Husbandry Manual
For
Rufous Bettong
Aepyprymnus rufescens

Mammalia: Potoroidae

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1. Introduction

The rufous bettong is the sole member of the genus *Aepyprymnus*, and is the largest of eleven species of potoroid occurring in Australia. All have suffered reductions in range and habitat since European settlement. Two species of potoroid, the desert rat-kangaroo *Caloprymnus campestris*, and broad-faced potoroo *Potorous platyops* have become extinct in historical times (Strahan, 1995).

Rufous bettongs have been held in most zoos around Australia, and generally do well in captivity (George, 1990). The rufous bettong was first kept in London Zoo in 1882 (Jackson, 2003). They are presently held in several institutions such as Warrawong, Waratah Park, Australia Walkabout Wildlife Park, Mt Rothwell Sanctuary and Australia Zoo. In large, feral predator-proof sanctuaries such as Waratah Park, rufous bettongs have been very successful (pers. obs.).

The rufous bettong is an endearing animal due to its large eyes, frequent vocalisation and apparent lack of fear of people. The species does well in captivity, and makes an excellent display animal. Rufous bettongs can make great contributions to public education about the effects of introduced predators, land clearing and the status of other less common potoroids.

The rufous bettong is an ideal experimental animal for the investigation of macropodid reproduction d u e to its rapid rate of reproduction, ease of handling and freedom from disease (NHMRC, 1995). It is one of the few potoroids whose temperament and choice of habitat allow it to be observed readily in the wild (Frederick and Johnson, 1996).

The reproductive behaviour of rufous bettongs is of interest to science, as a tendency towards polygynous and monogamous systems differ from the promiscuous social systems of most macropodids, and extend the range of mating systems known from the superfamily Macropodoidea. More research is needed, and if verified, it will be most useful in interpreting the influences of ecology and body size on the evolution of mating systems in the group as a whole (Frederick and Johnson, 1996).

2. Taxonomy

2.1 Nomenclature

The rufous bettong was first described as *Bettongia rufescens* by Gray in 1837. The species was renamed *Aepyprymnus rufescens* by Garrod in 1875.

Class: Mammalia
Order: Marsupialia
Superfamily: Macropodoidea
Family: Potoroidae
Genus: *Aepyprymnus*
Species: *rufescens*

Etymology
Aepyprymnus – high rump
rufescens - reddish

2.2 Subspecies

None.

2.3 Recent Synonyms

Bettongia rufescens by Gray 1837.

2.4 Other Common Names

Rufous rat-kangaroo, red rat-kangaroo, red bettong.

3 Natural History

3.1 Morphometrics

3.1.2 Mass And Basic Body Measurements

Male rufous bettongs weigh up to 3kg, whilst females weigh up to 3.5 kg (Dennis and Johnson in Strahan, 2000, Seebeck and Rose, 1989). A captive female at Taronga Zoo weighed 4.2 kg (Canfield et al, 1990)

Head and body length is from 375 – 390mm. Tail length is from 340 - 390mm. Total length is from 615-780mm (Dennis and Johnson in Strahan, 2000).

Rufous bettongs stand about 35cms tall (Johnson, 1978).

3.1.3 Sexual Dimorphism

There is no obvious sexual dimorphism, indeed, some texts state there is no size difference between male and female rufous bettongs (Tyndale-Biscoe, 2005). Frederick and Johnson (1996), described the "sexually monomorphic potoroid marsupial, the rufous bettong," and went on to say that, as in other potoroids, males and females are similar in body size, form and colour. However, females may weigh up to 500 grams more than males (Dennis and Johnson in Strahan, 2000).

3.1.4 **Distinguishing Features**

The rufous bettong has short forearms, small paws with five digits, well developed hind limbs, large feet with four digits, two with syndactyly the largest being the fourth. They have short, rounded erect ears, and a weakly prehensile tail used to carry nesting material. The muzzle is short and blunt and fully furred. The Rufous Bettong has a broad head, rounded ears and bristly fur. The fur is light grey flecked with reddish hairs. The fur on the back of the ears is black (pers. obs.)

The rufous bettong is the sole member of the genus *Aepyprymnus*, although, at first glance it is very similar to members of *Bettongia*. The most obvious difference being that *Aepyprymnus* has hair on the central part of the muzzle (Dennis and Johnson in Strahan, 2000).

The "genus is characterized by the absence of posterior palatal foramina" and "the skull is very densely ossified and is proportionally much heavier than those of other potoroids" (Seebeck and Rose, 1989. pg. 11).

The rufous bettong has 32 chromosomes rather than the 22 for other bettongs (Tyndale-Biscoe, 2005). This is the highest number of chromosomes for all marsupials (Tyndale-Biscoe, 2005).

3.2 Distribution and Habitat

The rufous bettong is distributed along the Australian east coast from north Queensland to northern New South Wales (See Figure 1). There was an isolated population found along the Murray River in central New South Wales and Victoria, although the rufous bettong has now been declared extinct in Victoria (Anon, 2003). The species can be found in a variety of habitats with a sparse or grassy understorey. These habitats range from coastal eucalypt forests, wet sclerophyll forests to low, dry, open woodland west of the Great Dividing Range (Dennis and Johnson in Strahan, 2000). "In Queensland, the animals inhabit the eastern slope of the range in vegetation cover that varies from open forest to tussock grassland" (Johnson, 1978 pg. 156). Studies of the rufous bettong at Wallaby Creek in north-eastern NSW showed they "were associated with a mosaic of grassland and open forest vegetation" (Southwell, 1987. Abstract). Southwell (1987) also found that the distribution of bettongs did not vary seasonally.

The home range of males covers 75-110 hectares, and females 45-60 hectares (Dennis and Johnson in Strahan, 2000). According to Frederick and Johnson (1996) Estimates of

home-range size vary from about 20 ha in northern New South Wales to 44-107 ha at Black Rock in North Queensland. Feeding ranges overlap extensively within and between the sexes, but there is evidence that individuals maintain discrete nesting ranges (Frederick and Johnson, 1996).

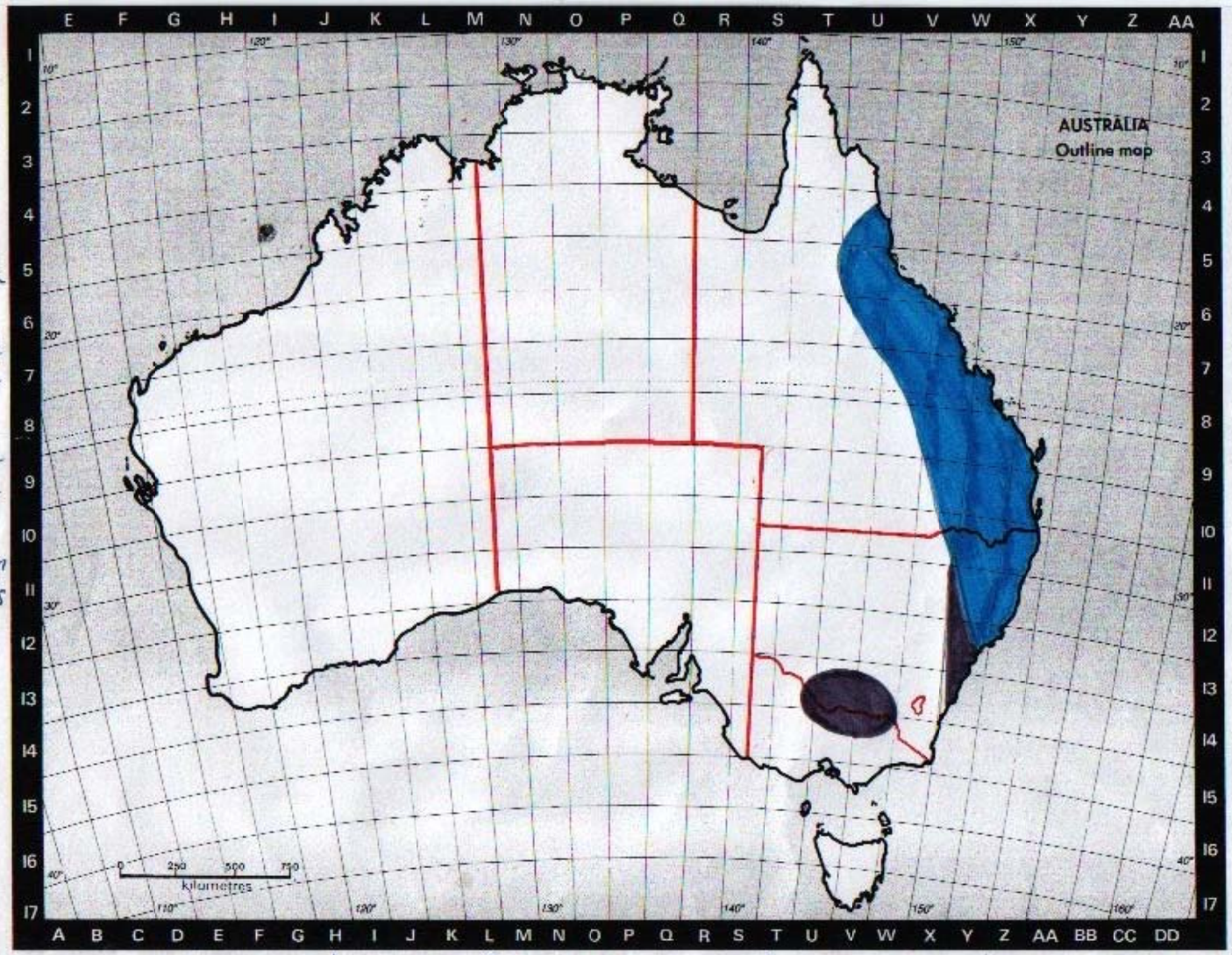

FIGURE 1. "NATURAL RANGE OF THE RUFOUS BETTONG."

3.3 Conservation Status

The rufous bettong is currently the most widely distributed potoroid in Australia, and its status seems secure for now due to fewer introduced predators in its range and less intensive land use practices (Dennis and Johnson in Strahan, 2000).

The rufous bettong is a protected species in Australia and is classified on the IUCN Red List as Lower Risk (low concern), (AMMSG, 1996) although this may need updating, as the classification is ten years old.

In Queensland it is still considered common.

In New South Wales "The rufous bettong (*Aepyprymnus rufescens*) is listed as VULNERABLE on the schedules of the NSW Threatened Species Conservation Act. The species was listed because:

- Its population and distribution have been severely reduced
- It faces severe threatening processes
- It is an ecological specialist (it depends on particular types of diet or habitat)" (Anon, No Date).

In Victoria, the rufous bettong has been declared extinct (Anon, 2003).

3.4 Diet in the Wild

The rufous bettong forages for fungi, roots, tubers, grasses, sedges, seeds, leaves and herbs. It relies heavily on its sense of smell to find food (pers. obs.). Bettongs often dig up tufts of grass to consume the roots using their strong, clawed forepaws (pers. obs).

Potoroids are known for their consumption of the fruiting bodies of underground fungi (truffles). This mycorhizal fungi forms important associations with the roots of trees, especially those in the *Myrtaceae* family (eucalypts). The association between fungi and tree greatly expands the surface area of the roots, and helps the tree to take up minerals from the soil (www.yaraandoo.com.au, 2006). Bettongs play an important role in forest ecology by dispersing the spores of the fungi in their dung, helping the fungi to spread to new hosts (www.yaraandoo.com.au, 2006). Reddell et al (1997) showed that the spores of mycorrhizal fungi were still viable after being passed in faeces, and colonized the roots of host-plant seedlings. The local extinction of bettongs may have wide ranging implications for the health of the whole ecosystem. However, more research is needed (Reddell et al, 1997).

Truffles are not as important to the diet, as in other species of Potoroid, such as the Long-nosed Potoroo *Potorous tridactylus*. The rufous bettong can meet 80% of its dietary needs from grass, hypogeal fungi form only a small proportion of its diet, mainly as a source of protein nitrogen (Tyndale-Biscoe, 2005). Fungal sporocarps are so sparsely scattered in woodlands, that foraging for them would waste too much energy (Tyndale-Biscoe, 2005).

Aepyprymnus rufescens can normally forego drinking altogether except in times of drought, when it excavates a hole in creek beds to attempt to reach the water level for a drink (Peterson, 2000).

3.5 Longevity

3.5.1 In the Wild

Accurate values are not known, however, estimates are from four to twelve years, with an average of about six years (P. Geddes, B. Liddle pers. comm.).

3.5.2 In Captivity

The average life expectancy for rufous bettongs in captivity is 7 – 12 years (Jackson, 2003).

3.5.3 Techniques Used to Determine Age in Adults

"All young potoroids have two premolars, which are shed near maturity and replaced by a single premolar. This transformation is a good diagnostic feature in determining maturity.The premolars and molars erupt sequentially and have been used to age potoroids. There is no forward progression of molar teeth once they have erupted. Subsequent ageing techniques, therefore, must be based on toothwear. The size of the molars decrease from anterior to posterior. Old animals occasionally develop supernumerary molars that erupt through the bone, but not the cheek membrane" (Seebeck and Rose, 1989. pg 7). "Tooth loss of the pattern seen in macropodids has not been recorded in potoroids and probably is not an important factor in mortality of old animals, although tooth wear may well be" (Seebeck and Rose, 1989. pg. 7).

