able to be raked and cleaned thoroughly, especially around the feed troughs or stations. In my experience it is best to not have too much ground cover around these areas, so the area is able to be maintained easily.

4.8 Nest Boxes or Bedding Material

As stated in section 4.7, southern bettongs create small nests that they create by digging small burrows in the ground, and then covering the burrows in grasses, leaves and sticks which they collect with their prehensile tails (Claridge *et al*, 2007). They move nests regularly. Some individuals may move every night, therefore nesting materials are required to be either available from the ground cover, or placed into the enclosure by the keepers.

Figure 5. Southern bettong using its prehensile tail to collect grass and sticks. Photography by L.Tuthill.

4.9 Enclosure Furnishings

B. gaimardi are known to hop along fence-lines therefore no obstacles are to be placed along the fence line of their enclosure. This will aid in preventing injury. All furnishings and fittings must be made in such a style and placed in positions to prevent injury to the animals. Ground cover must be planted and placed in such positions that create many pathways for the bettongs. This will prevent stereotypic behaviour. The ground cover will also provide sight barriers so the animal may escape from the public or other bettongs within the enclosure. Ground cover furnishings include, grass tussocks, small shade trees, low plants and bushes, and leaves. If implementing plants, they must be non-toxic. They also require hollow or solid logs and rocks, in which they may retreat into or behind for security. The soil must be deep enough for them to create their nests (DPI-NSW, 2006 & Zoo Reach).

5.0 General Husbandry

5.1 Hygiene and Cleaning

Enclosures must be designed and constructed in a way that ensures that the well being and good health of the animal is put first. The materials used in an enclosure should be selected for the ease of maintenance, durability, cleaning and all items should be non-toxic. The enclosure should be cleaned on the 20:80 rule, 20% of the enclosure is cleaned daily, whilst once a week the remaining 80% is cleaned. The 20% of the enclosure cleaned daily should be concentrated around the food troughs and water containers.

Any food scraps must be removed and the area under and around the food troughs should be raked daily, as well as the water containers cleaned thoroughly with a hard brush then fresh water supplied daily. Every 3 months steel wool should be used on the water containers as well as the food troughs to clean any stubborn dirt.

At Moonlit Sanctuary we use food buckets to transport the food from the food preparation shed to the enclosures, these buckets are cleaned daily using 'Earth' dish washing liquid, then rinsed in fresh water and left out to air dry. Food containers should be dried thoroughly before placing food into them.

Enclosure furnishings should be cleaned regularly, including shelter areas, which may be cleaned with an anti-bacterial spray. If natural nesting material is not available, nesting material should be offered on a regular basis. As the southern bettong moves nests on a regular basis cleaning of old nesting material is not required. In some enclosures the nesting material may need to be removed after the animal has moved out.

See Appendix 1 for the annual cycle of maintenance.

Figure 6. Area around food trough is soil not grass or other kinds of cover. This makes it easier to maintain on a daily basis. Photography by L.Tuthill.

5.2 Record Keeping

Each individual should be identifiable by some method, see section 5.3. Records for each individual should include scientific name, common name, individual identification, any distinctive markings and if it has an institutional name. If possible there should be records of the dams and sires of each individual. All records of acquisitions and disposals should be kept in a safe secure place. All births and deaths should be recorded, as should any movements internally in the park (Zoo Reach – website).

Clinical data, including routine health checks as well as any veterinary examination details, must be kept; this includes dates and any treatments given. During routine health checks, weights and measurements (see section 7.4) should be recorded, as well as any dietary changes.

As *Bettongia gaimardi* are continuous breeders, if you have male and female adults you can almost guarantee that the female will always have pouch young. Records should be kept on when pouch young are seen out of the pouch, as there is only a two week period when the joey is old enough to hop in and out of the pouch. After that the adult will not allow the young back in. Once the joey is out of the pouch, sexing of the individual should be done, if it has not already been done.

Any behavioural issues with individuals must be recorded.

5.3 Methods of Identification

The best method we have found at Moonlit Sanctuary of identification for southern bettong's is inter-scapular injectable microchips. Once in place the microchip will not affect the animal's behaviour. Moonlit Sanctuary uses Trovan microchips. Depending on how many individuals you have in a collection, you may be able to use individual markings, but this is not very accurate when you have multiple animals. Southern bettongs may also have tracking collars placed on them. This would be useful if you had a large free range area for them.

Figure 7. A volunteer at Moonlit Sanctuary micro-chipping a bettong for identification purposes. Photography by L.Tuthill.

5.4 Routine Data Collection

Data should be collected in routine health checks. The information that should be collected can be found in section 7.4. A visual assessment of each individual should take place daily. Any abnormalities should be recorded and acted upon.

6.0 Feeding Requirements

6.1 Wild Diet

The southern bettong, amongst other rat-kangaroos, was previously thought to be a herbivore, but more recent studies uncovered them to be mainly mycophagists, fungus eaters. Truffles are the main food source. Truffles are defined, by many sources, as fleshy edible fungi, mainly from the genus *Tuber*, that grow underground on or near the roots of trees. This beneficial symbiosis is called mycorrhizae. The bettongs dig the truffles out of the soil using their well adapted forepaws (Claridge *et al*, 2007).

The diets of the southern bettong have been researched mainly using faecal analysis. This is a non-intrusive method of examining. Other methods include looking at the stomach content, which means that you would need a dead specimen. Faecal analysis is not the best way of determining diets, as some foods are more digestible than others, so the faeces do not always reflect the correct amounts consumed. Throughout the year, fungal spores dominated faecal samples of the southern bettong. The content varies between 78-97%. In spring and summer other food sources such as fruits, seeds, roots, leaves and gums are important.Claridge *et al.* (2007) include a table in their book "Bettongs, Potoroos and the Musky Rat-kangaroos" that breaks the diets of these species into minor and major components.

Vascular plant components							Fungal fruit-bodies			
Flower	Fruit	Seed	Leaf/Stem	Root/Tuber	Bulb	Exudate	Hypogeous	Epigeous	Inverts.	Other
		x		x	x	x	xx	x	x	

x = minor or seasonal component of the diet
xx = major component of the diet

Figure 8. Summary of the diets of a Southern Bettong. Re-modified from Claridge *et al.* (2007).

Southern bettongs have a well developed sense of smell, enabling them to locate fruiting bodies of fungus. Studies have been undertaken trialling the ability of captive *Bettongia gaimardi* to locate the fruit bodies of *Mesophellia*. The observations of this experiment revealed the animals dug directly over filter papers that contained fungus extract and over buried fungi rather than the controls that were put out.

There is not much information regarding the nutritional value of fungi for southern bettongs. Although it is believed that one of the benefits of eating fungal fruit bodies is thar they are rich in nutrients. Compared to seeds and leaves they accumulate higher concentrations of phosphorous, nitrogen and potassium (Claridge *et al,* 2007).

6.2 Captive Diet

The following diet is suggested by Steven Jackson (2003) in "*Australian Mammals – Biology and Captive Management*" for a single *B. gaimardi*:

Eukanuba kibble (amount not specified)
40 grams of apple
30 grams of orange
50 grams of banana
30 grams of pear
30 grams of corn
30 grams of carrot
30 grams of potato or sweet potato
2 grams of silverbeet
10 grams of sprouted seed
5 grams of pet health food
20 grams of pasture replacement pellets
5 mealworms

At Moonlit Sanctuary we have the following diet in place for each bettong:

50 grams of Barastoc kangaroo and wallaby pellets (pasture replacement pellets)
30 grams of Peter Gibbs wheat
30 grams of Peter Gibbs cracked maize
30 grams of mixed vegetables – diced
25 grams of diced apple
25 grams of sliced carrot
20 grams of sliced mushroom

> *The mixed vegetables include pumpkin, broccoli, cauliflower, corn, sweet potato and red sweet potato (this depends on what is in season).

Although Steven Jackson's diet has a greater variety of foods, the diet provided by Moonlit Sanctuary is adequate for a year round diet. As the southern bettongs are continuous breeders, both in captivity and in the wild, there is no need to amend the diets.

Figure 9. Food Bucket, containing enough food for 8 *B. gaimardi*. Photography by L.Tuthill.

Water:
Southern bettongs get most of the water they require from food. There are few records of this species drinking water in the wild. Even so, fresh water should always be made available to the animals.

6.3 Supplements

Supplements for the diet provided by Jackson (2003) include:
6 grams of egg or cheese, 3-4 times per week
2 almonds, 3-4 times per week
5 mls of nectar mix, 3-4 times per week (nectar mix Appendix 2)
5 sultanas or sunflower seeds, 2-3 times per week

Supplements at Moonlit Sanctuary include (per animal):
5 mealworms, 3 times per week
5 grams of boiled egg with shell, 3 times per week
2 almonds, 3 times per week

6.4 Presentation of Food

Water containers should be made from non-porous, smooth and easy to clean materials, and placed away from direct sunlight to aid in reducing algal growth. These containers must be cleaned and fresh water offered daily. The water containers should be placed away from fences, or enclosure boundaries as bettongs like to hop along these perimeters.

Food bowls should be collected and cleaned thoroughly on a daily routine. In larger colonies food troughs are recommended. These must also be cleaned thoroughly on a daily basis. The size and number of troughs provided depends on the number of animals in each enclosure. A larger area is recommended to reduce stress and fighting amongst the individuals. The diets stated above, should be fed out on a daily basis. In my experience at Moonlit Sanctuary it is best to feed the animals at night, as they are nocturnal. We conduct night tours and we feed the bettongs during the tour. This enables them to have time to forage prior to being fed at a trough, and it also aids in reducing pest animals. If this is not possible then it is best to feed them as late in the day as possible. That way the food remains fresh and it has less chance of becoming contaminated with ants, or birds taking the seeds or other pest animals stealing an easy meal.