4. Housing Requirements

4.1 Exhibit/Enclosure Design

Enclosures for rufous bettongs can be quite simple in design, although, as they are able to climb, dig and jump, careful consideration must be given to these abilities. The fence may be made of either a smooth, unclimbable material such as steel Colourbond or chain mesh, and be at least 1.5 metres tall. A fence with walls extending at least 30 cm below the soil or a 50cm horizontal mesh "apron" should be put in place to prevent individuals digging out. Small enclosures, (with limited room to escape) should be snake-proof, particularly in areas where large pythons are present. Rufous bettongs are territorial and aggressive, therefore overcrowding should be avoided to reduce stress and injury. Small enclosures (less than 70 square metres) should only have one male to reduce the risk of injury associated with fighting.

One of the threats to rufous bettongs in the wild is predation by feral animals, so the enclosure, and/or the institutions perimeter, must be fox, cat and dog proof. Such fences are usually electrified, at least two metres tall, and have a 500-600 mm wide apron of 1.4 mm mesh with 40mm wide holes (pers. obs). The mesh of the fence should have holes smaller than 80 mm to prevent juvenile foxes from squeezing through. Large shrubs and trees should be cleared from at least three metres either side of the enclosure to prevent predators climbing over. Several institutions use various designs for fox-proof fencing, such as Scotia Sanctuary, Waratah Park, and Australia Walkabout Wildlife Park (pers. obs.). Some have an overhang with an electric wire at the top (Waratah Park), while others use vertical mesh only with two electric wires (Australia Walkabout Wildlife Park). (See Figure 1).

Figure 1. Electrified feral predator-proof perimeter fence at Australia Walkabout Wildlife Park (Photo: N. Carson).

All fence poles should be on the outside of the mesh to prevent injury from collisions during capture, as macropods will usually flee along fencelines.

The minimum standards for exhibiting macropods in NSW state "Establishments exhibiting macropods shall have a dog and fox-proof perimeter fence. (Min.2m high, 0.5m beneath ground and 0.5m overhang at 45 degrees outward. If not constructed from smooth unclimbable panel - other appropriate alternatives will be considered.) If climbing species (Musky Rat Kangaroo, Rock Wallabies, Tree Kangaroos and Bettongs) are to be enclosed by unroofed fences, then the fences shall either be made of a material which is not climbable (min. l.4m high; 2m for Rock Wallabies) or be rimmed by 45 degree outrigger 0.5m wide facing into the enclosure" (Anon. No date 1).

Shelter should be provided by thick bushes, grass tussocks, rocks, hollow logs and shade trees (either within or outside the enclosure). Artificial shelter may need to be provided especially over feeding areas to prevent spoilage.

Johnson (1978 pg. 157) successfully kept a wild caught colony in a 56 metre squared mesh enclosed yard "with 1.8 metre high fences of 38mm mesh wire embedded in concrete foundations. Hessian 2m high was attached to the lower inside of the fence to

prevent injury to newly captured animals that collided with the fences". The hessian was removed when the colony had settled. Johnson (1980) kept two males and five females in a 70 square metre enclosure.

Rufous bettongs are nocturnal so they may be displayed in a reverse lighting enclosure. Several free range sanctuaries such as Australia Walkabout Wildlife Park and Waratah Park conduct nocturnal tours, where bettongs display very well with other macropods, allowing the public to get very close and observe natural behaviours. The provision of unobtrusive 12 volt lighting and torchlight doesn't seem to alter their behaviour (pers. obs.).This form of display also offers great educational opportunities, as the public learn about the benefits of feral animal free sanctuaries, and the threats facing many Australian mammals.

4.1.2 Walk-through exhibits

Due to their brash nature, rufous bettongs are great display animals in walk through enclosures (pers. obs.). Such enclosures should be designed so the public stay on walking tracks and don't harass animals, or attempt to feed inappropriate food. This is particularly important for rufous bettongs to ensure their well-concealed nests aren't trampled, and could be achieved, for example, by constructing raised boardwalks. Enclosures should be large enough so that animals do not feel trapped or cornered by visitors. A refuge area should be provided so that animals are not stressed. Waratah Park is a 12 hectare free-range park, where the walk through exhibit works very well. Visitor access is restricted to guided tours, so that the public are always supervised. Tours are timed to begin at sunset, when rufous bettongs become active. Food such as hulled oats and dog biscuits are scattered around the tracks shortly before sunset. The walking track, and interesting features are illuminated with 12-volt lights, and guides use a spotlight. Tour groups remain on a series of walking tracks in a 1.6 hectare area surrounded by 6 or 8 strand plain wire fencing. This fencing allows animal access to and from other areas of the park, and provides refuge, but restricts public movement.

4.2 Holding Area Design

Holding areas will be necessary to treat sick and injured animals, and for new introductions. Access to both indoors and outdoors should be provided, and a good sized pen would, for example have a 2m x 2m indoor area and a 2m x 4m outdoor area (Williams, 1995). Fences should be 2m high, and climb-proof or the area could be roofed. For hygiene, and ease of cleaning, concrete floors are best, but can pose problems of their own (Williams, 1995). Smooth concrete floors should be avoided due to the possibility of injury from animals slipping over, especially when wet (Williams, 1995). Rough concrete floors, though preferable, can damage bettongs feet after long periods. Sand, or sawdust can be added to avoid this problem, but must be replaced daily (Williams, 1995).

4.3 Spatial Requirements

The minimum area recommended for a pair of rufous bettongs is 15 square metres, with an additional 5 square metres for each additional animal (Jackson, 2003).

The minimum floor area provided per pair of rufous bettongs in New South Wales (Anon. No date 1) and Queensland (Anon, 1992) is 10 square metres, with an additional 2.5 square metres added to the enclosure size for each extra adult female. An additional 5 square metres shall be added to the area of the enclosure size for each extra adult male (Anon. No date 1).

4.4 Position of Enclosures

The Rufous Bettong is a nocturnal species, and therefore rests during daylight hours. The enclosure, however should be positioned so that bettongs have the ability to choose sunny or shaded areas during the day.

4.5 Weather Protection

Rufous bettongs are nest builders, so sufficient natural nesting material must be provided so that individuals may construct their own nests. Nests may be constructed of grass, leaves, *Casuarina sp*. needles, pine needles or hay. Nests are often constructed under overhanging grass tree leaves, grass tussocks and thick leaf litter, and positioned with the rear against a log or stump for protection (pers.obs.).

Plenty of cover should be provided in the form of grass tussocks and shrubs to enable the bettongs to feel secure, and, if kept in an outdoor enclosure, to protect from extremes of temperature, and predation from birds of prey.

Simple rain shelters should be constructed over feed stations to prevent food spoilage (See Figure 2).

Rufous bettongs have been kept successfully indoors, usually in nocturnal houses under reverse lighting conditions. A layer of soil, leaf litter, and several grass tussocks should be provided.

Figure 2. Simple feed shelter serving two adjoining enclosures at Australia Walkabout Wildlife Park (Photo: N. Carson).

4.6 Temperature Requirements

Rufous bettongs naturally ranged over a large area of eastern Australia from tropical Queensland to northeast New South Wales and central Victoria, and so can tolerate a wide range of temperatures. This may range from sub-zero overnight temperatures to diurnal temperatures over 40 degrees Celsius, and from low to high humidity. Generally, additional heating is not required under Australian conditions.

The rufous bettongs nest has an important insulative function during the day, the resting period of the animals, but is only seldomly used at night (Reubsamen et al, 1983).

4.7 Substrate

Enclosures are best if on a natural soil with plenty of vegetation, due to the bettongs habit of foraging for roots, tubers and fungi. A concrete floor is not advisable for long term enclosures, due to the bettongs digging habits and possible damage to the animals feet. Animals kept indoors can develop excessively long claws on the hindfoot which may need trimming (Jackson, 2003).

4.8 Nestboxes and/or Bedding Material

Rufous bettongs construct nests for shelter during the day, and individuals may have as many as four nests in use at any one time (P. Geddes pers. comm.). Long fibrous plant material such as grass, stringybark, lucerne stalks, and *Casuarina sp*. needles must be available for nest construction.

4.9 Enclosure Furnishings

Natural grass tussocks should be provided, as they are favoured sites for nest construction. Grass trees (*Xanthorrhoea spp*.) are favoured for nests by bettongs due to the long overhanging leaves, which provide additional shelter and camouflage (pers. obs.). Several, rotting stringybark logs (*Eucalyptus spp*.) provide nesting material, and attract insects and fungi that the bettongs will eat. Johnson (1978) recommended planting the enclosure with clumps of tall grass, with about one clump per square metre.

5. General Husbandry

5.1 Hygiene and Cleaning

Regimes for regular cleaning should be derived, to ensure all staff know what needs to be done on any given day.

Daily cleaning should be done in the morning, and include raking to remove faeces, and leftover food. All waste should be disposed of in bins which are taken off site. Food and water bowls should be rinsed every day. Food bowls should be dry before placing food in them. Feeding should only ever be done after cleaning has been completed. The timing of feeding depends on whether the enclosure is outdoors or an indoor, reverse-lighting nocturnal house. For outdoor enclosures, feed should be presented just before sunset, because if it is left out all day it will attract vermin, and begin to rot. Animals in indoor enclosures should be feed around the time they first become active.

Freshly dug holes may need to be filled in for keeper and animal safety, and if they are close to the fence. Filling in holes may also help with enrichment, as the bettongs can re-dig them.

Every second day, food and water bowls should be thoroughly washed with an anti-bacterial solution. For example on Monday, Wednesday, Friday and Sunday. Bowls must be thoroughly rinsed and dried before being used by bettongs again.

For small enclosures (< 30 square metres) substrate should be sifted, debris removed and new topsoil added every month.

Nesting material should be replaced monthly.

Animals should be wormed with an anthelmintic such as Panacur every three to six months depending on enclosure size, number of animals, and results of faecal floats.

New tussocks, shrubs should be planted as necessary.

5.2 Record Keeping

A record of the health, condition and reproductive status of captive animals should be updated routinely (Jackson, 2003).

"The collection of information on physical and behavioural patterns of each individual can contribute greatly to the husbandry of these species. It also allows the history of each individual to be transferred to other institutions if required and greatly facilitates a cooperative approach to data collection amongst institutions. In most of the larger institutions, ARKS (for general information on births, transfers and deaths), SPARKS (breeding studbook for species) and MedARKS (veterinary information) are used. These systems have been developed by the International Species Information System (ISIS), which is part of the Conservation Breeding Specialist Group (CBSG) software. As these are standardized, there is a high degree of efficiency in transferring information between institutions" (Jackson, 2003. pg 258).

Records should be kept of:

- Identification numbers (should be given after permanent emergence from the pouch, and/or upon arrival at the institution)
- Any veterinary examinations conducted (recorded on the day they are performed)
- Treatments provided (recorded as they are given)
- Behavioural changes or problems (as noticed)
- Reproductive behaviour or condition (as noticed)
- Weights and measurements (should be weighed monthly)
- Changes in diet (as changed)
- Movements of individuals between enclosures or institutions (as carried out)
- Births with dam and sire if known (at emergence from pouch)
- Deaths with post mortem results (Jackson, 2003).
-

Comprehensive, daily records are not always possible in large, free-range sanctuaries. However, identification numbers, behavioural changes, reproductive behaviour, veterinary treatment, births and deaths should all be recorded whenever possible.

5.3 Methods of Identification

According to Jackson (2003) "identification techniques must have a number of attributes in order to be effective including:

- Being permanent
- Positively identifying the animal as an individual
- Being inexpensive and easy to apply
- Not unreasonably damaging the individual
- Being relatively painless to apply
- Not interfering with the animal's mobility
- Being adaptable to modern data retrieval systems

- Being clearly visible
- Being unalterable".

There is not a particular method of identification that is best in all situations, so some people recommend the use of two methods to avoid misidentification (Jackson, 2003). The various types of identification and their attributes are presented below.

5.3.1 Passive Integrated Transponder (PIT) tags

These tags, or microchips are implanted between the scapulae of individuals with a syringe. The injection site should be sealed with tissue glue (Vetbond) or a similar fast setting adhesive (Jackson, 2003. Pers. obs.).. This method of identification, works very well and cannot be seen by the public, so it doesn't detract from the look of the animal. The disadvantages are that it can be expensive if many animals are implanted, and that the animal must be caught to confirm identification with a PIT tag reader (Jackson, 2003).

5.3.2 Tattoos

Tattoos can be made on the inside of the ear or inside the hind leg (Jackson, 2003). Tattoos are an inexpensive method and could work well with rufous bettongs due to their light skin colouring (Jackson, 2003). The disadvantage with tattoos, are that they can fade and once again, the animal must be caught for identification (Jackson, 2003).

5.3.3 Visual identification

Identification of rufous bettongs by size, sex, colour and markings, is quite difficult (pers. obs.) and not reliable for inexperienced people (Jackson, 2003). This method is also inadequate if large numbers are kept in a free-range situation.

5.3.4 Ear tags

Metal ear tags stamped with identification numbers are used on many species of macropod (Jackson, 2003). They are inexpensive but not necessarily reliable as they can be pulled out, so they should be positioned quite low on the ear. They also require the animal to be caught for reading the tag. Plastic disc ear tags can be used with different colours and positions in the ear (Jackson, 2003). They are more expensive than metal ear tags but animals can be identified from a distance, and so would be effective for large exhibits (Jackson, 2003). However, they do fade, and would not be effective for large populations (>50).