Figure 10. Feeding trough. Photography taken by L.Tuthill.

To encourage natural foraging in the *B.gaimardi* behavioural enrichment should be provided when feeding the animals. Burying either slices or whole mushrooms around the enclosure encourages the southern bettong to use its exceptional olfactory system to locate the food then the well developed forepaws to uncover the treat. Mealworms can be scattered around the enclosure so they can also forage for them.

7. Handling and Transport

7.1 Timing of Capture and Handling

When capturing an animal some level of stress is imposed on the animal, no matter which technique is used. In our experience capturing the *B. gaimardi* during the day was more stressful for the animal than during the night when they are naturally active. When released, animals caught during the day became almost disorientated and were more likely to cause themselves harm by hopping into a fence or other obstruction. The animals caught during the day were also less likely to be eating comfortably that night. Animals caught during the night, when they were already active, were observed to be less stressed. Once released, after a short period of time, they have been seen eating at the feeding trough. All captures must be well organised to reduce stress on the animal. If they are housed in a nocturnal house then capture should take place in the morning.

7.2 Catching Bags

Captured southern bettongs should be placed into soft cloth bags, made from either calico, hessian or other thick cotton fabric. The fabric should be dark in colour as this reduces the stress levels of the animal. *Bettongia gaimardi* normally become fairly sedate once placed into a dark handling bag. If the bag is light in colour the animal may struggle to try to escape and potentially cause itself harm (Claridge *et al*, 2007). Bags should have a mouth wide enough so the animal can swiftly be placed into it.

7.3 Capture and Restraint Techniques

Reduction of stress is the most important aspect to think about when capturing a southern bettong. The easiest way to reduce stress in a routine capture and restraint is to make the process as fast and efficient as possible. The safety of the people involved in the capture and the safety of the animal involved in the capture are of highest priority.

There are two main capture techniques that may be used when capturing a southern bettong, either by physical restraint or chemical restraint.

The routine technique used to capture *Bettongia gaimardi* is by physical restraint, for which there are two methods. The first physical restraint method includes using nets, towels and at least three people. *Bettongia gaimardi* are best captured along a fence line. One person should be waiting with a net in a set position along the fence, whilst at least two people herd the animal along the fence line toward that person where it gets into a position so that the person with the net can swiftly net the animal. If the animal escapes the capture attempts more than twice, leave it and try again at a later time. If it is chased for too long or becomes too stressed it may get capture myopathy. If the animal begins to lick its forearms the person in charge of the capture must call it off until at least the next day, as this is a sign of stress.

Once the animal is in the net a towel should be placed over the animal for a brief moment so the animal may calm down. Once calmed, the towel remains over the head of the *Bettongia gaimardi* whilst one person finds the base of the tail. Once this has been located remove the animal from the net and towel. Keeping the animal's hind legs pointed away from any persons, transfer the animal into a catching bag. Make sure the animal is placed into the bag slowly to avoid any injury. The bag should be held off the ground.

The second physical restraint technique only works if the animals you are capturing are used to people and are approachable. If someone is able to get close to the animal then you can grab it at the base of the tail and put it straight into a bag. This is a good technique which does not stress the animals as much as there is no chasing involved and it is over very quickly. At Moonlit Sanctuary, this technique is preferred.

The other technique sometimes used on *Bettongia gaimardi* is chemical restraint. This may be via darting with an immobilization drug, for example a combination of tiletamine and zolazepam. This method is not readily used in captive populations.

Caution must be taken when handling *Bettongia gaimardi* during capture and restraint. Although they rarely get above 2kg in weight, the handler should be wary of the teeth, claws and hind legs at all times.

7.4 Weighing and Examination

A number of measurements are able to be taken when the *Bettongia gaimardi* is restrained; these include the animals weight, the length of its head, tail and hind-feet. These measurements may be taken with a ruler or dial callipers. Some of these measurements may be used for age determination, such as a combination of body weight and hind foot length (Claridge *et al*, 2007).

The animal may be weighed easily whilst it is in the capture bag. It may be placed onto scales or hung from hanging scales. When taking the above measurements the animal's eyes should be kept covered to reduce stress. The measurements can be taken whilst the animal's head is kept in the bag, or it may be removed from the bag and its head covered with a towel. One person can restrain the animal whilst one person takes the measurements. As well as taking measurements, the general health of the animal should be checked; this includes checking the body condition, the teeth and mouth for problems such as lumpy jaw.

Pouches should be routinely checked to see whether there are young present. Pouch condition may be noted. When adult females have larger young, they may eject their young from the pouch during capture or whilst being restrained. The young must be replaced into the pouch before release. There are a few methods of doing this:

- The joey may be placed back into the pouch and the pouch taped over. When the adult moves away she can remove the tape when she feels safe.
- The adult female and the joey may be left in a handling bag under dense vegetation. The bag may be left slightly open so that they move off together when they feel safe.
- The adult female is restrained in an upright position. The joey is placed back into the pouch and the pouch closes naturally. If the animal is not in an upright standing position the mother may leave the pouch entrance floppy, and the joey may fall out (Claridge *et al,* 2007).

7.5 Release

In our experience capture and restraint should take place at dusk or at night. Therefore once the animal has been assessed the release will be shortly thereafter. When released the *Bettongia gaimardi* will hop away swiftly. It is therefore important to release the animal in an open section of the enclosure where it is not going to hop off into a fence or any other obstacle in which it could potentially harm itself. To reduce the stress of the animal, it is best to have a minimum number of people around at the release site. It is especially important not to stress the animal out as soon as it emerges. The animal should be released facing away from the person doing the release and no one visible to the animal when it comes out of the capture bag. Before releasing females with pouch young ensure the young have not been thrown out of the pouch and are sitting in the bottom of the bag.

7.6 Transport Requirements

7.6.1 Box Design

For trips over 24 hours the transport box should be made from fibreboard, hardboard, wood or plywood.

For trips under 24 hours the *Bettongia gaimardi* should be hung in a hessian bag, or a bag made from open weave material, and placed into a transport box.

The box must not have internal framework, this aids in reducing injury to the bettong during its trip. The plywood or wood must be 6mm thick and both screwed and glued to form secure sides and bottom. These containers must not have slated floors. The open end of the enclosure is to be made from the material and once in place must be screwed at either end to secure the door. The ceiling is to be made from flexible wire mesh with padding between the animal and the mesh; this stops the animal from becoming injured if it attempts to jump. The enclosure must only be big enough for the animal to stand, lie and turn around; if it is too large the animal may have room to injure itself. No light should be allowed into the transport box, except through the ventilation holes. These holes are to be placed 5 cm from the roof and 5 cm from the floor of the box, and no larger than 15mm in diameter. The floor of the box must contain absorbent materials that will absorb any spillages. Spacing blocks are to be placed on the outside of the transport box on all four sides and should be 2.5cm thick. For IATA box design see Appendix 16.4.

The outside of the box must have labels affixed to it, stating "BETTONG", "LIVE ANIMAL", "THIS WAY UP", "KEEP COOL" and "HANDLE WITH CARE". There must also be an envelope with the name, address and number of the sender, as well as the same details for the receiver. It also will include the number of species being sent, the common and scientific name of the animal (Zoo Reach).

7.6.2 Furnishings

The floor must have a layer of newspaper, then a layer of bedding material, this may be material such as shredded paper or wood shavings. The box must not have any internal framework. Depending on the duration of the transport both food and water may be required (see 7.6.3).

7.6.3 Water and Food

Bettongia gaimardi are not known to drink a lot of water, as they receive most of their water from their food. A water container must be provided on trips longer than 12 hours duration. A small amount of carrot and apple is to be provided on all transports longer than 24 hours.

7.6.4 Animals per box

No more than one animal must be transported per box. Adult females must not be transported if they are carrying joeys unless they are very young and are still attached to the teat.

7.6.5 Timing of Transport

Southern bettongs should not be transported in severe heat. If possible overnight flights would be preferable for long flights.

7.6.6 Release from the Box

The release of the southern bettong from the transport box should follow the same guidelines as the release from the capture bag. See 7.5.

8. Health Requirements

8.1 Daily Health Checks

As the southern bettong is a nocturnal animal, daily health checks are difficult. During the day we check for solid consistent faecal matter, ensure that all the food has been consumed, any fur found on the ground which may suggest fighting or mating, and most importantly, check that there are no animals out and hopping around. It is not normal behaviour for a southern bettong to be out during the day. If an animal is out of its nest during the day it needs to be caught and a physical examination is required.

As we run night tours at Moonlit Sanctuary, we are able to check on the individual animals in a natural environment. At night, or late in the afternoon, we check that individuals are moving freely and comfortably, their body and coats are in good condition, and their eyes are fully open and alert. It is also important when housing the animals in colonies to check for submissive animals that might be getting picked on by dominant animals. This behaviour can lead to an animal not being able to feed from feeding troughs and becoming weak and more susceptible to disease.

One of our southern bettongs was seen out early in the afternoon. It was offered food and was not interested. The animal was noted to not be moving freely and looking poorly. That night the animal was not seen eating, and not displaying normal behaviours. The next morning I went to check on this individual, but it had unfortunately died overnight. It was taken to the veterinarian for an autopsy and found to have either salmonella or coccidia. Any other animals displaying similar signs were to be removed from the colony immediately for treatment, as both of these diseases can spread rapidly through a population.