Frederick and Johnson (1996) used reflective eartags made from reflective tape fixed to brass eartags in three easily distinguishable colours (red, blue-green or white). The tags were placed in one or two positions per ear, allowing Individuals to be recognisable at a distance of up to 100 m using a spotlight and binoculars (Frederick and Johnson, 1996).

5.3.5 Ear notching or punching

Notches or punches can be used in various combinations and positions to represent numbers (Jackson, 2003). These can be used to identify large numbers of animals, however, they can look unsightly (Jackson, 2003). Care must be taken to avoid blood vessels when using this method (Jackson, 2003).

5.3.6 Freeze Banding

This particular method has the advantage of being permanent, however, for identification, animals must be caught. This method also requires veterinary care as animals need to be captured and anaesthetized for its application to be painless, and eliminate the chance of smudging from the animal moving (Jackson, 2003).

5.3.7 Collars

Rufous bettongs have been successfully identified using small vinyl neck collars painted with reflective paint of different colours (Johnson, 1980). Reflective collars can be seen from a distance, however they are not aesthetically pleasing (Jackson, 2003).

5.4 Routine Data Collection

Rufous bettongs should be checked visually every day and their condition recorded as detailed in Section 5.2. Any unusual behaviour or changes to diet should also be recorded. Weighing needs to be carried out regularly, and should be done every month. The weight of female rufous bettongs could be taken approximately 21 days after mating, or 21 days after a joey permanently leaves the pouch so that the pouch may be checked at the same time for new births. Once a joey permanently vacates the pouch, it should be identified using one of the methods described in Section 5.3.

6. Feeding Requirements

6.1 Captive Diet

Jackson (2003) recommends feeding ad lib for macropods, however this has the disadvantage of attracting birds and rodents, which may carry pathogens such as worms (see section 8.3 on known health problems). Bettongs should be fed just before sunset, so that food is available, and fresh when they become active, and naturally begin feeding. In nocturnal houses, the "sunset" will be early in the morning. The diet does not need to be changed at certain times of the year for breeding or nutritional reasons, however the wild diet should be replicated closely wherever possible, and variety is strongly recommended. I would not recommended giving macropods sharp feeds such as dry seeds and Lucerne stalks due to the possibility of the gum being pierced, and allowing access to bacteria that cause lumpy jaw (Jackson, 2003).

"Rufous Bettongs are simple to feed – they will eat small quantities of fresh green grass, most fruits (such as apples, pears), vegetables (particularly root ones such as carrots, potatoes, etc but also cabbage, sweet corn), various grains (such as rolled oats, sunflower seed), nuts (almonds, peanuts), commercial kangaroo pellets, mushrooms and even live food (such as longicorn larva, and other insects). I regularly feed my animals dog pellets and dried bread also. Naturally fresh water must be available at all times" (Keynes, 2001).

Listed below are several diets used by institutions around Australia. The diet varies slightly between institutions due to enclosure size, and the natural availability of wild food within the enclosure. For example, Waratah Park has 12 hectares of mixed bushland and pasture for the bettongs to forage naturally, so supplemental food is given only.

The NPWS Queensland at Pallarenda had an enclosure where two hoppers provided commercial poultry laying pellets (17% minimum crude protein) ad lib. 125g sliced sweet potato per animal was placed in the yard each afternoon, and fresh green grass including roots was supplied twice a week (amount not specified) (Johnson, 1978, and Johnson, 1980).

Cowan Field Station provided for each animal -
Half an apple
Half a banana
A medium carrot
Half a pear
Half a slice of bread
A small amount of dog kibble and Kangaroo Cubes (exact amount not specified) (Williams, 1995).

Healesville Sanctuary uses the following diet (Jackson, 2003).

Ad Lib
Water

Daily Diet (per animal)
Eukanuba Pet Food Kibble (amount not specified)
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms

A good weekly feeding regime provides variety for animal enrichment, and gives room for food substitution if certain foods are unavailable. It will also provide a balanced diet, and help prevent a dominant individual eating all of its favourite food and others missing out. An example follows -

Sunday –
30g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
2 almonds
5mL nectar mix
20g mushrooms

Monday –
20g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange

50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
6g egg and cheese
5mL nectar mix

Tuesday –
40g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
6g egg and cheese
5 sultanas/hulled oats

Wednesday –
30g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
2 almonds

5 sultanas/hulled oats
20g mushrooms

Thursday –
40g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
6g egg and cheese
5mL nectar mix

Friday –
20g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced
30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealworms
2 almonds
5mL nectar mix
20g mushrooms

Saturday –
30g Eukanuba Pet Food Kibble
40g apple – 2cm cube
30g orange
50g banana
30g corn
10g sprouted seed
30g carrot – sliced

30g pear
30g potato/sweet potato
5g pet health food – 1cm cube
20g pasture replacement pellets
2g silverbeet
5g mealwormspellets and fruit
6g egg and cheese
5 sultanas/hulled oats

6.2 Supplements

Waratah Park provides nightly supplemental feed for bettongs foraging in a 12 hectare area (pers. obs.) A 20 litre bucket full of equal amounts Shiny Coat dog kibble and hulled oats is scattered around the public walking tracks on feeders or hidden under leaf litter for around 100 bettongs (pers. obs.). Occasional supplements of potato, and quartered peanut butter sandwiches are offered.

6g egg and cheese – 3-4 times per week
2 almonds – 3-4 times per week
5mL nectar mix – 3-4 times per week
5 sultanas/sunflower seeds – 2-3 times per week
Other fruit and vegetables in season (Jackson, 2003)

Minced meat
Sprouted seed
Meal worms
Boiled egg
Wren mix (Higgins et al, 1997).

6.3 Presentation of Food

By scatter feeding and burying of food, it looks to the public as though animals are foraging naturally. At Waratah Park, feed is spread out along the route taken by public visitors, which is approximately 300m long. This method attracts animals close to the public for viewing, and also spreads the feeding bettongs, minimizing aggressive behaviour, and therefore potential injuries. In smaller enclosures, food should be presented off the ground in dishes spread throughout the enclosure.

It is important that the location of any hidden food is recorded so that staff can keep track of the amount of food eaten, and uneaten food can be removed before it rots and attracts vermin.

7 Handling and Transport

7.1 Timing of Capture and Handling

To avoid overheating, rufous bettongs should be caught when the weather is coolest, and as these animals are nocturnal, the best time would therefore be during the night. If that is not possible, or if they are kept in a nocturnal house, then early morning is best.

7.2 Catching Bags

Hessian sacks are usually the best, although pillowcases can be used. Thickly woven cloth ensures the animal will be in darkness, and will settle down more quickly (Jackson, 2003). Bags should have a wide mouth so that bettongs can be covered quickly, as they may be struggling and kicking (Jackson, 2003).

7.3 Capture and Restraint Techniques

The capture of rufous bettongs should be well planned, using experienced staff who are well aware of their role in the process (Jackson, 2003). Extended chasing may result in the animal injuring itself on a fence or other obstacle, or developing capture myopathy. Rufous bettongs are best handled by the base of the tail, taking care to avoid the hind legs which may kick violently. Bettongs may also bite and scratch and may also climb up their tail to bite when held (S. Byrne pers. comm.). The animal should be transferred quickly to a hessian sack or similar, ensuring its neck is not bent backwards at the bottom of the bag (pers. obs.). The bag can then be tied up with string, and kept in the shade until examination / transport is required.

Depending on the enclosure size and number of animals to be caught, several methods of capture can be used for rufous bettongs.

Treadle cage traps (30 x 30 **x** 60 cm) can be used to trap rufous bettongs in large enclosures (Frederick and Johnson, 1996). Traps may be baited with a peanut butter sandwich or rolled oats. Traps should be pegged or weighed down to prevent a trapped animal from overturning them (pers. obs.). This also stops larger animals in multi-species exhibits such as swamp wallabies *Wallabia bicolour* from knocking the traps about in an effort to reach the bait (pers. obs.). Rufous bettongs should not be left in the trap for extended periods, example overnight, due to stress, cold or heat exposure, and the likelihood of injury from jumping inside the cage.

If bettongs are kept in a small enclosure, and nests are easily located, they may be captured in the nest. Although, in doing so, nests may be destroyed. Wild or free range bettongs normally take off with great speed from the nest once someone gets within a couple of metres, and therefore capture can be quite difficult using this method (pers. obs.).

Sick or very tame individuals can quite often be approached, and grabbed by the tail, but if they escape, they will often be more wary and difficult to capture again (pers. obs.). Other bettongs usually become wary after noticing the caught animal struggle, and this may make capture of several individuals increasingly difficult (pers. obs.).

Rufous bettongs may also be caught by having several keepers drive them along a fenceline, while another one or two staff follow with nets. A good net for bettongs would be a hoop net 80cm in diameter, made of 5cm mesh attached to a 2m long handle (Johnson, 1978). Staff leave a narrow gap between themselves and the fence, and block access to the centre of the enclosure, so the animal is forced to hop along the fence. When a bettong attempts to hop past, staff quickly bring the net forward against the fence to catch it. Once caught, the opening of the net should be blocked by covering or twisting it, or placing it on the ground (Jackson, 2003).

Female rufous bettongs carrying pouch young may drop the joey during capture (pers. obs. Jackson, 2003). Females known to be carrying young, and needing capture must be monitored closely, and any dropped young should be placed back in the pouch as soon as possible. Females in bags for transport may drop their young and then injure it in their struggle to escape (pers. obs.). To avoid this, pouches can be closed with masking tape, which the female will remove after calming down (Jackson, 2003). Females carrying large joeys should not be transported.

7.4 Release

Bettongs should be released from the bag in an open area free of obstacles, as they may hop very quickly and erratically (pers. obs). Before releasing any females with young, make sure the young are still in the pouch and not at the bottom of the bag. Animals recovering from anaesthetic should be released in quiet, shady areas, free of obstacles as they may be unsteady on their feet for some time (pers. obs.).

7.5 Transport Requirements

7.5.1 Box Design

A diagram of the box design for bettong transport is provided in the IATA standards (see appendix).“Framework shall be 20mm x 20mm light timber for macropods weighing less than 20kg. Macropod transport containers shall not have internal framing. Bottom and fixed sides shall be of 6mm plywood glued and screwed. Macropod transport containers shall not have slatted floors. The end is to be closed by a sliding door of 6mm plywood which, once in place, shall be secured by screws at each end. The ceiling shall not be solid. It shall consist of flexible chicken wire mesh, padded on the underside with hessian to protect the animal's head should the animal become agitated and jump. The container shall be large enough for the animals to turn around, to lie and to stand

comfortably. Dimensions shall not exceed these criteria as no room for exercise is needed and animals may hurt themselves if too much room is provided. A transport container for macropods shall not allow the entry of light, except through ventilation holes. The ventilation holes shall be 5cm below the internal roof height and 5cm above absorbent material used on the floor of the container to prevent spillage. The ventilation holes of 15mm diameter shall be pierced at no greater than 10cm centres at the top and bottom of each side. Spacing blocks of 2.5cm shall be fixed to the outside of the box on all four sides (Anon. No Date 1).

The container should be labeled “LIVE ANIMAL” “BETTONG” “FRAGILE”.

Several bettongs in separate bags may be carried within one container, depending on its size. Bettongs have been transported interstate in heavy hessian bags held in airline 'pet packs' (NHMRC, 1995).

7.5.2 Furnishings

It is best if no box furnishings are provided to minimize risk of injury.

7.5.3 Water and Food

For transport over short distances, up to a few hours, water and food is not necessary. Over long distances it can be provided in spill proof plastic containers.

7.5.4 Animals per Box

One only, unless bags can be hung from the inside of a container . It is not recommended to transport females with pouch young due to the possibility of ejection of the young and injury or death.

7.5.5 Timing of Transportation

The trip should be as short as possible, and carried out in the cool of day or at night to reduce the risk of the bettong overheating.

7.5.6 Release from Box

The box should be slowly released in an open area with no obstacles, the same as would be done when releasing an animal from a bag. The box can be left open, in the enclosure, allowing the bettong to adjust to its new surroundings and leave the encosure when it is ready (Jackson, 2003). As with release from a bag, check the box for any pouch young that may have been dropped.

8. Health Requirements

8.1 Daily Health Checks

Due to the rufous bettong's habit of sleeping in a concealed nest, daily health checks are best carried out when the animals are active i.e. at night (or reversed night in a nocturnal house). Animals becoming active during daylight can be a good way to notice something not right, although this may simply mean they are after food intended for other animals such as at Warrawong Sanctuary and at Waratah Park (pers. obs.). Keepers should be familiar with normal behaviour, so that anything unusual can be noticed readily. The amount of food eaten, and of what type should also be noted daily. The following list of things to check comes from Jackson (2003) pg. 268-69.

- coat condition
- fur on the enclosure floor – suggesting fighting or mating
- appetite
- discharges – from the eyes, ears, nose, mouth or cloaca
- faeces - number and consistency
- cloaca and rump – for wetness
- nose – wrinkles may suggest dehydration
- dirt around the mouth – suggesting dirt eating (pica)
- changes in demeanor
- injuries – including swellings around the face (indicating lumpy jaw), lameness, reluctance to move or stiffness (indicating myopathy, muscle strains, injuries)
- presence and development of pouch young by observation of the bulge in the pouch
- semen plugs, suggesting mating
- aggressive behaviour at feed stations

8.2 Detailed Physical Examination

8.2.1 Chemical Restraint

Adult macropods do not require pre-anaesthetic fasting, however animals being hand-reared should fast for at least an hour (Jackson, 2003).