8.2 Detailed Physical Examination

During physical examination important aspects to check include:

- Body condition – best assessed by muscle mass around the spine and base of the tail. As a quick check you may check the muscle mass between the hips. If the area is concave the animal is in poor condition, more rounded the better the condition.
- Eyes – make sure they are bright and alert, no puss or swelling; normal light response.
- Nose – make sure no mucus is present.
- Mouth – check teeth are clean and healthy, and no swelling of gums.
- Anus – check for signs of diarrhoea.
- Coat – ensure no patches missing and it looks healthy; check for ectoparasites.
- Temperature – this can be taken through the rectum and should be 35-36 degrees Celsius.
- Weight – record and compare to previous examinations. Weight records can give an indication of an animal's health.
- Pouch – check condition, length of teats. If young present record any accessible details, such as sex, weight and age.
- Testes – on males check they are firm not soft and the size.

8.3 Routine Treatments

Routine treatments of the *Bettongia gaimardi* include regular worming treatments, which consists of spraying food with worming treatment over a three day period every three months. Moonlit Sanctuary uses Panacur25 at the dose rate of 1ml per 5 kg, see Appendix 3 for the material safety data sheet of Panacur25.

8.4 Known Health Problems

8.4.1 Ectoparasites:

Cause – There are a number of ectoparasites that may be found on the *Bettongia gaimardi*, including ticks and fleas. These may be brought in on other animals that may come in contact with the population.

Signs – Itchiness, hair loss, anaemia, paralysis, visible parasites.

Treatment – Ivermectin, Malathion or pyrethrin baths for fleas and manual removal of ticks. Seek veterinary advice.

Prevention – No real preventative. Mites may be the result of overcrowding.

8.4.2 Endoparasites:

Cause – There are natural levels of endoparasites found in wild populations of southern bettongs. Very rarely in the wild are individuals found with heavy loadings. In captive populations endoparasites are found in higher quantities and re-infestations are common - this is usually due to high stock levels. Some of the gastrointestinal parasites include tapeworms, flukes or round worms.

Signs – Diarrhoea, anorexia or under weight and under condition, inappetence or difficulty breathing. Faecal testing will show levels of infestations.

Treatment – Seek veterinary advice. Worming treatments should be undertaken such as ivermectin, Cydectin and Panacur.

Prevention – Prophylactic treatments are best done on a regular basis, such as worming treatment placed over food for a period of three days every three months. This will keep the endoparasitic load down, regular faecal floats should be undertaken to check these levels. Avoid high stock levels. Reduce the spread of endoparasites by keeping good hygiene, such as regular faecal removal, cleaning food and water troughs daily, and making sure the animals do not stand and/or defecate in food/water facilities.

8.4.3 Protozoans

8.4.3.1 Coccidiosis:

Cause – Coccidia is a protozoal disease caused by *Eimeria kogoni*. It is caused by poor hygiene, stress, over-crowding, moist, and contaminated yards. It mainly affects pouch young and older, less healthy animals. Coccidia can spread through a colony swiftly if measures are not taken to control or prevent it.

Signs – Diarrhoea or black tarry faeces that may contain blood; weakness, lethargy, sudden weight loss and death.

Treatment – Seek veterinary advice. Unfortunately once signs of this protozoal disease are noticed death is normally imminent.

Prevention – Good husbandry is essential in preventing the spread of coccidia, which includes daily cleaning of water containers, cleaning raised food troughs, remove faeces and rake around food troughs on a regular basis. Ensure low stock levels are kept. Enclosures should not be kept moist; they should be well drained, and if possible should have north facing slopes.

8.4.3.2 Toxoplasmosis

Cause – *Toxoplasma gondii* is a intracellular protozoan parasite that is able to affect any warm blooded animal. Macropods seem to be very sensitive to this protozoan. Toxoplasmosis is is transferred from cats. Bettongs may become sick with this by consuming food that has been contaminated with infected cat faeces (Jackson, 2003).

Signs – Sudden death without signs is usually experienced once the disease begins, respiratory signs, neurological signs and depression. Other signs that are experienced may include; lethargy, depression, inappetence, convulsions, diarrhoea, staggering, apparent blindness and paralysis.

Treatment – Seek veterinarian advice. Treatments include sulphadimidine, pyrimethamine and clindamycin. Treatment is usually unrewarding, and death is normally imminent. Animals that are diagnosed with this disease should generally be euthanased due to the pain of encephalitis associated with the disease (Jackson, 2003).

Prevention – Ensure cats cannot access food stores, such as lucerne, or the enclosures.

8.4.4 Bacteria

8.4.4.1 Salmonellosis:

Cause –*Salmonellosis* is a bacterial disease. It is caused by poor hygiene, overcrowding, stress, potentially carried in on humans and transmitted to the animal.

Signs – Diarrhoea or black tarry faeces, lethargy, poor appetite (inappetence), weakness and death. Unsteady gait may be noticed in the animal, convulsions with muscle stiffness and often the animal may have inappetance due to stiffness in the jaw resulting in drooling saliva.

Treatment – Seek veterinary advice. This bacterial disease may be treated successfully if signs are noticed early and the animal is caught before the disease progresses. Treatments include muscle relaxants and intravenous fluids.

Prevention – Good husbandry is very important in preventing salmonella. This includes daily cleaning of water containers, cleaning raised food troughs and removal of faeces. Prevent overcrowding by holding low stocking rates. One of our animals potentially had salmonella and died although good husbandry had been kept. It was thought that potentially the salmonella was brought in by someone on our night tour, as people have up close experiences with these animals. Since this incident we have brought in anti-bacterial hand cleaner that people must apply prior to feeding/handling the bettongs.

8.4.4.2 Lumpy Jaw or Necrobacillosis

Cause –Lumpy jaw is a result of bacteria penetrating the gums, once in the gum line they attack the jawbones resulting in the decay of the bone and the loss of teeth (Jackson, 2003). It is generally associated with poor hygiene, overcrowding or a poor diet which may contain soft foods such as pears, apples and bread alongside inadequate roughage. The soft foods allow the jaw to become soft which in turn then allows bacteria that cause cellulitis and necrosis of the tissue to enter the mouth, causing tooth root abscesses and swelling of the mouth (Jackson, 2003).

Signs – Facial swelling, weight loss, excessive salivation, tongue flicking, dyspnoea, rhinitis, dull eyes, weakness and loss of condition.

Treatment – Seek veterinarian advice. In the advanced stages the animal should be euthanased. If detected early, teeth may be removed surgically followed by injections of

antibiotics (Jackson, 2003).

Prevention – Provide hard foods to strengthen teeth and gums. Good hygiene should be kept, removing faecal matter particularly around the food areas, food should be provided off the ground to reduce the chance of intake of the bacteria (Jackson, 2003). Sharp feeds such as lucerne should be avoided as they may injure the bettong's gum and provide access for the bacteria. Do not over crowd enclosures.

8.4.4.3 Tetanus

Cause –*Clostridium tetani* is a bacterium that may enter an anaerobic wound from the soil (Jackson, 2003).

Signs – Often sudden death, prolonged contraction of the muscles. Convulsions, unsteady gait, muscle stiffness, often unable to eat resulting in drooling, nostril dilation, laboured breathing and respiratory failure (Jackson, 2003).

Treatment – Seek veterinarian advice. Intravenous fluids and muscle relaxants. Diazepan, procaine penicillin, benzathine penicillin, tetanus antitoxin and toxoid (Jackson, 2003).

Prevention –Vaccinate hand reared animals when they start grazing (Jackson, 2003).

8.4.5 Trauma

Cause – Significant trauma can occur to both soft tissue and bones from collisions. Bettongs may injure themselves against fences or other obstacles, entanglement in nets, and falls. These injuries may include lacerations, broken bones in the face, fractures in the neck, spine and legs. We had one female bettong that had severe trauma to her left eye. We assumed she must have run into a solid obstacle, such as the shelter or a tree. We had to have her eye removed due to the severity of the injury.

Signs – Swelling, limping, lacerations, bleeding, unnatural behaviours, such as being out during the day when they are nocturnal.

Treatment – Seek veterinarian advice.

Prevention – Do not over crowd, prevent circumstances where the animal may get spooked.

8.4.6 Capture Myopathy

Cause –Stress from excessive chasing of animals prior to capture, or during capture when the animal is struggling to get out of the net. Muscle damage due to exertion, cramping or trembling, lactic acid builds up faster than it can be metabolised, which produces local and systemic acidosis and necrosis of muscle cells (Jackson, 2003).

Signs – Stiffness or paralysis in one or more limbs, spasms of muscle groups, twisting of neck, laboured breathing, tremors, rapid heart rate, muscle twitching and a reluctance to move. The signs are normally seen one to two days after the capture but may occur up to one month after (Jackson, 2003).

Treatment – Seek veterinarian advice. Once muscle necrosis has occurred generally euthanasia is required. Wrapping towels soaked in iced water around some regions of the bettong may be useful, such as forearms, inner thighs, thorax and forehead (Jackson, 2003). Other treatments include corticosteroids, intravenous fluids, diuretics, Vitamin E, selenium and diazepam.

Prevention – Captures should be undertaken as fast as possible. If the capture is not

successful initially do not excessively chase the animal. Give it time to relax in between attempts. Diazepam may be used immediately after capture if the animal is highly stressed.

8.5 Quarantine Requirements

Quarantine is required if an animal from another population has been brought in, either from the wild or from another captive population, as there is a risk of diseases spreading from the introduced animal to the captive population. A quarantine enclosure should be available at all times, this should be a similar environment to what the animal has been kept in or about to be placed into. Southern bettongs can become stressed quite easily. If an animal is unwell then is caught up and placed into quarantine the last thing you want to do is stress it unduly. For minimum requirements on enclosure size please see section 4.2.