"All macropods shall be sedated with diazepam administered under the supervision of a registered veterinarian before being enclosed in transport containers" (Anon. No date 1). Diazepam (valium) is administered at a dose of 0.5-2.0 mg/kg, by intramuscular injection with dose dependant on the individual temperament of the animal (Jackson, 2003). Diazepam is important as a muscle relaxant and anxiolytic to help prevent capture myopathy (Jackson, 2003).

Tiletamine/zolazepam (Zoletil) is used for anaesthesia at a rate of 5-15 mg/kg by intramuscular injection (Jackson, 2003).

Anaesthesia is best done by isoflurane and oxygen delivered via a face mask (Higgins et al, 1997).

The following information comes from Holz (2005).

“Inhalation anesthesia is the technique of choice. If the animal weighs <10 kg, and can be manually restrained, the safest way to induce general anesthesia is via a non-rebreathing circuit (e.g., Ayre's T-piece) and a mask. Masks can be custom made using variably sized plastic bottles. The bottom is cut off and a piece of rubber glove is stretched over the opening. A hole is then made in the glove to accommodate the animal's face. For animals in bags anesthesia is induced by extracting the macropod’s head and placing the face in the mask. In this way the operator is protected to some extent from the powerful hindlimbs as they are contained within the bag.

On a non-rebreathing circuit induction involves exposure to 5% isoflurane delivered at an oxygen flow rate of 200 ml/kg/min with a minimum of 1L/min. For a rebreathing circuit, oxygen flow rate should be 50 ml/kg/min. Maintenance of anesthesia generally requires 2% isoflurane, but this varies between species and individuals.

If isoflurane is unavailable halothane is an acceptable substitute, but is not as safe and requires close monitoring”. See Appendix for further information on chemical and manual restraint.

8.2.2 Physical Examination

Weighing can be done by hanging the sack containing the animal on a set of hanging scales, and then subtracting the weight of the bag and string. Physical examination can be carried out in the bag. The bettongs eyes should be covered to reduce stress, and keep the animal still. The pouch can be examined by two people, where one restrains the legs, and the other checks the pouch. Or by sitting on the ground and examining the animal in the bag between your legs, taking care to avoid being kicked (Jackson, 2003). “The condition of the pouch can be: 1) dirty, indicating a non pregnant animal with no young, 2) clean, indicating oestrus, 3) glandular, indicating pregnancy, 4) pouch young present, 5) an elongated lactating teat for a young at foot, or 6) regressing and producing only a clear fluid when squeezed” (Jackson, 2003 pg. 266).

The following should also be checked (Jackson, 2003):

- Body condition – by feeling the base of the tail, scapula spine and between the hips.
- Temperature – normally 35-36.5 degrees Celsius, taken through the rectum via the cloaca.
- Weight – regular weighing can be used to determine trends, and notice state of health.
- Pulse rate and respiratory rate – taken under anaesthesia only, as they are likely to be raised after capture.
- Fur – check for alopecia, parasites, fungal infections or trauma.

- Eyes - should be clear, bright and alert. Should have normal bilateral papillary light response, normal corneal reflex, and be free of discharge.
- Check for presence of lumps over body and auscultation of lungs.
- Cloaca – should be clean, check for semen plugs.
- Pouch – check condition of pouch as in section 8.2.2. if pouch young present, check age, sex weight.
- Males – check testes for size and consistency, and extrude penis and assess.

8.2.3 Routine Treatments

For the prevention of heavy endoparasitic worm infestations, bettongs should be treated with an anthelmintic such as Panacur every 3-6 months.

Any antibiotic treatments should not be given orally, as they may disturb the bettongs natural array of bacteriophages in their fermentative forestomachs" (Klieve, 1991).

8.3 Known Health Problems

8.3.1 Ectoparasites

Cause – Rufous bettongs may be affected by several types of ectoparasite such as ticks, biting lice (Pers. obs.), fleas, chigger mites and sarcoptic mites (Jackson, 2003).
Signs – Mites can cause dermatitis, crusting, erythema, pruritus and alopecia (Jackson, 2003). Clusters of mites may be found around the pinnae (Jackson, 2003). Immunosuppressed bettongs tend to be more affected by the affects of paralysis ticks, and may host large numbers (up to 40 pers. obs.). Affected bettongs are obviously weak and slow, may become active during the day and are easily approached (pers. obs.). Bettongs suffering from a high tick burden may become anaemic (pers. obs.).
Diagnosis – Ticks may be very hard to find amongst the fur if they are in small numbers, however they become easier to find as they become engorged with blood and grow (pers. obs.) Fleas can usually be seen on close inspection moving around in the fur, and are easily seen against the rufous bettongs white belly fur (pers. obs.). For mites, a skin scraping may need to be taken, and examined by a veterinarian for confirmation (pers. obs).
Treatment – Ticks can be removed with tweezers, or engorged female paralysis ticks are easily removed by hand (pers. obs.). If new hatchings persist, bathe in Ectodex (Starr in Hand, 1995). Biting lice *Heterodoxus ampullatus* can be dusted with Kix powder (Johnson, 1978), or the bettong's dorsal area may be sprayed with Fly Away (pers. obs.). Mites, causing alopecia and self -trauma, may be treated using malathion (NHMRC, 1995) or ivermectin or moxidectin pour on 200 ug/kg repeated weekly for four to six treatments (Jackson, 2003).
Prevention – Bettongs released into large enclosures or sanctuaries where intensive husbandry is not possible, should be treated with Frontline Plus to prevent tick infestations whilst the animals are acclimatizing (pers. obs.). Keep hand reared animals away from dogs and cats to prevent flea infestations (Williams in Hand, 1995). Reduce stocking rates for enclosures, to prevent stress related outbreaks of mites (Jackson, 2003).

8.3.2 Endoparasitic worms

Cause – Macropods, including rufous bettongs can host a variety of gastrointestinal parasites such as flukes (trematodes), tapeworms (cestodes) or roundworms and strongyloides (nematodes) (Jackson, 2003). Species of parasite particularly associated with rufous bettongs include *Potorostrongylus aepyprymnus* (Nematoda) (Smales, 1997), and the rat lungworm *Angiostrongylus cantonensis* (Nematoda) (Higgins et al, 1997). "The rat lungworm is excreted in rat faeces as a first stage larva. It develops into a third stage larva within several species of slugs and snails and is transferred to its definitive, paratenic or abnormal host by ingestion of the mollusk or possibly its slime trail or faeces" (Higgins et al, 1997. pg. 564). *Capillaria* worms have been found in the lungs of rufous bettongs (Williams in Hand, 1995).
Signs – Clinical signs for rat lungworm range from unilateral hindlimb paresis to bilateral hindlimb paralysis and "multifocal neurological deficits" (Higgins et al, 1997). Some cases may develop urinary stasis necessitating manual expression of the bladder (Higgins et al, 1997). Individuals have developed unilateral lesions caused by excessive grooming (Higgins et al, 1997). Strongyloides can result in weight loss (Jackson, 2003).
Diagnosis – At necropsy live *Angiostrongylus cantonensis* may be found in the brain

(Higgins et al, 1997). Faecal flotation is useful for most gastrointestinal helminthes (Jackson, 2003. pers. obs.). Although *Strongyloides* is difficult to diagnose ante mortem because larvae and not eggs are excreted in faeces (Jackson, 2003). *Strongyloides* can be diagnosed using the Baermann technique to separate active larvae from fresh faeces (Jackson, 2003). *Capillaria* worms in the lungs of bettongs can cause respiratory problems and coughing (Williams in Hand, 1995).

Treatment – Parasites can be treated with anthelmintics including ivermectin 200 ug/kg and Cydectin (moxidectin) (200-500 ug/kg) (orally, topically and by injection), benzimidazoles, Systamex (oxfendazole) and Panacur (fenbendazole) and levamisole (Jackson, 2003). The clinical symptoms of *Angiostrongylus cantonensis* in rufous bettongs have been treated with daily parenteral dexamethasone (4mg/kg reducing to 2mg/kg sid over 4 days), intramuscular amoxycillin and subcutaneous fluids to maintain hydration (Higgins et al, 1997). Daily diazepam (2mg intramuscular injection Canfield et al, 1990) or vitamin E should be administered to reduce stress and the risk of capture myopathy during treatment (Higgins et al, 1997). The prognosis for bettongs with rat lungworm is poor due to the need for complete recovery of hindlimb function, and their propensity to develop complications during long periods of immobile hospitalisation and regular handling (Higgins et al, 1997). *Capillaria* worms have been treated with Panacur and injectible Avomec (Williams in Hand, 1995).

Prevention – For rat lungworm *Angiostrongylus cantonensis*, prevent access to slugs and snails, and rat faeces (Higgins et al, 1997). Therefore, enclosures must be well drained so they are less attractive to slugs and snails. Enclosures should be rat-proofed, or if that is impossible (as in large sanctuaries) then uneaten food must be removed as soon as possible, and food should not be given ad lib. Enclosures should also be at least spot raked daily to remove faeces from bettongs and other animals.

8.3.3 Protozoans

8.3.3.1 Toxoplasmosis

Cause – An intracellular protozoan parasite *Toxoplasma gondii*. Australian marsupials are very sensitive to toxoplasmosis possibly because they were not exposed to it before the arrival of its carrier, the domestic cat in the 18th century (Jackson, 2003). Bettongs can contract the disease by eating food contaminated with cat faeces (Jackson, 2003). Disease may not be apparent after infection until a period of immunosuppression triggers clinical disease (Jackson, 2003).

Signs – Various signs include lethargy, depression, reduced appetite, respiratory distress, convulsions, diarrhoea, staggering, lack of coordination, circling and apparent blindness as a result of encephalitis and paralysis (Jackson, 2003). Sudden death may occur without signs (Jackson, 2003).

Diagnosis – Usually based on clinical signs, serology and histopathology (Jackson, 2003). For ante mortem diagnosis, serological testing is used to detect rising IgG *Toxoplasma gondii* titres (Jackson, 2003). A useful method is the Direct Agglutination Test or Modified Agglutination test using the Antigene toxo-AD kit and microtiter plate reagents (Jackson, 2003). For post mortem diagnosis histopathology is used, with lesions generally found in the lungs, brain, adrenal glands, lymph nodes and pancreas (Jackson, 2003).

Treatment – Toxoplasmosis is a fatal disease, and most animals die before an accurate diagnosis can be made (Jackson, 2003). Bettongs that do survive to diagnosis should generally be euthanased due to the pain from associated encephalitis (Jackson, 2003). Toxoplasmosis may recur in animals that initially recover due to stress or old age (Jackson, 2003). Treatment is usually unsuccessful, but has been tried with macropods, using potentiated sulphonamides, sulphadimidine and pyrimethamine or clindamycin, 11 mg/kg body weight twice daily orally or intramuscularly for at least 30 days (Jackson, 2003). Atovaquone may also be used to treat toxoplasmosis at a dose of 50-100 mg/kg/day for 30 days (Jackson, 2003).
Prevention – Exclude cats from feed, food storage areas and enclosures.

8.3.4 Bacteria

8.3.4.1 **Lumpy jaw or Necrobacillosis**

Cause – Bacteria such as *Fusobacterium necrophorum, Corynebacterium pyogenes,* and *Bacteroides (Dichelobachter) nodosus* (Jackson, 2003). The most common reason for the onset of this disease is through an infected tooth (Williams in Hand, 1995). This may be caused from damage to teeth and skull bones from a fence collision (Williams in Hand, 1995). Gums pierced by sharp food such as bird seed and lucerne stalks also allow bacteria to enter the system. Often, by the time the symptoms are noticed, the bone around the infection becomes necrotic (Williams in Hand, 1995). The bacteria can spread from the infected animal to others in the enclosure by shared drinking water, food and faeces.
Signs – Excessive salivation and chewing and rapid swelling of the face (Williams in Hand, 1995). Weight loss and flicking of the tongue, dysphagia, dyspnoea, rhinitis, dull eyes, poor coat and progressive weakness due to difficulty eating (Jackson, 2003).
Diagnosis – Facial abscesses, clinical signs and anaerobic culture (Jackson, 2003). Radiography is useful to assess the amount of bone damage (Jackson, 2003).
Treatment – Depending on the stage of necrosis, teeth removal, the insertion of a surgical drain in the jaw, and daily intramuscular injections of antibiotics such as Amoxil and Baytril can be very successful (pers. obs. in a red-necked wallaby *Macropus rufogriseus*).
Prevention – Supply hard (but not sharp) foods such as pellets and dry grass to strengthen the gums and teeth (Jackson, 2003). Avoid food such as hard seeds (oats with husk, sunflower seeds) and spiky lucerne stalks that may damage the gums. Remove faeces from around feed areas daily to reduce spread of bacteria. Remove affected individuals from enclosure immediately after signs of infection are noticed, and wash all feed and water troughs with an anti-bacterial solution. If possible, rest contaminated enclosures for three to four weeks (Jackson, 2003). Footvax may be effective as a vaccination to prevent lumpy jaw (Jackson, 2003).

8.3.4.2 Pneumonia

Cause – Associated with gram negative bacteria including Pseudomonas sp., Klebsiella sp. Or Escherichia coli (Jackson, 2003). Pneumonia is often seen in hand-reared macropods. Causes include; exposure to cold draughts, being cold or wet in the pouch, force feeding, smoke inhalation and using a teat with too large a hole (Austin, 1997).

Signs – Most signs are only seen late in severe disease, when it is often too late (Austin, 1997). Discharge from the nose, a rattly chest, abnormal, rapid noisy breathing, drowsiness, changes in body temperature (higher or lower), loss of appetite and looking sick (Austin, 1997).
Diagnosis – Clinical signs, auscultation of the chest or trans-tracheal wash and culture (Jackson, 2003).
Treatment – Dexadreson (dexomethosone) 1 mg/kg SID IV (Jackson, 2003). Antibiotics such as Baytril 5 mg/kg bodyweight subcutaneous SID (Jackson, 2003).
Prevention – feed joeys carefully, do not force feed joeys, keep the joey warm, allow the joey to hop around (at the suitable age) to exercise its lungs, massage the joey and turn over regularly to prevent secondary pneumonia (Austin, 1997).

8.3.4.3 Salmonella

Cause – The bacterium **Salmonella** sp. (Jackson, 2003). Poor hygiene, stress and overcrowding (Austin, 1997).
Signs – Diarrhoea, dysentery, dehydration and depression (Jackson, 2003). Sudden death pneumonia, may progress to septicaemia and death (Austin, 1997).
Diagnosis – Via faecal culture (Jackson, 2003).
Treatment – Is not recommended because most animals die, even with treatment, survivors usually become carriers and salmonella is a Zoonosis (Austin, 1997). Treatment may be attempted with antibiotics chosen from the results of culture and sensitivity, including Baytril (enrofloxacin) 5 mg/kg intramuscular SID 7-10 days (Jackson, 2003).
Prevention – Maintain good hygiene and minimize stress.

8.3.4.4 Tetanus

Cause – The bacterium *Clostridium tetani* entering an anaerobic wound from the soil (Jackson, 2003).
Signs – Signs of tetanus include violent tetanic spasms made worse by external stimuli such as loud noises, touching (Austin, 1997). Unable to eat due to jaw stiffness, drooling, nostril dilation, protruded nictitating membrane, laboured breathing and death as a result of convulsions and respiratory failure (Jackson, 2003). **Diagnosis** – Clinical signs (Jackson, 2003).
Treatment – The disease has a rapid course and usually has 100% mortality (Austin, 1997). Although Jackson (2003) recommends treatment using intravenous fluids, muscle relaxants such as diazepam (2 mg/kg IM), procaine penicillin (30 mg/kg intramuscularly), benzathine penicillin (25 mg/kg IM) and tetanus antitoxin and toxoid (Jackson, 2003).
Prevention – Vaccination can begin when hand-reared animals start grazing (Jackson, 2003). Inject the five-in-one vaccine (1 mL) subcutaneously or tetanus toxoid (0.5 ml) intramuscularly (Jackson, 2003). The dose should be given twice, four weeks apart, then annually or opportunistically (Jackson, 2003). The vaccine can have severe side effects (Austin, 2003).

8.3.5 Fungi and yeasts

Cause – The yeast *candida albicans* can result in candidiasis or thrush, and is most often seen in hand-reared joeys (Jackson, 2003). The causes are poor hygiene, stress, and

improper use of antibiotics, or an outbreak may occur following a long course of antibiotics (Austin, 1997). Fungi that can affect bettongs include the ringworm fungus *Trichphyton* spp. or possibly *Microsporum* spp. (Jackson, 2003).
Signs – Oral thrush will cause difficulty in swallowing, a lack of appetite, grey to white bare areas, curd-like custard patches in the mouth and throat, saliva may appear rusty coloured, and there may be foul-smelling diarrhoea (Austin, 1997). Gastrointestinal thrush may cause infection in the stomach and intestines, and joeys may not feed even when force fed (Austin, 1997). Signs of ringworm are oval to round areas of hair loss mainly on the limbs and tail (Austin, 1997). *Trichphyton* infection appears to be pruritic, whilst *Microsporum* is non-pruritic (Jackson, 2003).
Diagnosis – For thrush, clinical signs or from laboratory diagnosis of oral and faecal swabs (Austin, 1997). Yeasts present in faecal smears do not necessarily indicate a problem, as *Candida* is normally present in the gastrointestinal tracts of many marsupials in low numbers (Jackson, 2003). For ringworm, a UV or black light can be passed over the body in a dark room, and fungi will luminesce (D. Figa pers. comm.). Other methods are culture and skin biopsy, or scraping and staining with 40% potassium hydroxide with Parker Ink and let stand for 24 hours (Jackson, 2003).
Treatment – Nystatin up to 50 000 IU/kg three times daily over three to five days is usually successful (Jackson, 2003). "Can be given as Nilstat Oral Drops (Wyeth Ayerst for Womens Health) or Mycostatin Oral Drops (Bristol-Myers Squibb Pharmaceuticals) at 0.1-0.5 ml/kg orally three times per day over three to five days. Failure of a *Candida* associated diarrhoea to resolve using nystatin should alert to concurrent disease such as salmonellosis" (Jackson, 2003. pg. 274). Ringworm can be treated with topical antifungal agents such as Triocil or Panolog, or 100 mg/kg Lufenuron orally once a month (Jackson, 2003).
Prevention - Improved husbandry and hygiene, and by reducing stress (Austin, 1997).

8.3.6 Viruses

Cause – Herpesvirus hepatitis.
Signs –In 1979, one male and ten female rufous bettongs died over five days at Perth Zoo from herpesvirus hepatitis (Dickson et al, 1980). No signs were observed (Dickson et al, 1980).The same syndrome in parma wallabies *Macropus parma* ran a protracted, and therefore quite different course to the explosive outbreak in rufous bettongs (Dickson et al, 1980). Signs reported for other macropods include conjunctivitis with pyrexia, and sometimes respiratory distress, uncoordination and death (Jackson, 2003).
Diagnosis – Post mortem histopathological examination reveals hepatitis characterized by diffuse necrosis, haemorrhage and numerous eosinophilic intranuclear inclusion bodies (Dickson et al, 1980).
Treatment – Not successful (Jackson, 2003).
Prevention – Quite difficult as the disease is widespread in macropods (Jackson, 2003). Isolate affected animals immediately. Reduction of stress may be important, as stress may allow latent macropod herpesvirus to be expressed as clinical disease (Speare et al in Grigg et al, 1989).

8.3.7 Trauma

Cause – Trauma can occur to bones, and soft tissue as a result of collisions with fences, and other objects, entanglement in nets and fighting (Jackson, 2003. pers. obs.). Injuries such as neck, spine and leg fractures, lacerations and eye trauma are more likely to occur during capture or on particularly windy nights when animals are nervous (Jackson, 2003. pers. obs.).
Signs – Various, but may include swelling, bleeding, fur loss and difficulty moving.
Diagnosis – By radiography and palpation under anaesthesia or heavy sedation (Jackson, 2003).
Treatment – Various, depending on diagnosis.
Prevention – Rufous bettongs are generally quite bold and not prone to colliding with fences due to nervous excitement (pers. obs.). However, every care must be taken, especially during capture as they can move rapidly. Condition animals to the presence of people during feeding time. Thoroughly pre-plan any capture events. Provide well designed enclosures.

8.3.8 Capture Myopathy

Cause – Physical and psychological stress from capture due to chasing and/or struggling to escape from nets and bags (Shepherd, 1990. Jackson, 2003). Characterised by the degeneration and necrosis of skeletal and cardiac muscles, due to the build up of waste products (Jackson, 2003).
Signs – Vary with the particular tissue damaged, and the location and extent of the damage (Shepherd, 1990). Animals may die quite soon after capture/handling, and show few symptoms except increased heart rate, increased body temperature, laboured breathing, and twitching in limb muscles (Shepherd, 1990). Beware, as these signs can be confused with normal responses to capture (Shepherd, 1990). “Less acute cases show signs consistent with skeletal muscle damage such as unsteadiness, stiffness, inco-ordination, paralysis of one or more limbs, twisting of the neck, myoglobinuria and reluctance to move” (Shepherd, 1990. pg. 144). The symptoms may become evident a few hours after the start of capture, and may not be obvious until the next day (Shepherd, 1990). Death is usually preceded by depression and coma (Shepherd, 1990). Animals that survive normally show continued signs of abnormal posture and gait, and probably dehydration and weight loss (Shepherd, 1990). “Deaths from predation, exposure, or starvation may occur up to a month or so after capture. In survivors with cardiac damage, any stress or excitement may precipitate sudden death. Survivors with kidney damage may show chronic illthrift” (Shepherd, 1990. pg. 144).
Diagnosis – Clinical signs associated with muscle damage and dark urine (Jackson, 2003). Take a blood sample and examine serum for the presence of enzymes released from damaged muscle (Shepherd, 1990). The main ones are CPK (creatinine phosphokinase) and SGOT (serum glutamic oxaloacetic transaminase) (Shepherd, 1990). Care must be taken in diagnosis, as elevated levels of these enzymes are not specific for capture myopathy, and other signs must be taken into account (Shepherd, 1990).
Treatment – Treatment is rarely successful, and generally not recommended (Jackson, 2003 and Shepherd, 1990). Once muscle necrosis has occurred, euthanasia is advised

(Jackson, 2003). However, treatments used include intravenous sodium bicarbonate (4-6 ml Eq $NaHCO_3$/kg) to counteract acidosis (Jackson, 2003). To prevent renal damage, use corticosteroids, intravenous fluids and diuretics (Jackson, 2003). Vitamin E and selenium appear to be useful, although selenium must be used in moderation as it can cause toxicity (Jackson, 2003). Diazepam (Valium) helps to control anxiety, and relax muscles (Jackson, 2003). A simple treatment is to wrap towels soaked in ice water around the forearms, inner thighs, body and forehead (Jackson, 2003).
Prevention – Due to the poor prognosis of animals suffering from capture myopathy, prevention is definitely the best cure. Make sure there are sufficient, experienced staff on hand, and pre-plan all captures so they are as short as possible. Capture bettongs at night or early in the morning when the temperature is lowest. It is very important to use diazepam (Valium) IM at 0.5-2 mg/kg immediately after capture, if there are no plans to use any other injectable agent such as tiletamine/zolazepam (Zoletil) (Jackson, 2003). Vitamin E injections are also useful for preventing capture myopathy (Jackson, 2003. pers.obs.).

8.3.9 Shock

Cause – A fall in total blood volume or effective circulating volume due to vasodilation and decreased blood pressure (Jackson, 2003). Shock may be the result of fear, pain, injury and immobilization drugs that depress respiration and induce severe hypotension (Jackson, 2003).
Signs – Pale or purple mucous membranes, rapid respiration, rapid thready pulse, apathy, prostration and cold extremities, and usually occurs soon after capture (Jackson, 2003).
Diagnosis – Weak pulse, decreased blood pressure and increased capillary refill times (greater than two seconds) (Jackson, 2003).
Treatment – Supportive treatment of steroids and fluids (Jackson, 2003).
Prevention – Reduce likelihood of injury with enclosure design and low stocking rates, and reduce stress.

8.3.10 Hyperthermia

Cause – Distress due to an excessive rise in body temperature (Jackson, 2003). Often seen in hand-reared joeys due to inappropriate housing and excessive exercise (Austin, 1997). May result from capture undertaken in high temperatures or humidity, excessive chasing, leaving an animal in direct sunlight or dehydration during transport (Jackson, 2003).
Signs – Bettong is hot, weak and panting (Austin, 2003). Sweating, rapid pulse, coma or convulsions (Jackson, 2003).
Diagnosis – Elevated rectal temperature (Jackson, 2003).
Treatment – cool the animal down by spraying with water, covering with a wet towel or placing in a cool bath (Austin, 1997). Can be treated with the use of steroids (Jackson, 2003).
Prevention – Avoid catching and transporting animals in the heat of the day (Jackson, 2003).

8.3.11 Vitamin E deficiency

Cause – Causes a disease called "white muscle disease", and is also related to low exercise, and associated with capture myopathy (Austin, 1997).
Signs – Tail weakness and floppy ears at first, progressing to weight loss, weakness in the hind legs and finally paralysis in two days to several weeks (Austin, 1997).
Diagnosis – Clinical signs and vitamin levels in the blood (Jackson, 2003).
Treatment – Given with oral vitamin E, supportive care and increasing enclosure size (Austin, 1997).
Prevention – Addition of artificial supplements to the diet (Jackson, 2003).

8.3.12 Other diseases

There are several other diseases affecting macropods for which there is no record of clinical symptoms in rufous bettongs. These include coccidiosis, a disease caused by protozoa such as *Eimeria aepyprymni* which has been found in faeces without clinical disease (Jackson, 2003). *Eimeria aepyprymni* was found in a captive rufous bettong, Aepyprymnus rufescens, in South Australia, but was absent in free-living bettongs originating from Queensland (Barker et al, 1988).

Canfield et al (1990) report on vasoformative proliferations in a captive seven year old female rufous bettong.

For further information on diseases affecting other macropods see Jackson (2003) and Speare et al (1989).

Occasional bouts of diarrhoea can be treated with the addition of Terramycin to the drinking water in prescribed amounts (0.5g/kg body weight) (NHMRC, 1995).