Bettongia gaimardi should be quarantined for at least thirty days. Complete isolation is required and tests must be run for parasites. If parasites are present then appropriate treatments must be administered. The animal must be clear of pathogens prior to being released into the population. Faecal tests should be taken over a three week period, one per week, with acceptable or negative results prior to leaving quarantine.

9. Behaviour

9.1 Activity

Southern bettongs are nocturnal, becoming active soon after dusk (Taylor, 1993). They remain active for various lengths of time before nesting again prior to sunrise (Claridge *et al*, 2007). During the day these animals remain in their nests. When night length is at its longest, mainly in May, Bettongia gaimardi have been known to leave their nests from between five to twenty minutes before dark. Activity levels differ depending on the time of year and the length of the night. During the shortest night lengths, November, bettongs are active for about 94% of the night, whereas in August when the night length is over 12 hours they are active less than 70% of the night (Claridge *et al*, 2007). Activity levels are approximately 7 hours during November and up to 10 hours during May. The time spent in their nests at the end of the night differs between months as well. During May and August their nests are not used during the middle of the night except during heavy rain periods, but the time spent at their nests at the end of the night during these months is longer than other months (Claridge *et al*, 2007). Individuals sometimes travel long distances, up to 1.5 kilometres, between nest sites and feeding areas (Strahan, 1995).

When moving at speed the southern bettong has bipedal locomotion. When it is moving at a slower rate it can use quadrupedal locomotion, and if it is walking very slowly it may use its tail as a prop and this locomotion is called pentapedal (Claridge *et al*, 2007). They are mainly ground dwelling but are able to climb if required.

9.2 Social Behaviour

Southern bettongs are usually solitary animals that have brief encounters during mating. The females have a short, two week, relationship with young that has emerged from the pouch, before the young is pushed away. They generally forage alone, but they may feed in small loose aggregations (Claridge *et al*, 2007).

Males have a home range of 47-85 ha and the females have a home range of 38-63 ha. Population density is expressed here as the number of animals per hectare. The southern bettong population density is 0.19 (Claridge *et al*, 2007). This is a very low density. It is thought that population densities are so low because the habitat cannot provide enough fungi all year around to support a larger numbers of animals. Both the foraging range and nest site locations of individuals overlap (Claridge *et al*, 2007). The males' home range generally overlap with the home ranges of other females but do not overlap with other males' (Jackson, 2003).

9.3 Reproductive Behaviour

Male bettongs regularly inspect the pouch and cloacal region of females, allowing them to detect the approach of oestrus. If this behaviour continues, non-responsive females lie on their side and kick strongly with their large hind limbs (Clardige *et al*, 2007). On the day of oestrus males and females hop to-and-fro in tandem; the male mounts the female and holds onto her flanks with his forelimbs. The male may bite the females neck in order to maintain his position. The mounting and thrusting may occur multiple times, but it is not known whether the male ejaculates more than once (Claridge *et al*, 2007). The females only mate on the night of oestrus. The disruption of fur on the back of the neck may be a sign that the female has mated.

9.4 Bathing

Bettongia gaimardi tend not to bathe.

9.5 Behavioural problems

In captivity males should not be housed together as they can show aggression towards one another. In a captive environment one male and multiple females may be housed in small colony groups. There is always the potential for females to damage other females' pouches by kicking them, however the male's aggression towards one another is much more serious. Males may chase one another, kicking and biting and potentially causing multiple wounds that may result in death (Clardige *et al*, 2007 & Jackson, 2003). Male juveniles should be removed from the colony once puberty is reached.

We monitor the behaviour of our southern bettongs almost every night of the year. When we take a tour through the colonies we check that there is no aggression amongst the group. On a couple of occasions we have had to remove one of the animals into our holding pens. One of the animals removed was a dominant female that was attacking other younger females.

9.6 Signs of stress

As with all macropods, southern bettongs cannot sweat, and if they become stressed and overheat they will be seen licking their forearms to cool themselves. Other signs of stress may include vocalisation, escape attempts, body trembling, head shaking, teeth grinding, reduced food consumption, weight loss, thumping the ground with hind feet and diarrhoea (Jackson, 2007).

9.7 Behavioural enrichment

Behavioural enrichment aims to create an environment that allows the animal to portray its natural behaviours and essentially mimics the animal's wild habitat (www.animalbehaviour.net/ExoticAnimals.htm). Bettongs do not require as much behavioural enrichment as other groups (Jackson, 2007). Providing nesting materials, such as long grass and sticks, to promote nest building behaviours is one form of behavioural enrichment. Scatter feeding promotes natural foraging behaviours, placing vegetables under grasses and wedged under logs keeps them busy and reduces boredom and repetitive behaviours. Another form of behavioural enrichment is to bury truffles or fungi in shallow holes so the bettongs have to dig them up.

Mixing species may provide enrichment, although care must be taken to mix species that are compatible.

9.8 Introductions and removals

New males should not be introduced into a group that already has a male, as this may cause heightened aggression and may lead to the subsequent death of one of the males. When introducing a male to a group that does not already have a male, or if introducing a new female to a group, there are generally few problems. One way of introducing new animals into a group is to create a secure enclosure within the enclosure in which the animal is to be released. That way the new animal may get accustomed to the new environment and both the new animal and the group can interact with a protective barrier between them.

When removing individuals from a colony and returning that individual at a later date there are generally no problems either.

9.9 Intraspecific compatibility

It is suggested in Jackson (2007) that *Bettongia* should be housed in a male:female ratio of 1:1-2. At Moonlit Sanctuary we currently house seven individuals in one enclosure without problems. They are still readily breeding and have enough space to build their own nesting sites. We provide enough food so that even the subordinate animals do not go hungry. If there

is adequate space, appropriate substrate and adequate food supply there is not a problem housing multiple *Bettongia gaimardi* together.

9.10 Interspecific compatibility

At Moonlit Sanctuary we have housed southern bettongs (*Bettongia gaimardi*) together with long-nosed potoroos (*Potorous tridactylus*) and bush stone curlews (*Burhinus grallarius*) with breeding success in both the bettongs and potoroos, but the curlew did not have a breeding partner. Jackson (2007) suggests that bettongs can readily be placed with other species, such as other species of bettongs, potoroos, echidnas, ring-tail possums, sugar gliders, squirrel gliders, yellow-bellied gliders, leadbeater's possum and tawny frog mouths without any problems.

9.11 Suitability to captivity

There are not many institutions that maintain populations of southern bettongs. We have successfully maintained and bred from our colony for over ten years. They tend not to be stressed in captivity when appropriate housing is provided, and some of our bettongs are happy to eat from visitor's hands during our guided night tours.

9.12 Communication

Southern bettongs use scent markings as a form of communication, as well as vocal communication of grunts and hisses (pers. obsv.).

10. Breeding

Oestrus cycle: 22.6 days
Gestation Period: 21.3 days
Young Per Birth: 1
Pouch life: 106 days
Weaning: 160 days
Sexual Maturity: 8-11 months

10.1 Mating Systems

Southern bettongs are polygynous (Jackson, 2007), where the males have more than one female as a mate.

Male southern bettongs regularly check the pouch and cloacal region of female to check if they are approaching oestrus. As they continue to do this, non-responsive females may lie on their sides and kick strongly with their hind legs (Claridge *et al*, 2007). Female and male bettongs are of similar size. This enables the females to fight-off over eager males and to defend nest sites and food items (Claridge *et al*, 2007).

As stated in section 9.3 - male bettongs regularly inspect the pouch and cloacal region of females, allowing them to detect the approach of oestrus. If this behaviour continues, non-responsive females lie on their side and kick strongly with their large hind limbs (Clardige *et al*, 2007). On the day of oestrus males and females hop to-and-fro in tandem; the male mounts the female and holds onto her flanks with his forelimbs. The male may bite the females neck in order to maintain his position. The mounting and thrusting may occur multiple times, but it is not known whether the male ejaculates more than once (Claridge *et al*, 2007). The females only mate on the night of oestrus. The disruption of fur on the back of the neck may be a sign that the female has mated.

10.2 Ease of Breeding

Southern bettongs breed well in captivity. Correct diet and husbandry of the species will enable them to breed continuously.

10.3 Reproductive Condition

10.3.1 Females

Reproductive condition can be divided into several categories as per Jackson (2007):

- Non-parous - these are females that have never bred. Their pouch is small with no skin folds, clean and dry with very small teats.
- Parous - females that have previously bred but are not breeding at present. Their pouch is distinct, but still small, dry and dirty, the teats are elongated slightly.
- Pregnant – The pouch is pink in colour and glandular swelling on the lateral margins of the pouch skin folds may be observed.
- Pouch young present – Young are attached to the teat.
- Lactating – Pouch area is large, large skin folds, hair is sparse and stained, teats are elongated and the skin is dark pink and smooth. The young are absent from the pouch but still suckling.
- Post lactation – teats expressing only clear liquid or teats regressing.

10.3.2 Males

As males breed throughout the year, their reproductive condition is difficult to define. Testis size increases sigmoidally with age, increasing most rapidly when near the age of puberty. This

time is accompanied by peak levels of testosterone that are not repeated again (Claridge *et al*, 2007). Once the male bettong is matured there are few changes in the testis size and body weight.

Southern bettongs possess a common uro-genital opening into which the penis and rectum open. There is a posterior digital process which is similar to a small finger. It protrudes and is connected to a number of anal glands (Claridge *et al*, 2007). Claridge (2007) suggests that the secretions of these glands are used in scent marking.

10.4 Techniques Used to Control Breeding

Techniques used to control captive breeding of the southern bettong are similar to those of other macropod species. These may include:

- Separation of males and females
- Vasectomy of males
- Castration of males
- Removing pouch young
- Immunocontraception
- Desexing females
- Culling

10.5 Occurrence of Hybrids

Jackson (2007) has noted that a female southern bettong, *Bettongia gaimardi*, has been bred with a male brush-tailed bettong, *Bettongia penicillata*. The sex of the offspring is not known. A lot of hybrid offspring are infertile, with deformed reproductive organs (Jackson, 2007).

10.6 Timing of Breeding

Southern bettongs are continuous breeders. They are able to produce young throughout the year. The monthly occurrence of births through captive and wild studies is presented by Rose (1986). In the winter months they have a peak in breeding. It is unusual to find an adult female without young in her pouch (Claridge *et al*, 2007).

10.7 Age at First Breeding and Last Breeding

Sexual maturity on females is judged as when a female bettong can produce young. For males it is when they achieve fertile mating or when they have copious amounts of motile sperm in their urine (Rose, 1986). Another indicator of maturity is when the deciduous premolar teeth are replaced by a single premolar (Rose, 1986).

In Rose's study of reproductive biology in *Bettongia gaimardi* (1986), he states that sexual maturity is reached at 272+/- 53 days, with little difference between the two sexes. Maturity is reached by 52 weeks in all southern bettongs.

Age of last breeding is not known, but it is thought that they breed until they die.

10.8 Ability to Breed Every Year

Southern bettongs breed continuously, from when they reach sexual maturity possibly up until when they die.

10.9 Ability to Breed More than Once Per Year

Southern bettongs are capable of reproducing more than one offspring per year. They have a relatively short pouch life and gestation, and are continuous breeders.

10.10 Nesting, Hollow or Other Requirements

Southern bettongs create small burrows that they cover with grasses, leaves and sticks to create nests in which they sleep during the day. They collect these items with their prehensile tails (Claridge *et al*, 2007). They move nests regularly. Some individuals may move every night, therefore nesting materials are required to be either available from the ground cover, or placed into the enclosure by the keepers.

10.11 Breeding Diet

Southern bettongs are continuous breeders, both in captivity and in the wild. Therefore, there is no need to amend the diet. See section 6.2 for captive diet details.

10.12 Oestrus Cycle and Gestation Period

The oestrus cycle is approximately 22.6 days +/- 3.5 days. Gestation is relatively short - 21 days. After this period the young is born and crawls into the pouch and attaches to one of the four teats (Rose, 1989). The mother enters post-partum oestrus. She mates and produces a fertilised egg that remains in embryonic diapause within her uterus (Rose, 1989). When the joey vacates the pouch it almost always coincides with the birth of another young. If the pouch young are lost or removed experimentally, a new young may be born without the presence of a male (Rose, 1986)

Anoestrus, which is the absence of an oestrus cycle and the presence of a dry scaly pouch, is a rare occurrence as oestrus cycles occur throughout the year in most female southern bettongs (Rose, 1986).

10.13 Litter Size

Only one young is born per birth.

10.14 Age of Weaning

Weaning age of the southern bettong is 160 days (Jackson, 2007).

10.15 Age of Removal from Parents

Southern bettongs should be removed at the age of weaning, at approximately 160 days, as the parents may become intolerant of them (Jackson, 2007).

10.16 Growth and Development

The embryonic growth rate in southern bettongs is as fast as, or faster, than other marsupials about which similar amounts of information is known (Claridge *et al*, 2007). Organs involved with respiration, digestion and the formation of urine are advanced at birth to allow the joey to survive in the pouch. Less essential organs such as, skeleton, eyes, ears and skin mostly develop whilst the joey is in the pouch (Claridge *et al*, 2007). The senses that are involved in the movement to the pouch are well developed at birth.

Southern bettong's growth rate in the pouch is far greater than that of larger macropods, such as wallabies and kangaroos. They spend four to five months in the pouch developing after birth (Claridge *et al*, 2007). At this stage the young are able to sustain their own body heat as fur growth becomes substantial; this is when the first excursion out of the pouch occurs. The young will huddle with its mother before and after the final pouch vacation (Claridge *et al*, 2007).

Estimations of age may be obtained by comparing head, foot and tail lengths. For further

information on this refer to Rose (1989). There are significant differences in weight and adult foot length of southern bettongs in captivity compared to the wild. Captive bettongs are heavier and wild bettongs have longer feet, although their head and tail lengths are similar (Rose, 1989).

Young bettongs grow more slowly in the wild than in captivity. This is thought to be due to the protein-enriched milk that is produced by captive females (Claridge et al, 2007 & Rose, 1989). Studies on southern bettongs have showed that wild parent-reared young weighed significantly less than captive raised young, so any growth curves that are based on captive bred animals must be used with caution (Jackson, 2007).

11. Artificial Rearing

11.1 Housing

Southern bettong joeys should be treated the same as other macropod joeys when it comes to hand rearing. They begin development in the pouch where they are dependent on their mother for milk and protection, venturing slowly out of the pouch until they can cope with the external environment. Minimising stress is the number one consideration for joeys that are taken into care (Jackson, 2003). The joey should be housed in a secure environment; kept away from other animals and children, in an escape-proofed area, free from obstacles and hazards. It should be kept hygienic and offered shelter from noise and weather (Jackson, 2003).

Joeys that require hand rearing need to be kept warm and dark in an artificial pouch. The pouch should be cotton lined as joeys often suck their pouches and fibres can come off woollen material and may be swallowed (White, 1997). Furless joeys may be housed in a polystyrene box with a well wrapped heat mat at the base, woollen blankets should be placed on top of the heat mat with an opening in the centre which may imitate the pouch (White, 1997). The joey may be placed in a cotton liner deep in the blankets. Furred joeys require a pouch that they can get in and out of easily. The outer bag should be sturdy, made from canvas or sheepskin, and should be cotton lined. Hessian should not be used as it may cause irritation and has the potential for nails to be caught up in the weave. The bag should be hung so the base just reaches the ground for easy access, if extra warmth is required a heat pad may be placed on the side of the pouch (White, 1997). For both furred and furless joeys the lining should be changed regularly, when soiled with milk, faeces or urine. The size of the pouch is dependent on the size of the joey. It should fit fairly snugly so it feels secure (Walraven, 1999).

11.2 Temperature Requirements

The temperature varies with the various stages of development. Furless joeys should be kept between 32-36 degrees Celsius, furred joeys are slightly cooler between 28-30 degrees Celsius (Jackson, 2003 & Walraven, 1999). Pouch young must be kept at a constant temperature. This may be done by using heat mats or hot water bottles with a minimum/maximum temperature gauge placed inside the pouch next to the joey monitoring the temperature. Heat mats are preferable to hot water bottles, as they maintain a constant heat, whereas the hot water bottles require reheating (pers. obsv.). It is important not to overheat the young. Towels must be placed between the heat source and the animal. If the pouch is too hot place more towels between the animal and the heat source. A humidicrib may be used as an alternative. This is a thermostatically controlled heat box.

11.3 Diet and Feeding Routine

A recently orphaned joey should not be fed until it is up to temperature. They are often cold when they are initially found. Feeding them in this state increases the risk of inhalation pneumonia.

Marsupial milk is considerably different from other mammal's milk. In the early stages of lactation the milk contains low levels of fat, high levels of carbohydrates although hardly any lactose (Claridge *et al*, 2007). Marsupials should not be fed cow's milk, as it is too high in lactose and fat. There are a number of low lactose milk formulas available. The three main formulas are: Biolac, Wombaroo Kangaroo Milk and Di-Vetelact. Once a joey has started on a particular formula it is recommended not to change formulas as this may cause intestinal upsets (Walraven, 1999).

When making the milk formula, the water used should be boiled. The formula can be made in advance and kept in the refrigerator for no longer than 24 hours. When the milk is being reheated only reheat the amount required for that feed as the remainder of the reheated milk must be discarded. The milk should be approximately 35 degrees Celsius.

Various sized teats are required to rear a very young bettong. For older bettongs there are commercially available teats that you can purchase from Wombaroo. These teats require holes to be punctured in the end which may be done with a sewing needle. It is important that the flow of milk is not too fast, as this can cause milk to end up in the lungs and cause complications (Walraven, 1999). As the joey grows the teat and hole size will need to grow as well. For very young joeys, teats are not available to purchase so make an emergency teat from an eye-dropper or small syringe with an intravenous catheter attached to the end. Catheters are available from veterinary surgeries.

The joey should be kept in the pouch for feeding. The initial few feeds may be difficult as the milk formula tastes different from the maternal milk (Walraven, 1999). Milk should never be forced down and the flow should not be too fast. If bubbles come out of the nose or the joey is choking on the milk,the flow is too fast (Walraven, 1999). When feeding the joey, try covering its eyes and make sure the environment is quiet, so it does not become distracted. Feeding can either be done while the joey lies on its back, or its side. If it is feeding on its side the milk has the opportunity to run out the side of the animal's mouth rather than the possibility of the joey choking on excess milk.

The number of feeds changes with the development of the joey. Unfurred joeys should be fed every two hours (Jackson, 2003). A joey should not be fed more than every two hours as they can become exhausted and possibly weaken (Walraven, 1999). Furred animals should be fed every four hours.

As the joey develops and emerges from the pouch it should be offered grasses and soil for 15 minutes per day. This time increases as the joey ages. Gut flora needs to be established. This can happen by offering the soil that comes with the foraging for grass, and it can be encouraged by adding natural yoghurt or a small amount of acidophilus powder in the formula (Jackson, 2003). Another method is by choosing a healthy adult's faeces (ensuring no parasites are present), grinding them up and mixing the faeces with warm water then straining to add 5ml to the joey's milk, or squirting the 5ml straight into the joey's mouth (Jackson, 2003). Gradually the captive diet items are introduced, root vegetables, kangaroo pellets, mushrooms, insects etc.