8.4 Quarantine Requirements

If possible, all new arrivals at an institution should be quarantined for six weeks, to prevent new diseases being introduced to the collection. During this time, animals should preferably be kept outside the institution so they have no contact with existing animals. Separate staff should also be used for Quarantine facilities so diseases are not spread by movements between areas. Footbaths should be used at all entry points and refreshed at least daily. Animals should be observed for any changes in behaviour, and given a thorough physical examination, as detailed above, every week whilst in quarantine. Faecal floats should be done to check for endoparasites, and the animal treated if necessary.

9. Behaviour

9.1 Activity

Johnson (1980) observed that rufous bettongs “emerged from their nest at dusk, the male always emerging 10-15 min ahead of any of the females. Most activity took place between 1830 and 2130 h. The two observations covering the whole night indicated a decrease in activity between 0200 and 0430 h. Activity in the early part of the night centred around the male's investigation of each female. This was followed by a period of alternate feeding and grooming, and then all animals slowly investigated the entire enclosure. Around 2200 h, animals tended to find a quiet position in the yard and remain stationary, either sitting quietly or occasionally grooming. This lull in activity was sometimes interspersed with short feeding periods. Activity recommenced about 0200 h, with animals collecting grass for nest building and occasional bouts of feeding, and by about 0430 h most rat-kangaroos had returned to their nests. During rain the activity of both males and females was depressed and the animals either returned to their nests or took refuge under a shelter. Wind also had an unsettling effect, tending to cause individuals to hop continually around the enclosure, and to panic at the slightest external sound”. (Johnson,1980).

Although a nocturnal species, rufous bettongs will sometimes become active during the day in captivity to feed, such as at Warrawong Sanctuary (B. Liddle pers. obs.)..

“The posture of an undisturbed animal was a bipedal stance with the vertebral column curved and forearms held tucked into the body, giving a hunched appearance. An alert posture was characterized by a bipedal stance with the vertebral column perpendicular to the ground and the forearms tucked into the body. The alarm posture began by a stamping of the hindfeet, after which the animal stood completely erect with its forearms held directly out from the body. To groom the pouch and cloaca1 areas the animal first stood erect and then lowered the head between the legs” (Johnson, 1980).

“In the usual resting posture, outside the nest, the animal sat on the base of the tail, which was between outstretched hindlegs. In the nest, the resting position was similar, except that the body was curved forward and the top of the head rested on the undersurface of the tail” (Johnson, 1980).

“The most common gait was a slow walk. The forepaws were placed on the ground and the hindfeet were brought forward slowly in unison underneath the body; the tail was held at an angle to the body and appeared to give some support. The slow hop was a bipedal gait with the vertebral column essentially horizontal and the forearms held in closely to the body. When a rat-kangaroo was startled, this slow hop became a very fast action, with the vertebral column held more upright” (Johnson, 1980).

“The fast hop in an alarmed animal was associated with foot stamping and the

utterance of a distinctive sound. After emergence on most nights, both sexes carried out a stretching movement. The animal would slowly stretch out, stomach down on the ground with the forepaws pointing forward and the tail and hindfeet stretched out directly behind. This position would be held for 5-30 s, and then the normal upright posture was resumed. On some occasions females, while stretched out, were observed to roll from one side to another. Both male and female usually groomed for a short period immediately after emerging and stretching, and for a long time after feeding. They utilized four grooming procedures:

Rubbing with licked forearms and forepaws. Both forearms and forepaws were licked and used simultaneously in a forward rubbing action, starting behind the ears and progressing to the nose. The whole sequence would be repeated 10-12 times.

Licking. The males groomed the cloacal and scrotal areas and inside of the legs by licking; females groomed the cloacal region and the inside of the pouch by licking; after copulation both sexes groomed around the cloacal region by licking" (Johnson 1980). Females which "raised pouch young to pouch eviction, were all observed to groom their respective young at foot by licking their heads and shoulders" (Johnson, 1980).

"Scratching with the hindfeet. Both sexes used the syndactylous toes of the hindfoot to groom the insides of the ears, around the ears and around the neck. The forefeet were placed on the ground and a hindfoot made a few rapid movements on the body surface and was then carried to the mouth and the toes licked. The action was repeated for several sequences" (Johnson, 1980).

"Scratching with the forepaws. Both sexes used the forepaws to scratch the cloacal and scrotal regions, the base of the tail and rump and the abdominal region. They took an upright stance while grooming these areas. The undersurface of the tail was vigorously scratched with the forepaws whenever the sand surface of the yard was wet; the posture during this activity was similar to the resting posture adopted while out of the nest. This activity was never observed when the sand was dry" (Johnson, 1980).

"Nest Building, Sleeping Places and Feeding

"Nests were constructed at the base of large tussocks in shaded areas of the enclosure, in small depressions excavated with the forepaws" (Johnson, 1980).

"The material was first collected in the mouth, then transferred to the forepaws and placed on the ground between the hindfeet, while the tail was curled back, down and forwards. All the weight was then taken on the forelegs and the hindfeet were used to push the material back over the tip of the curled tail and to tramp it down. The animal tightened its curled tail, gripping the nest material, and then hopped off" (Johnson, 1980).

"The first addition of nest material was dropped into the excavation and all subsequent additions were carried inside the nest. The rat-kangaroo did this by using the nose and forehead to lift the existing nest and to carry material into it, where much shuffling ensued. A completed nest usually took two or three nights to build, after which only occasional additions were made. Unless the animal was disturbed, it emerged from the nest slowly, using its nose and forehead to lift the grass gently,

thus causing minimal damage to the nest" (Johnson, 1980)..
"No nest site was used by any individual for very long. The usual period of occupation was 7-10 days, the nest then being vacated only to be taken over by another animal. Normally one individual occupied each nest at a time; the only exceptions being when a lone female nested with her young at foot, and occasionally when an animal that had been disturbed from its nest during the day took refuge in an occupied nest" (Johnson, 1980).
"In feeding, rat-kangaroos used their forepaws to pick up and hold the food pellets and chopped potato. Regurgitation or merycism took place on occasions; the regurgitated material was dropped directly onto the ground in liquid form and was then re-eaten. The animals drank freely from water supplied in an automatic watering trough" (Johnson, 1980).

"Marking and Exploratory Behaviour
Cloaca1 marking of positions in the enclosure and of introduced objects was observed on many occasions, females indulging in this activity more frequently than males. The posture assumed for marking was very unusual and was characterized by the animal arching the tail, squatting on its hindfeet with the cloacal region on the ground, and then slowly moving off in a shuffling hop (Fig. **3).** Such objects as chopped potato and new nest material were frequently marked. Also, during some of the investigatory digging an animal would sniff a position, dig and then mark the excavation. As tail arching had not previously been described for macropods, tests were carried out to determine whether it was actually associated with the marking procedure" (Johnson, 1980). "It was impracticable to enter the yard and check the marked areas for scent, nor was it possible to see if fluid was emitted during this procedure " (Johnson, 1980).

"The enclosure was relatively small and all parts were covered by all animals in their routine activities each night. As the male emerged from the nest 10-15 min before the females, he used this time to investigate the enclosure. He usually emerged, groomed for a short period and then slowly moved around the enclosure, especially on the fence line, sniffing the ground and repeatedly carrying out a short digging routine. This involved three or four scraping actions with the forepaws, sand being thrown between the hindfeet. The male then sniffed the small excavation and either repeated the action once or more or moved on and commenced the routine at a new spot. Females were noted carrying out a similar digging routine, but not as frequently as the males. Animals were never observed to gather food from these excavations, although observations in the wild indicated that digging of this type was used to gather food" (Johnson, 1980).

"When new grass clumps (intended for shade) were introduced into the yard all animals thoroughly investigated the addition. The clumps were cautiously approached and the grass and disturbed soil were thoroughly investigated by sniffing. All new introductions to the pens, either grass clumps or feeding containers, were always approached cautiously and investigated " (Johnson, 1980).

9.2 Social Behaviour

The following observations come from Johnson (1980).
Interactions
(i) *Male-male*
The males were extremely aggressive; one male would repeatedly chase another and savage fighting usually resulted. In all fights the subordinate male lay on its side and attempted to ward off the other male by repeatedly kicking with its hindfeet, while the dominant male kicked and bit. This was accompanied by high-pitched growling from the subordinate male. The harassment was so constant that the subordinate male was removed 11 days after the establishment of the colony in order that its wounds could be treated, but it died two days later.

(ii) *Female- female*
"Females were characteristically non-aggressive to each other" (Johnson, 1980). "When two females met they stood facing one another and the dominant female smelt the nose of the subordinate. When the dominant female continued to move closer to the subordinate, the latter slowly turned her head and allowed the dominant female to smell the side of her mouth; this was accompanied by low growling from the subordinate animal. At this stage of the interaction the subordinate moved off" (Johnson, 1980).

"Squabbles generally developed over one female trying to take food from another, and these were usually short, any aggressive action being limited to the dominant female supplanting the other by striking it with the forepaws. When a more serious fight did develop, the subordinate female lay on her side and lashed out at the aggressor with her hind feet from this defensive position. All aggressive interactions were accompanied by growling (the volume of which increased with the severity of the action) by the subordinate female" (Johnson, 1980).

Allogrooming was observed on one occasion, when one female groomed another by licking the side of the neck (Johnson, 1980).

(iii) *Male-female*
"Male rat-kangaroos on the whole have little contact with females except for the nightly investigation, mating and the occasional aggressive chase. The nightly investigation began when the male attempted to mount most of the females. Even though a female was not near oestrus the male continued to attempt mounting until she threw herself on the ground on her side and kicked vigorously at the male with the hindfeet, accompanied by much growling. The male would then stand beside her with one foot advanced and hit this on the ground; this would continue until the female ceased kicking and allowed the male to sniff the pouch area and cloaca. Once this was done the female resumed the normal upright posture and the male tended to ignore her. During this activity the male vigorously wriggled its tail laterally, but no vocalization was heard from him. Occasionally, a male would chase a female for no apparent reason and if he came too close to her during the chase, she would throw herself on her side on the ground; he then usually moved off and ignored her" (Johnson 1980).

(iv) *Subadult interactions*
"Juveniles at foot did not engage in fights of any description, but by the time they were subadult squabbles over food occasionally developed with one (identified as the dominant animal) pushing the other (the subordinate) away with its forepaws. As the young males neared maturity at about 340 days old, and were beginning to show interest in adult females, the adult male began to chase them aggressively and the young males were therefore removed" (Johnson, 1980).

"Vocalizations and Sounds
The most frequently uttered' vocal sound was a low-volume growl made by a female when she was investigated by the male. As the female neared oestrus and the attentions of the male became more vigorous, the sound changed to quite a loud growl. The low-pitched growl was also used during agonistic interaction between females and in cases of homosexual behaviour. Females used a soft grunt to call frightened pouch young which strayed too far from the parent. This grunt was returned by the young as it searched for its parent.
When the animals were disturbed by a noise outside the enclosure, a low, short hissing sound was made in conjunction with the hitting of the hindfeet on the ground; this brought all activity in the yard to a standstill. When the alarmed animal fled for cover it made a low, drawn-out hissing sound in full flight. This had the effect of sending all the other individuals fleeing for cover" (Johnson, 1980).

9.3 Reproductive Behaviour

General Reproductive Behaviour in Johnson (1980)

"Investigation. The male investigated each female each night; the procedure has been described above. As a female approached oestrus the investigations grew more vigorous and the male tended to spend a lot of time just following or being near the female.
Mating. During the study five successful matings were observed, with durations ranging between 60 and 90 s. Only once was a second mating observed and this was 30 min later. All observed matings took place just after emergence from the nest and the male's nightly investigation of the female. The male mounted from behind, clasping the thorax of the female with his forearms, while the female had her hindquarters raised and her forelegs on the ground.
Parturition. Birth was never observed and it seemed likely it took place in the

nest; only one young was born from each pregnancy. Pouch young were born to all females. Three (one male and two females) survived to be used for observation as subadults" (Johnson, 1980).
"Post-partum females spent considerable time in licking the inside of the pouch and presumably the pouch young. The young commenced to put its head out of the pouch at about 90 days and made short excursions from the pouch from about 98 days old. When it was out of the pouch the female regularly groomed it by licking, and cleaned the interior of the pouch while it was vacant. Initially the excursions by the pouch young were short, but increased in length until the pouch young was evicted at about 114 days old. While out of the pouch, the young spent most time near the female and during these periods they would pick up grass and other food materials, and chew but not swallow them. The young could re-enter the pouch only if the female bent forward and allowed the mouth of the pouch to open" (Johnson, 1980).

"The female would stand upright every time the young attempted to enter; in this way the young could only put its head into the pouch to suckle. She still occasionally groomed the young, but by now it had begun to attempt to groom itself. When a pouch young came into contact with a female other than the mother and attempted to follow this female, she would growl at it and push it away with her forepaws. Young were generally weaned about 50 days after pouch eviction. Whether the young left the nest of its own accord or was driven out by the mother was never observed" (Johnson, 1980).

"Homosexual Behaviour. This was observed within the colony on 19 separate occasions. One female would be approached by another female, which proceeded to sniff the cloaca and pouch opening of the first and then appeared to become sexually excited. The subject female would then lie on her side and lash out with the hindfeet, and the female displaying pseudo-male responses stamped her foot in a fashion similar to the male. The subject female was normally subordinate to the other" (Johnson, 1980).

"Mounting was observed on three occasions during one night only. During all three, the male was nearby but ignored the proceedings" (Johnson, 1980).

9.4 Bathing

Rufous bettongs generally do not choose to enter the water.