11.4 Specific Requirements

Stress is the biggest problem with hand raising joeys and it can be fatal. It is extremely important to keep noise levels to a minimum and to not over handle the animal (Jackson, 2003).

As stated above, joeys should not be fed until their body temperature is correct, as feeding a joey when its body temperature is low may increase the risk of inhalation pneumonia. If warming the joey is taking too long it may be given fluids subcutaneously then bottle fed later (Jackson, 2003).

Joeys often suffer from dehydration when first found. To check for dehydration, pinch the skin between the shoulders, if the skin stays 'peaked' for several seconds the joey may be dehydrated. If the skin bounces back immediately the joey is well hydrated (Walraven, 1999). If the joey is dehydrated it may be given 100mls of boiled water with 5 grams of glucose. It may also be given electrolytes such as vytrate (10ml of vytrate to 125ml of water) and lectade (Jackson, 2003). These products are available from veterinary clinics.

Inside the mother's pouch is warm and moist, which creates a humid environment, keeping the joey's skin soft and supple. Orphaned joeys that are placed in pouches have to adjust to drier conditions, therefore it is essential to lubricate the skin of furless joeys so it does not become dry and cracked (White, 1997 & Jackson, 2003). The skin may be lubricated with Sorbolene cream, not with added glycerine or vitamin E, which is fragrance-free and can be purchased at

chemists.

11.5 Data Recording

Data recording is extremely important. Accurate records may assist veterinarians to diagnose a problem if the animal becomes sick. It allows comparison with growth curves to assess the progress and may help in gathering information about Southern bettongs that is not currently available (Jackson, 2003). Information gathered may help assist future hand-rearing of southern bettongs in captivity, which would be vital information if the animal was to become endangered. When an animal is initially brought in for artificial rearing it should be recorded what the sex is, the approximate age and the weight. Daily records of the following should be recorded:

- Date and time
- Body weight
- Temperature in pouch
- Any veterinarian examinations and findings

At each feed the following data should be recorded:

- Activity/Demeanour
- Characteristics and frequency of faeces
- Frequency of urination
- Milk consumed
- Solids offered and eaten

11.6 Identification Methods

Pouched joeys may be kept in different coloured pouches if multiple joeys are being cared for at once. Visual identification is easy if caring for a small number of joeys at once. When joeys are fully furred other methods of identification may be used. Details of these can be found in section 5.3 of this manual.

11.7 Hygiene

Hygiene is very important when hand raising orphaned bettongs. Poor hygiene can be fatal for the joey. Hands should be washed thoroughly before and after handling each joey. Use antibacterial solution on your hands when dealing with furless joeys (Jackson, 2003). Bottles, teats and other feeding equipment should be sterilised before and after use. This may be done by using warm soapy water with a suitable antibacterial solution, or you may boil them for 10 minutes. After they are sterile wash them in cold water (Jackson, 2003).

After each feed the animal must be cleaned with spilt milk, urine or faeces washed off the animal using moist cottonwool and then dried with paper tissue (Walraven, 1999). Joeys should not be bathed but gently wiped down instead. Attention should be paid in particular to the area under the chin of the joey, as they are susceptible to dermatitis infection in this area due to milk being left on the fur (Walraven, 1999).

Fresh food must be prepared daily and kept in the refrigerator (Walraven, 1999). The milk formula should be made up with boiled water and kept in the fridge for no longer than 24 hours. It should not be heated up more than one time. If there is any left over discard it (Jackson, 2003).

The artificial pouch should be kept clean, and the animal should not at any stage be left in a soiled pouch. If the joey is toileted after each feed, the animal is less likely to soil the pouch (Walraven, 1999). Pouches can be soaked in commercially available nappy-wash then machine washed.

Joeys require toileting. Marsupial mothers lick the joeys cloaca to stimulate urination and defecation. If the joey is not stimulated in an artificial environment they may develop kidney problems (Walraven, 1999). Stimulation can be done by gently rubbing the cloaca with a moistened cotton wool ball. This should not be done excessively as it can lead to cloacal prolapse (Jackson, 2003). When the faeces changes from paste to pellets the joey should be placed on the ground to urinate and defecate so it learns to toilet standing up (Walraven, 1999).

11.8 Behavioural Considerations

At stated previously, stress is the number one concern with hand-raising joeys. Reducing stressors such as contact with multiple carers, contact with other animals (especially cats as they can carry toxoplasmosis), try to reduce loud noises, avoid inappropriate temperatures and constant handling (Jackson, 2003). Reducing handling to one carer is a good way to reduce stress on an orphaned joey, but you have to be careful that the joey does not get too attached to the carer as this makes weaning a harder process (Jackson, 2003).

11.9 Use of Foster Species

Cross fostering is when the young of a target species is removed and placed into the pouch of recipient species with a pouch young of similar size (Jackson, 2003).

In Tasmania, cross-fostering has been successful in Long-nosed Potoroos (*Potorous tridactylus*) and southern bettongs (*Bettongia gaimardi*) (Claridge *et al*, 2007). This has been a PhD project of Beate Sterneberg under Randy Rose. They have attempted over 30 pouch swaps.

11.10 Weaning

As the joey develops and begins to leave the pouch on its own accord it should be given access to grass and soil, at least 15 minutes a day, to develop muscles in its legs and to try some grass (Jackson, 2003).Gradually the joey should be offered less milk and more time accessing grasses and shoots. As it develops further root vegetables, kangaroo pellets and fungi should be introduced. The bettong joey achieves substantial fur growth at 12 weeks of age. The first pouch vacation is normally one week after that (Claridge *et al*, 2007). It is important to weigh the joey during the weaning process to ensure the animal is still putting weight on (Walraven, 1999).

11.11 Rehabilitation and Release Procedures

Before a southern bettong may be released it must pass a number of criteria. These include: being physically fit and healthy and free of disease, maintaining good body condition and be on a natural diet. It should be able to recognise its own species and interact socially with them, and show natural behaviours towards them. The bettong should not be imprinted on humans and should show appropriate levels of fear towards both humans and predators. They should also be able to seek shelter in their environment, so it is important to provide natural shelter items (Jackson, 2003). Joeys must be fully weaned prior to release. The release of the animal should be close to where it was found. The animal should not be released in bad weather conditions, and being nocturnal, they should be released at dusk which would give them plenty of time to find food and a nest site (Walraven, 1999).

12. Acknowledgements

I would like to thank my partner Jonathan for his insight and guidance throughout. I would also like to thank my sister Anita and her husband Paul for their help and support. Sue Fitzgerald also for editing my manual and making very useful comments. In addition, I would like to thank Faye Sambell for reviewing the manual from a keeper's perspective.

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www.animalbehaviour.net/ExoticAnimals.htm

IUCN Redlist:
www.iucnredlist.org

Zoo Reach:
Standards for Exhibiting Captive Macropods (Kangaroos, Wallabies and Allies) in New South Wales. Exhibited animal protection act.
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15. Glossary

Acidosis – Accumulation of lactic acid in body tissue more rapidly than it can be metabolised.

Cellulitis – An acute spreading bacterial infection below the surface of the skin characterised by redness, swelling, warmth and pain.

Dyspnoea – Hampered breathing, increased frequency and amplitude of respiratory motion.

Encephalitis – Inflammation of the brain.

Necrosis – The death of living cells caused by progressive enzymatic degradation. It may affect groups of cells or part of a structure or an organ.

Rhinitis – Inflammation of the cells lining the nose

Sigmoidally – In a sigmoidal manner. Having the shape of a letter S.

16. Appendices

16.1 Appendix - Annual Cycle of Maintenance Activities

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
BREEDING SEASON	■	■	■	■	■	■	■	■	■	■	■	■
ENCLOSURE REPAIRS								■				
ENCLOSURE RENOVATIONS	■						■					
FULL CLEAN OF ENCLOSURE		■										
WORMING TREATMENT			■			■			■			■
ANNUAL HEALTH CHECK				■								

- Breeding season is continuous.
- Enclosure repairs are done in August or as required.
- Enclosure renovations are done in January because it is hot and July because it is wet. That way we can assess if our shelters are being used and we can improve upon them. Also they are both times when we start to get busier and having refreshed enclosures is good for both the animals and the visitors.
- Full cleaning is undertaken in February.
- Routine worming treatments are done every 3 months.
- Annual health checks and micro-chipping is undertaken in April.

16.2 Appendix – Nectar Mix

Nectar Mix at Moonlit Sanctuary:

- Measure out 550mls of honey into a plastic jug
- Add 550mls of boiling water
- Whisk until a smooth consistency is reached
- Add four scoops of fibre (Farex baby cereal) and two scoops of sustagen (vanilla), whisk in well
- Add one raw egg and whisk until smooth
- Add one banana and blend with bar mix until smooth (only when banana available)
- Divide the mixture equally into two nectar bottles, ensure they are well sealed
- Place into fridge

16. 3 Appendix - Panacur25 MSDS

Intervet Schering-Plough Animal Health

MATERIAL SAFETY DATA SHEET

Section 1 - Identification of Chemical Product and Company

Intervet Australia Pty Limited
91-105 Harpin Street
Bendigo East, Vic 3550, AUSTRALIA
Company ABN: 79 008 467 034

Tel: 1 800 033 461
Fax: 1 800 817 414

Substance:	Water solution/suspension of ingredients.
Trade Name:	**Panacur 25 Oral Anthelmintic for Sheep, Cattle and Goats**
Recommended Use:	Oral anthelmintic for sheep, cattle and goats.
APVMA No:	37097
Creation Date:	September, 2009
This version issued:	September, 2009 and is valid for 5 years from this date.

Section 2 - Hazards Identification

Statement of Hazardous Nature:
This product is classified as: Not classified as hazardous according to the criteria of SWA.
Not a Dangerous Good according to the Australian Dangerous Goods (ADG) Code.
Risk Phrases: Not Hazardous - No criteria found.
Safety Phrases: S25. Avoid contact with eyes.
SUSDP Classification: S5
ADG Classification: None allocated. Not a Dangerous Good under the ADG Code.
UN Number: None allocated

Emergency Overview

Physical Description & Colour: White milky liquid.
Odour: Slightly chalky odour.
Major Health Hazards: no significant risk factors have been found for this product.

Potential Health Effects

Inhalation:
Short Term Exposure: Available data indicates that this product is not harmful. In addition product is unlikely to cause any discomfort or irritation.
Long Term Exposure: No data for health effects associated with long term inhalation.

Skin Contact:
Short Term Exposure: Available data indicates that this product is not harmful. It should present no hazards in normal use. However product may be mildly irritating, but is unlikely to cause anything more than mild discomfort which should disappear once contact ceases.
Long Term Exposure: No data for health effects associated with long term skin exposure.

Eye Contact:
Short Term Exposure: This product may be mildly irritating to eyes, but is unlikely to cause anything more than mild discomfort which should disappear once product is removed.
Long Term Exposure: No data for health effects associated with long term eye exposure.

Ingestion:
Short Term Exposure: Significant oral exposure is considered to be unlikely. However, this product may be irritating to mucous membranes but is unlikely to cause anything more than transient discomfort.
Long Term Exposure: No data for health effects associated with long term ingestion.

Carcinogen Status:
SWA: No significant ingredient is classified as carcinogenic by SWA.
NTP: No significant ingredient is classified as carcinogenic by NTP.
IARC: No significant ingredient is classified as carcinogenic by IARC.

Section 3 - Composition/Information on Ingredients

Ingredients	CAS No	Conc,%	TWA (mg/m^3)	STEL (mg/m^3)
Fenbendazole	43210-67-9	25g/L	not set	not set
Other non hazardous ingredients	various	<10	not set	not set
Water	7732-18-5	to 100	not set	not set

This is a commercial product whose exact ratio of components may vary slightly. Minor quantities of other non hazardous ingredients are also possible.
The SWA TWA exposure value is the average airborne concentration of a particular substance when calculated over a normal 8 hour working day for a 5 day working week. The STEL (Short Term Exposure Limit) is an exposure value that may be equalled (but should not be exceeded) for no longer than 15 minutes and should not be repeated more than 4 times per day. There should be at least 60 minutes between successive exposures at the STEL. The term "peak "is used when the TWA limit, because of the rapid action of the substance, should never be exceeded, even briefly.

Section 4 - First Aid Measures

General Information:
You should call The Poisons Information Centre if you feel that you may have been poisoned, burned or irritated by this product. The number is 13 11 26 from anywhere in Australia (0800 764 766 in New Zealand) and is available at all times. Have this MSDS with you when you call.

Inhalation: First aid is not generally required. If in doubt, contact a Poisons Information Centre or a doctor.
Skin Contact: Irritation is unlikely. However, if irritation does occur, flush with lukewarm, gently flowing water for 5 minutes or until chemical is removed.
Eye Contact: No effects expected. If irritation does occur, flush contaminated eye(s) with lukewarm, gently flowing water for 5 minutes or until the product is removed. Obtain medical advice if irritation becomes painful or lasts more than a few minutes. Take special care if exposed person is wearing contact lenses.
Ingestion: If product is swallowed or gets in mouth, do NOT induce vomiting; wash mouth with water and give some water to drink. If symptoms develop, or if in doubt contact a Poisons Information Centre or a doctor.

Section 5 - Fire Fighting Measures

Fire and Explosion Hazards: There is no risk of an explosion from this product under normal circumstances if it is involved in a fire.
Only small quantities of decomposition products are expected from this products at temperatures normally achieved in a fire. This will only occur after heating to dryness.
Fire decomposition products from this product are likely to be irritating if inhaled.
Extinguishing Media: Not Combustible. Use extinguishing media suited to burning materials.
Fire Fighting: If a significant quantity of this product is involved in a fire, call the fire brigade.

Flash point:	Does not burn.
Upper Flammability Limit:	Does not burn.
Lower Flammability Limit:	Does not burn.
Autoignition temperature:	Not applicable - does not burn.

Flammability Class: Does not burn.

Section 6 - Accidental Release Measures

Accidental release: This product is sold in small packages, and the accidental release from one of these is not usually a cause for concern. For minor spills, clean up, rinsing to sewer and put empty container in garbage. Although no special protective clothing is normally necessary because of occasional minor contact with this product, it is good practice to wear impermeable gloves when handling chemical products. In the event of a major spill, prevent spillage from entering drains or water courses and call emergency services.

Section 7 - Handling and Storage

Handling: Keep exposure to this product to a minimum, and minimise the quantities kept in work areas. Check Section 8 of this MSDS for details of personal protective measures, and make sure that those measures are followed. The measures detailed below under "Storage" should be followed during handling in order to minimise risks to persons using the product in the workplace. Also, avoid contact or contamination of product with incompatible materials listed in Section 10.

Storage: This product is a Scheduled Poison. Observe all relevant regulations regarding sale, transport and storage of this schedule of poison. Protect this product from light. Store in the closed original container in a dry, cool, well-ventilated area out of direct sunlight. Make sure that the product does not come into contact with substances listed under "Incompatibilities" in Section 10. Some liquid preparations settle or separate on standing and may require stirring before use. Check packaging - there may be further storage instructions on the label.

Section 8 - Exposure Controls and Personal Protection

The following Australian Standards will provide general advice regarding safety clothing and equipment:
Respiratory equipment: **AS/NZS 1715**, Protective Gloves: **AS 2161**, Industrial Clothing: **AS2919**, Industrial Eye Protection: **AS1336** and **AS/NZS 1337**, Occupational Protective Footwear: **AS/NZS2210**.

SWA Exposure Limits	TWA (mg/m^3)	STEL (mg/m^3)

Exposure limits have not been established by SWA for any of the known significant ingredients in this product.

The ADI for Fenbendazole is set at 0.05mg/kg/day. The corresponding NOEL is set at 5mg/kg/day. ADI means Acceptable Daily Intake; NOEL means No-observable-effect-level. Taken from Australian ADI List, Dec 2008.

No special equipment is usually needed when occasionally handling small quantities. The following instructions are for bulk handling or where regular exposure in an occupational setting occurs without proper containment systems.

Ventilation: No special ventilation requirements are normally necessary for this product. However make sure that the work environment remains clean and that vapours and mists are minimised.

Eye Protection: Eye protection is not normally necessary when this product is being used. However, if in doubt, wear suitable protective glasses or goggles.

Skin Protection: The information at hand indicates that this product is not harmful and that normally no special skin protection is necessary. However, we suggest that you routinely avoid contact with all chemical products and that you wear suitable gloves (preferably elbow-length) when skin contact is likely.

Protective Material Types: There is no specific recommendation for any particular protective material type.

Respirator: Usually, no respirator is necessary when using this product. However, if you have any doubts consult the Australian Standard mentioned above.

Section 9 - Physical and Chemical Properties

Physical Description & Colour: White milky liquid.
Odour: Slightly chalky odour.
Boiling Point: Approximately 100°C at 100kPa.

Freezing/Melting Point:	Approximately 0°C.
Volatiles:	Water component.
Vapour Pressure:	2.37 kPa at 20°C (water vapour pressure).
Vapour Density:	No data.
Specific Gravity:	No data.
Water Solubility:	Completely soluble in water.
pH:	No data.
Volatility:	No data.
Odour Threshold:	No data.
Evaporation Rate:	No data.
Coeff Oil/water Distribution:	No data
Autoignition temp:	Not applicable - does not burn.

Section 10 - Stability and Reactivity

Reactivity: This product is unlikely to react or decompose under normal storage conditions. However, if you have any doubts, contact the supplier for advice on shelf life properties.

Conditions to Avoid: Protect this product from light. Store in the closed original container in a dry, cool, well-ventilated area out of direct sunlight.

Incompatibilities: No particular Incompatibilities.

Fire Decomposition: Only small quantities of decomposition products are expected from this products at temperatures normally achieved in a fire. This will only occur after heating to dryness. Carbon dioxide, and if combustion is incomplete, carbon monoxide. Nitrogen and its compounds, and under some circumstances, oxides of nitrogen. Occasionally hydrogen cyanide gas in reducing atmospheres. Water. Carbon monoxide poisoning produces headache, weakness, nausea, dizziness, confusion, dimness of vision, disturbance of judgment, and unconsciousness followed by coma and death.

Polymerisation: This product will not undergo polymerisation reactions.

Section 11 - Toxicological Information

Local Effects:

Target Organs: There is no data to hand indicating any particular target organs.

Classification of Hazardous Ingredients

Ingredient	Risk Phrases

No ingredient mentioned in the HSIS Database is present in this product at hazardous concentrations.

Section 12 - Ecological Information

Insufficient data to be sure of status. Expected to not be an environmental hazard.

Section 13 - Disposal Considerations

Disposal: Dispose of small quantities and empty containers by wrapping with paper and putting in garbage. For larger quantities, if recycling or reclaiming is not possible, use a commercial waste disposal service.

Section 14 - Transport Information

ADG Code: This product is not classified as a Dangerous Good. No special transport conditions are necessary unless required by other regulations.