9.5 Behavioural Problems

Males can be extremely aggressive towards each other. Males should not be kept together in small enclosures due to the risk of injury. Young males should be removed at weaning.

9.6 Signs of Stress

Can include:

- Weight loss
- Activity during daylight
- Licking of forearms
- Growling
- Kicking, struggling during restraint
- Teeth grinding
- Loss of appetite
- Body/head shaking (pers. obs.).

9.7 Behavioural Enrichment

Several enrichment strategies are highly recommended, including:

- Scatter feeding
- Providing tussocks and scattering nesting material around the enclosure
- Providing truffles, rotting logs and deep soil
- Burying food.

9.8 Introductions and Removals

Introductions of new individuals need to be managed carefully, especially for males, due to their aggressive nature. A good technique for introducing new animals is to place a new animal in an adjacent enclosure to allow them to get used to each other.

"New animals need to be introduced slowly – e.g. by placing them in a smaller enclosure within the breeding enclosure for some weeks to get everyone used to each other with a barrier in-between" (Keynes, 2001). It may be necessary to remove dominant individuals so that the dynamics are reformed when the new animal is introduced (H. Hughes pers. comm.)

"Males may display aggressive behaviour towards dams a n d / o r joeys and may need to be removed. It is preferable to house the animals in pairs rather than groups at the time of permanent pouch emergence of young, because at that time the newly emerged young is vulnerable to being trampled in the vigorous courtship chasing that occurs prior to the post-partum mating. Young males which have recently left the pouch need to be protected from attack by adult males" (NHMRC, 1995 pg. 6).

"*Response to a new animal*
The introduction of a new female to the enclosure… created a disturbance, and the male… became intensively interested in her, sniffing the pouch area and cloaca and attempting to mount her. After a time the resident females cautiously approached… and sniffed firstly the fur and then the head and mouth" (Johnson, 1980). When the new female "came unexpectedly into contact with any of the resident animals they fled from her. This created a situation where the members of a once stable group of animals no longer recognized one another, so that at each meeting of any of the animals, identity had to be established by nose and mouth sniffing. This situation lasted about two nights, after

which the group again settled down and dominance among the females was established, although there was considerable
individual variation in response to new animals and objects" (Johnson, 1980).

9.9 Intraspecific Compatibility

Male rufous bettongs can be "too aggressive to allow more than one per enclosure" (Johnson, 1978 pg. 157). Therefore, the number of males in any enclosure should be limited.

9.10 Interspecific Compatibility

I have kept rufous bettongs with a wide range of species such as, eastern grey kangaroos, red-necked wallabies, parma wallabies, red-necked pademelons, swamp wallabies, long-nosed potoroos, brush-tail possums, long-nosed bandicoots and emus. Occasional minor fighting occurred between species over food, however I have never experienced any major problems or injuries as a result. In general, the rufous bettong ignores other species in the same enclosure, as long as there is plenty of space for both, and therefore it is quite compatible with a wide range of Australian natives (See Figure 3).

"Rufous Bettongs are generally inoffensive to other animals and can be kept safely with a variety of other native animals, such as Potoroos, Wallabies etc" (Keynes, 2001).

Figure 3. Rufous bettong in a walk through enclosure with eastern grey kangaroos at Waratah Park (Photo: N. Carson).

9.11 Suitability to Captivity

Rufous bettongs generally do well in captivity, given the right conditions and care.

10 Breeding

10.1 Mating System

The mating system of the rufous bettong is generally polygonous. “Males maintain transitory contact with as many females as possible, visiting at their nest sites, of which they have an intimate knowledge. Males that successfully mate are ones that have associated with the female previously” (Tyndale-Biscoe, 2005 pg. 362).

“Females as they approached oestrus were followed continually by several males, with one male following very closely and preventing others from approaching. In two well-studied cases, the male who defended priority of access to the female was the same individual who had most often associated with that female when not in oestrus. These males demonstrated intimate knowledge of the nesting locations of the females and were able to join them very early each evening, and defended them against other males with little overt aggression. The mating system in this population appears to be promiscuous, but with a hint of monogamy arising from the tendency of some males to persistently investigate and ultimately to guard sexual access to certain individual females” (Frederick and Johnson, 1996).

“Prior association with the females may have conferred two kinds of sexual advantage on these males. First, the male may have been able to monitor the female's reproductive condition very closely, and thus anticipate the time at which she would be ready to mate. Second, the male had the opportunity to become familiar with the female's preferred feeding sites and nest locations, and this may have helped him to find the female quickly when she was close to oestrus, and also to relocate her quickly if separated from her during the night”(Frederick and Johnson, 1996).

Female rufous bettongs have been shown to be philopatric, with daughters tending to occupy ranges adjacent to their mothers and sons dispersing clear of the study grids (Pope et al, 2005).

10.2 Ease of Breeding

Rufous bettongs breed well in captivity, given the right enclosures, food and as long as stress is minimised. The female will be ready to mate one day after paturition resulting in a quiescent blastocyst (Johnson, 1978).

With the ability to give birth every 115 days, rufous bettongs are potentially able to have three young per year.

There is a theory that if female rufous bettongs are not impregnated at their first oestrus, then they will be unable to breed in future (H. George pers. comm.).

10.3 Reproductive Condition

10.3.1 Females

"The condition of the pouch can be: 1) dirty, indicating a non pregnant animal with no young, 2) clean, indicating oestrus, 3) glandular, indicating pregnancy, 4) pouch young present, 5) an elongated lactating teat for a young at foot, or 6) regressing and producing only a clear fluid when squeezed" (Jackson, 2003 pg. 266).

10.3.2 Males

Mature males are able to breed throughout the year.

10.4 Techniques Used to Control Breeding

Several techniques may be used, such as:

- Separation of the sexes
- Castration
- Vasectomy
- Culling
- Transfer
- Removal of pouch young
- Contraception using Suprelorin (Dr. C. Herbert pers. comm.) (Jackson, 2003).

10.5 Occurrence of Hybrids

None known, although a hybrid between a *Bettongia penicillata* male and a *Bettongia gaimardi* female has been produced (Jackson, 2003).

10.6 Timing of Breeding

Births may occur in every month of the year (Johnson, 1978 and Jackson, 2003). As with most macropods, female rufous bettongs have a post partum oestrus. Oestrus usually occurs on the same day as birth, and on occasions within a few hours of birth (Johnson, 1978). Mating at this time results in a quiescent blastocyst. The removal of existing pouch young results in the birth of the quiescent embryo 18 – 20 days later (Johnson, 1978). Removal of pouch young from females not carrying a quiescent blastocyst results in oestrus 18 – 21 days later (Johnson, 1978). Young from quiescent embryos are born 115 – 124 days after the birth of the first young (Johnson, 1978). Parturition is believed to occur in the nest (Johnson, 1978).

10.7 Age at First Breeding and Last Breeding

Information varies for age at first breeding in the rufous bettong. According to Williams (1990) females are sexually mature at eleven months of age. Whilst during Johnson's (1978) studies in Townsville, the youngest captive male to reproduce successfully was 379 days, and the youngest female was 313 days (Johnson, 1978). Rufous bettongs can generally breed up until they die (Jackson, 2003).

10.8 Ability to Breed Every Year

Yes. Bettongs are generally able to breed from sexual maturity up until they die.

10.9 Ability to Breed More than Once Per Year

Yes up to three times. Females have a single pouch young at any one time and are capable of having roughly three pouch young in a year (Pope et al, 2005).

10.10 Nesting, Hollow or Other Requirements

Rufous bettongs do not have any specific breeding nest requirements, as they sleep in a nest nightly. However, the female will usually share her nest with the young until it finishes suckling at about 161 days old (Johnson, 1978).

10.11 Breeding Diet

No specific breeding diet required.

10.12 estrous Cycle and Gestation Period

The oestrus cycle ranges from 21-25 days (Johnson, 1978). The gestation period in rufous bettongs ranges from 22-23.6 days (Johnson, 1978).

10.13 Litter Size

One, limited by pouch size.

10.14 Age at Weaning

Rufous bettongs are weaned at about 164 to 172 days old (Johnson, 1978).

10.15 Age of Removal from Parents

At weaning, i.e. approximately 170 days old.

10.16 Growth and Development

Johnson (1978) prepared growth charts for the rufous bettong (Appendix) after studying nine wild-trapped females. The pouches of all females were inspected daily, and the date of each birth recorded. The lengths of the tail and each hindfoot of all pouch young were measured at weekly intervals (Johnson, 1978). The observation of nine pouch young revealed that: eyes opened at an average age of 85.2 days, range 82 to 91 days; body hair appeared at a mean age of 87.5 days, range 79 to 92 days; and the young became permanently detached from the teat at an average of 87.3 days, range 84 to 92 days (Johnson, 1978). Only five young completed pouch life, with the average date of vacation being 114 days, range 105 to 119 days (Johnson, 1978). The young at foot suckled for about another 50 days (Johnson, 1978). Use caution with growth charts, as wild parent reared potoroids may weigh significantly less than hand-reared ones (Jackson, 2003).

11 Artificial Rearing

11.1 Housing

Rufous bettongs may, in many ways, be treated as other macropods for the purpose of hand-rearing (S. Byrne pers. comm.). The main concern initially is to reduce stress and keep the joey warm. When choosing an area to keep a joey, make sure it is secure from children and animals, hygienic, escape-proof, free of hazards and sheltered from weather and noise (Jackson, 2003). When discovered, joeys are usually hypothermic and need to be warmed with a heating pad set at 32-34 degrees Celsius, or hot water bottle (Jackson, 2003). In an emergency, joeys can be kept close to the rescuers body, under their shirt until more appropriate equipment can be found.

Pouches should be made of soft natural fabrics such as wool and cotton flannelette, and be of an appropriate size. Beanies and jumpers can make effective pouches. Layers of towels should be used between the joey and the heat source to control the temperature, and so that layers can be added or removed as required (Austin, 1997).

Pouches should be hung off the floor on a coat hanger or similar, so that older joeys van easily enter or leave and for comfort (Austin, 1997).

Hessian sacks, or loosely woven material should not be used for pouches, as they may cause irritation, and animals may get their nails caught in the weave (Austin, 1997).

11.2 Temperature Requirements

For unfurred joeys, the temperature should be kept at about 33.5 – 34 degrees Celsius, although “cool joeys” may be perfectly fine at 32 degrees Celsius (J. Wong pers.comm.). The joey’s temperature must be continually monitored, and it is best to use a digital thermometer with a probe that can be placed against the joeys skin (J. Wong pers. comm.). Adjust the insulation surrounding the heat pad / hot water bottle as necessary.

11.3 Diet and Feeding Routine

Cow’s milk is not recommended for feeding to marsupials, as the high amounts of fat and lactose are poorly digested and result in dehydration and diarrhoea (Jackson, 2003). The most highly recommended formulas are Di-Vetelact and Wombaroo milk replacers (Austin, 2003). Some carers will only use Wombaroo (H. George pers. comm.).

Macropod milk changes composition throughout lactation, with carbohydrates decreasing towards late lactation, whilst lipids increase (Jackson, 2003). The Wombaroo kangaroo milk replacers are multi-staged to cover these changes with the use of different age factor formulas (Austin, 1997). The stages are based on the length of natural pouch life, with 1.0 being pouch life completed, and 0.5 being half of pouch life completed. Wombaroo kangaroo milk replacers are packaged in <0.4, 0.4, 0.6 and >0.7 formulas. It is recommended to only use >0.7 Wombaroo kangaroo milk replacer for rufous bettongs, as their pouch life is comparatively short, and development rapid (H. George pers.comm.). Charts are provided with the product to assist in preparing correct amounts for feeding. Many carers feed 10-30% body weight. Di-Vetelact has a low energy concentration and canola oil should be added before feeding (Jackson, 2003). Some 2-5 ml can be added per

100 ml milk during the last phase of feeding (Jackson, 2003). This should be fed at approximately 20% body weight except for very small joeys (Jackson, 2003). Gut flora can be established by feeding soil, fresh grass or natural yoghurt (acidophilus) (Jackson, 2003). Pureed faeces from a healthy adult bettong can also be fed with milk formula (Jackson, 2003).

The following information can be used to estimate the growth rates for rufous bettong joeys. The information comes from Austin's (1997) work with Tasmanian bettongs *Bettongia gaimardi* Johnson's (1978) paper on rufous bettongs, and a discussion on rufous bettongs with Helen George. Their growth rate is twice as fast as that in macropodids (Seebeck and Rose, 1989).

Birth – embryonic in appearance with pink, transparent skin. Firmly attached to the teat. Eyes closed and appearing only as dark dots. Ears fused to the head. Well developed forelimbs. Undeveloped hindlimbs. Weight approximately 0.4 grams.
10 days – can determine sex.
20 days – lip grooves develop on the side of the mouth.
30 days – stiff hair appears around the nose and above the eyes.
50 days – hairs appear between the eyes and mouth. Starting to become pigmented. Able to release their hold on the teat – lips fully open.
60 days – Starting to become active in the pouch – turning around. Front teeth have appeared. Ears free of head. Eyes still closed.
70 days – Hair appears under the chin, between the branches of the lower jaw, on forearms and the wrists. Unco-ordinated.
80 days – Back pigmented and covered with fine fur (79 to 92 days). Fur growing rapidly. Eyes open. Ears now erect. Moves around in the pouch more.
90 days – whole body pigmented and covered in fine fur. Starting to leave the pouch for short periods. Permanently detached from the teat around 84 to 92 days. Looks like a miniature adult bettong. Grazing whilst hanging out of the pouch.
100 days – Fully furred and more co-ordinated.
110 days – very agile and out of the pouch (range 105 to 119 days), but still suckles from mother until weaned. Eating solid food.
160 days – Fully weaned and independent. Should be wild and uncatchable.
Rufous bettongs disperse from the mother at approximately 161 days old (H. George pers. comm.).