Section 15 - Regulatory Information

AICS: All of the significant ingredients in this formulation are compliant with NICNAS regulations.
The following ingredient: Fenbendazole, is mentioned in the SUSDP.

Section 16 - Other Information

This MSDS contains only safety-related information. For other data see product literature.

Acronyms:

ADG Code	Australian Code for the Transport of Dangerous Goods by Road and Rail (7th edition)
AICS	Australian Inventory of Chemical Substances
SWA	Safe Work Australia, formerly ASCC and NOHSC
CAS number	Chemical Abstracts Service Registry Number
Hazchem Code	Emergency action code of numbers and letters that provide information to emergency services especially firefighters
IARC	International Agency for Research on Cancer
NOS	Not otherwise specified
NTP	National Toxicology Program (USA)
R-Phrase	Risk Phrase
SUSDP	Standard for the Uniform Scheduling of Drugs & Poisons
UN Number	United Nations Number

THIS MSDS SUMMARISES OUR BEST KNOWLEDGE OF THE HEALTH AND SAFETY HAZARD INFORMATION OF THE PRODUCT AND HOW TO SAFELY HANDLE AND USE THE PRODUCT IN THE WORKPLACE. EACH USER MUST REVIEW THIS MSDS IN THE CONTEXT OF HOW THE PRODUCT WILL BE HANDLED AND USED IN THE WORKPLACE.

IF CLARIFICATION OR FURTHER INFORMATION IS NEEDED TO ENSURE THAT AN APPROPRIATE RISK ASSESSMENT CAN BE MADE, THE USER SHOULD CONTACT THIS COMPANY SO WE CAN ATTEMPT TO OBTAIN ADDITIONAL INFORMATION FROM OUR SUPPLIERS

OUR RESPONSIBILITY FOR PRODUCTS SOLD IS SUBJECT TO OUR STANDARD TERMS AND CONDITIONS, A COPY OF WHICH IS SENT TO OUR CUSTOMERS AND IS ALSO AVAILABLE ON REQUEST.

Please read all labels carefully before using product.
This MSDS is prepared in accord with the SWA document "National Code of Practice for the Preparation of Material Safety Data Sheets" 2nd Edition [NOHSC:2001(2003)]

16.4 Appendix – IATA Box Design

CONTAINER REQUIREMENT 83

The illustrations shown in this Container Requirement are examples only. Containers that conform to the principle of written guidelines for the species but look slightly different will still meet the IATA standards.

Applicable to:

Small Species	*Large Species*
Bettong species	Kangaroo
Cuscus species	Tree kangaroo
Rat kangaroo	Wallaby species

See USG Exceptions in Chapter 2.

1. CONTAINER CONSTRUCTION

(see Exception QF-01 in Chapter 3)

Materials

Wood, plywood, hardboard, fireboard

Principles of Design

The following principles of design must be met in addition to the General Container Requirements outlined at the beginning of this chapter.

Dimension

The container must allow the animal to stand fully erect, to turn around and lie down comfortably but these criteria must not be exceeded as too much space may cause the animals to hurt themselves. The measurements will vary with the species involved. If the total weight of the container plus animal exceeds 60 kg (132 lb) metal reinforcement of the whole container must be carried out.

Frame

The frame must be made from 2 × 2 cm (¾ × ¾ in) light wood with its parts screwed together.

Sides

The sides, top, bottom and door of the container for the large species must be made of 1 cm (⅜ in) plywood (or similar), this can be reduced to 0.6 cm (¼ in) plywood (or similar) for the small species. The parts can be screwed or nailed and glued with a non-toxic glue to the frame.

Floor

The floor must be solid and covered with a deep layer of absorbent material, such as wood shavings for bedding.

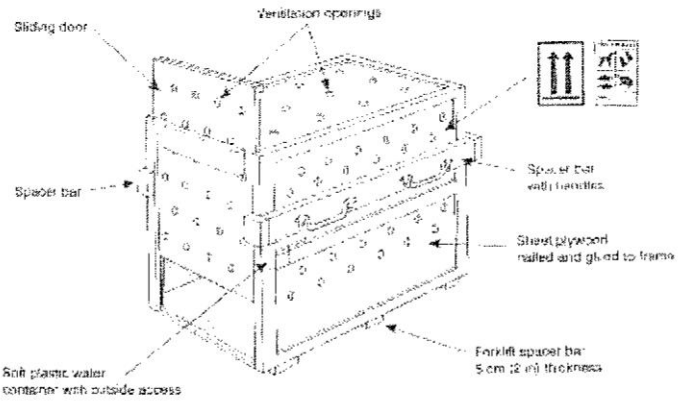
Roof

The ventilated plywood (or similar) roof must be padded with a soft non-destructible material in case the animal becomes agitated and jumps. The roof must have ventilation openings made over its entire surface.

Doors

A sliding door of 0.6 cm (¼ in) wood or plywood must be provided at one end of the container. It must be fastened with screws after loading so that it cannot be opened accidentally. Alternatively the lid of the container can be used as the access in which case it must be screwed to the frame and not nailed and glued.

EXAMPLE:



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CONTAINER REQUIREMENT 83

The illustrations shown in this Container Requirement are examples only. Containers that conform to the principle of written guidelines for the species but look slightly different will still meet the IATA standards.

Applicable to:

Small Species	*Large Species*
Bettong species	Kangaroo
Cuscus species	Tree kangaroo
Rat kangaroo	Wallaby species

See USG Exceptions in Chapter 2

1. CONTAINER CONSTRUCTION

(see Exception QF-01 in Chapter 3)

Materials

Wood, plywood, hardboard, fibreboard.

Principles of Design

The following principles of design must be met in addition to the General Container Requirements outlined at the beginning of this chapter.

Dimension

The container must allow the animal to stand fully erect, to turn around and lie down comfortably but these criteria must not be exceeded as too much space may cause the animals to hurt themselves. The measurements will vary with the species involved. If the total weight of the container plus animal exceeds 60 kg (132 lb) metal reinforcement of the whole container must be carried out.

Frame

The frame must be made from 2 × 2 cm (¾ × ¾ in) light wood with its parts screwed together.

Sides

The sides, top, bottom and door of the container for the large species must be made of 1 cm (⅜ in) plywood (or similar), this can be reduced to 0.6 cm (¼ in) plywood (or similar) for the small species. The parts can be screwed or nailed and glued with a non-toxic glue to the frame.

Floor

The floor must be solid and covered with a deep layer of absorbent material, such as wood shavings, for bedding.

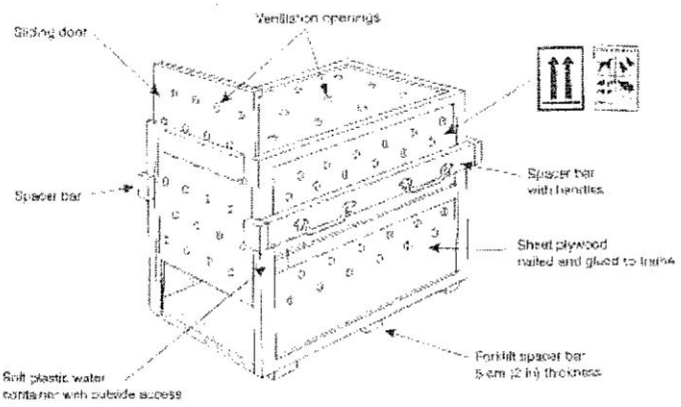
Roof

The ventilated plywood (or similar) roof must be pacced with a soft non-destructible material in case the animal becomes agitated and jumps. The roof must have ventilation openings made over its entire surface.

Doors

A sliding door of 0.6 cm (¼ in) wood or plywood must be provided at one end of the container. It must be fastened with screws after loading so that it cannot be opened accidentally. Alternatively the top of the container can be used as the access in which case it must be screwed to the frame and not nailed and glued.

EXAMPLE:



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16.5 Appendix – Food Products

Barastoc Stockfeed
70-80 Bald Hill Road
Pakenham, VIC, 3810
Australia
P: 03 5941 2800
- Kangaroo and wallaby pellets

Farex (Heinz)
Locked Bag 19057
Southbank, VIC, 3006,
Australia
P: 1800 633 333
F: 03 9861 5650
- Baby cereal

Iams Australia New Zealand
PO Box 6116 or Unit A2 1-3 Rodborough Road
Frenchs Forest, NSW, 2086
Australia
P: 02 8977 2500
F: 02 8977 2588
E: kim-mouret@iams.com
W: www.iams.com
- Eukanuba premium kibble

Peter Gibbs Stockfeeds Pty Ltd
Hartington Street (cnr Marlborough Street)
PO Box 157, Glenroy, VIC, 3046
Australia
P: 03 9300 2088
F: 03 9300 2522
W: http://www.pgsf.com.au
- Cracked maize
- Wheat

Sharpe Laboratories Pty Ltd
12 hope Street
Ermington, NSW, 2115
Australia
P: 03 9858 5622
F: 03 9858 5957
E: sharpe@myoffice.net.au
- Di-Vetelact low lactose animal milk formula

Wombaroo Food Products
PO Box 151
Glen Osmond, SA. 5064
Australia
P: 08 8379 1339
F: 08 8379 1339
E: wombaroo@adelaide.on.net
- Teats
- Wombaroo Milk Formulas
- Heating pads

16.6 Appendix - Identification Equipment

Microchips Australia
22 Fiveways Boulevard
keysborough, VIC, 3173
Australia
P: 03 9706 3100
F: 03 9706 3198
E: info@microchips.com.au
W: www.microchips.com.au
- Microchips and scanners