Very young joeys can be fed with a glass syringe fitted with a small rubber teat (pers. obs.). Older joeys can be fed with a bottle and a kangaroo teat manufactured by Wombaroo. The teat can be punctured with a kitchen skewer or needle (J. Wong pers. comm.). It is important that the hole is not too big, otherwise excess milk may end up in the airways and cause complications. As the joey grows, teat size and hole size will need to grow too. Feed the joey in a comfortable position on it's back (Austin, 1997). Warm the milk to 32-36 degrees Celsius, this can be done by sitting the syringe / bottle in boiling water until the vessel is warm (not hot) to the touch of your lips (J. Wong pers. comm.).

The number of daily feeds decreases as the joey grows. Young, unfurred joeys should be fed every 2-3 hours around the clock (Jackson, 2003). Night feeds can be reduced once the joey is consuming the necessary amount over 24 hours (Jackson, 2003). Furred joeys are fed an increased volume five times per day (Jackson, 2003). By about 114 days of age, at pouch emergence, the number of feeds are reduced to two or three a day, and weaning commences (Jackson, 2003).

11.4 Specific Requirements

Make sure the joey is warm before feeding (especially the first feed after rescue) to reduce the risk of inhalation pneumonia (Jackson, 2003). Apply Sorbolene cream daily to the skin of unfurred joeys to keep them moist, and mimic the moist nature of the mothers pouch (J. Wong pers. comm.). Keep stress to a minimum, and maintain high standards of hygiene (Jackson, 2003). Dehydrated joeys can be given boiled water with 5 g of glucose to 100 ml of water (Jackson, 2003). They can also be given electrolytes such as lectade and vytrate (10 ml vytrate to 125 ml water) (Jackson, 2003).

11.5 Data Recording

When it is decided an animal needs to be hand-reared, the sex, weight and approximate age using growth charts should first be recorded (Jackson, 2003). As hand-rearing progresses, several things should be recorded daily to assist veterinarians, allow comparison with growth curves and assist future hand-rearing of bettongs which may become extremely important if they become endangered (Jackson, 2003). These are as follows: date, time, body weight, general activity and demeanour, characteristics and frequency of defecation and urination, amount (g) of food offered, food consumed, and veterinary examinations and results (Jackson, 2003). Temperature, time, amount of food consumed, characteristics of faeces and any additional notes should be recorded at every feed (J. Wong pers. comm.).

11.6 Identification Methods

Visual identification is usually easy if caring for small numbers of animals, or joeys of different ages. Joeys could be kept in different coloured pouches. Once the joey is fully furred, one of the identification methods mentioned earlier in this manual, such as microchips or ear tags, may be used.

11.7 Hygiene

Good hygiene is critical if a hand-reared joey is to survive, due to its susceptibility to many of the diseases outlined earlier. All bottles, teats, and syringes must be washed and rinsed after use, and then sterilized before each use (J. Wong pers. comm.). This can be done by placing equipment in boiled water and then microwaving for about one – two minutes (J. Wong pers. comm.).

Wash hands before and after handling.

Clean any spilt milk formula, faeces and urine from the joeys skin as soon as possible, and then dry the joey (Jackson, 2003).

Avoid contact with other animals unless you are sure they pose no health problems (Jackson, 2003).

Fresh formula must be made up every 24 hours, using boiled water, so that only clean nutritious formula is being fed (Austin, 1997). Keep the formula in the fridge, and warm each feed amount only before it is fed to the joey (Austin, 1997).

Pouches and liners must be washed whenever soiled or wet (Austin, 1997).

For toileting, the cloaca needs to be stimulated by being gently rubbed with a damp tissue, to simulate a mothers licking (Austin, 1997). Care must be taken not to rub the cloaca too much, otherwise it may become inflamed (Austin, 1997). Joeys can be trained to defecate after each feed, and therefore keep their pouch clean. The joeys faeces will change consistency and colour naturally with age, from yellow paste to a mustard coloured toothpaste consistency, to darker pellets (Austin, 1997).

Rub Sorbelene cream into an unfurred joeys body daily to prevent dry, cracked skin and simulate the moist environment of the mother's pouch (J. Wong pers. comm.).

11.8 Behavioural Considerations

Ensure that the joey does not become too attached to the person raising it, for ease of weaning and release (Jackson, 2003). Minimise stress by restricting care to one person, and keeping the joey in a quiet area (Jackson, 2003). Do not associate the joey with domestic cats and dogs, as they need to develop a fear of predators if release is to be successful (Jackson, 2003). Cats also carry Toxoplasmosis which is usually fatal to marsupials.

11.9 Use of Foster Species

Cross fostering involves the transfer of pouch young from a target species into the pouch of a recipient with a pouch young of similar size (Jackson, 2003). There is no record of cross fostering between rufous bettongs and other potoroids or macropods. Cross fostering is being used between the endangered Gilbert's potoroo *Potorous gilbertii* and the long-nosed potoroo *Potorous tridactylus* (www.esf.org.au, 2006). However, female rufous bettongs could potentially be used as foster mothers for endangered species such as the northern bettong *Bettongia tropica*, that display post partum oestrus and embryonic diapause.

11.10 Weaning

Before weaning is attempted, make sure the joey is having plenty of grass, other solid foods and is lapping water(Austin, 1997). When the bettong is about 115 – 120 days old,

the number of feeds per day should be gradually decreased, then the amount of formula being fed without watering it down (Austin, 1997). This should be done over a period of several weeks until the joey is fully weaned at about 160 days old. Do not keep the joey on milk for too long – estimate the age by development stage, and not size, as bettongs are very small and grow quickly (H. George pers. comm.).Wherever possible, feed natural items such as native grasses (including roots), invertebrates and fungi, and allow access to soil and nesting material.

11.11 Rehabilitation and Release Procedures

Joeys must be fully weaned before release (Austin, 1997). They must have a good body weight without being obese, and contact with people must be gradually decreased over a period of time prior to release (Austin, 1997). The bettong must be fit and healthy and free of disease (Austin, 1997). Bettongs must be able to recognize and flee from danger e.g. dogs (Austin, 1997). Hand-reared rufous bettongs are released after they reach a weight of 500 grams (S. Byrne pers. comm.) or at 161 days old (H. George pers. comm.). Prior to release, bettongs should be kept in an enclosure where they have access to grass, roots, soil and rotting timber (S. Byrne pers. comm.). Bettongs must be able to recognize and find natural foods such as grass, invertebrates and fungi. Animals should be given a diet which consists of the same species of plants and insects that are to be found in its eventual release site (Austin, 1997). Bettongs must be able to construct their own nest from natural materials. The release site should be near where the animal was first found, have plenty of available food and water, and not be overcrowded with the same species (Austin, 1997). If possible release the animal with another bettong of similar age (Austin, 1997). Contact your local wildlife authority for advice, regulations and permits (see Appendix).

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http://www.yaraandoo.com.au/bettongs.html

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12 Glossary

Alopecia – hair loss.

Dysphagia – difficulty swallowing.

Dyspnoea – difficulty breathing.

Rhinitis – inflammation of the mucous membranes of the nose.

Appendix

Computer Software

International Species Information System (ISIS)
12101 Johnny Cake Ridge Road
Apple Valley, Minneapolis 55124. U.S.A
Ph: +19529979510
Fax:+19524322757
Email: isis@isis.org
Internet: www.isis.org

- Animal Record Keeping System (ARKS)
- Single Population and Record Keeping System (SPARKS)
- Medical Animal Record Keeping System (MedARKS)

Conservation Breeding Specialist Group

Species Survival Commission, IUCN – The World Conservation Union
Dr U.S. Seal, CBSG Chairman
12101 Johnny Cake Ridge Road
Apple Valley, Minneapolis 55124-8151, U.S.A.
Ph:+19529979800
Fax:+19524322757
Email: office@cbsg.org.
Internet: www.cbsg.org.

- Vortex – Population Viability Analysis program
- Conservation Assessment and Management Plans
- Training Courses and Workshops
- Global Zoo Directory

Identification Equipment

Animal Electronics I.D. Systems

PO Box 189
Kiama, New South Wales 2533, Australia
Ph: +6126742407
Fax: 61242323350
Email: aeids@bigpond.com
Internet: www.animal-id.com.au

- Implant chips and scanners

Central Animal Records

22 Fiveways Boulevard
Keysborough, Victoria 3173, Australia
Ph: +61397063100
Fax: +61397063198
Email: info@car.com.au
Internet: www.car.com.au

- PIT Tags and scanners

Digital Angel Corporation (Destron Fearing)

490 Villaume Avenue
South Paul, Minneapolis 55075-2445, U.S.A.
Ph: +16514551621
Fax: +16514550413
Email: webmaster@destronfearing.com
Internet: www.destronfearing.com/
* PIT Tags and scanners

DLC Aust Pty Ltd

17 – 19 Horne St
Hoppers Crossing, Victoria 3029, Australia
Ph: +61393609700
Fax: +61393609994
Email: info@dlc.com.au
Internet: www.dlc.com.au

- Tattoo Equipment

Sieper & Co. Pty. Ltd.

101 Deakin St. Silverwater, New South Wales 2128, Australia
PO Box 6724, Silverwater, New South Wales 1811, Australia
Ph: +61297480700
Fax: +61297480566
Email: msieper@compuserve.com
Internet: www.sieper.com.au

- Metal eat tags and pliers

Food Products

Aristopet

874 Kingsford Smith Drive
Eagle Farm, Queensland 4009, Australia
Ph: +61736302166
Fax: +61736302177
Email: sales@aristopet.com.au
Internet: www.aristopet.com.au

- Insecticidal dusting powder for lice and mites
- Rat and mouse pellets

Biolac

Geoff and Christine Smith
PO Box 93
Bonnyrigg Plaza, New South Wales 2177, Australia
Ph: +6198239874
Fax: +61298239874

- Biolac milk for marsupials
- Marsupial feeding teats

Biotech Pharmaceuticals

100 Antimony St
Carole Park, Queensland 4300, Australia
Ph: +61732719600 or +611800620898
Fax: 61732711315
Email: biotech@bit.net.au
Internet: www.biotechpharmaceuticals.com.au

- Milton – sterilizing milk feeding apparatus

Castlereagh Feeds Pty Ltd

933 Castlereagh Rd
Castlereagh, NSW 2750, Australia
Ph: +61247761173
Fax: +61247761484
* Feeds such as pellets, hulled oats

Iams Australia New Zealand

PO Box 6116 or Unit A2 1 – 3 Rodborough Road

Frenchs Forest, New South Wales 2086, Australia
Ph: +61289772500
Fax: +61289772588
Email: kim.mouret@iams.com
Internet: www.iams.com

- Eukenuba Premium Kibble

Sharpe Laboratories Pty Ltd

12 Hope St
Ermington, New South Wales 2115, Australia
Ph: +61298585622
Fax: +61298585957
Email: sharpe@myoffice.net.au

- Di – Vetelact and Digestalact low lactose animal milk formula

Vetafarm

PO Box 5244 or 3 Bye St
Wagga Wagga, New South Wales 2650, Australia
Ph: + 61269256222
Fax: + 61269256333
Email: vetafarm@vetafarm.com.au
Internet: www.vetafarm.com.au

- Poly – aid Plus – energy drink for sick/injured wildlife
- Soluvet – water soluble vitamin supplement

Womberoo Food Products

PO Box 151
Glen Osmond, South Australia 5064, Australia
Ph: + 61883791339
Fax: + 61883791339
Email: wombaroo@adelaide.on.net

- Wombaroo Milk Formulas
- Teats
- Kangaroo Milk Replacer - <0.4, 0.4, 0.6>0.7 – for all macropods
- Feeding Bottles – 120 m;\l with gradations
- Heating pads – 10 watts, 260 x 360 mm
- Latex Teats:
  FM – Out of pouch kangaroos, wombats and koalas
  MTM – In pouch kangaroos
  STM – small in pouch kangaroos
  TM – out of pouch kangaroos

Young Stock Feeds Pty Ltd

133 – 135 Lovell St
Young, New South Wales 2594, Australia
PH: + 61263821666
Fax: + 61263823536
Email: ymgroup@bigpond.com.au

- Kangaroo Cubes

Catching And Handling Equipment

Aces Animal Care and Equipment & Services
PO Box 591 or 151 Park Road
Cheltenham, Victoria 3192 Australia
Ph: +61395854908
Fax: +61395854399
Email: aces@animalcare.com.au
Internet: www.animal.care.com.au
* Ketch poles, gloves, nets, traps

Elliott Scientific Equipment
PO Box 1155 or 1 Sayers Road
Upwey, Victoria 3158 Australia
Ph: +61397542171
Fax: +61397548975
* Elliot traps – collapsible aluminium traps

Mascott Wireworks
11 Dunlop Street
Enfield, NSW 2136, Australia
Ph: +61296422028
Fax: +61296424338
Email: mww@braenet.com.au

- Cage traps

Wildlife & Animal Capture Equipment Services
PO Box 334
Warwick, Queensland 4370, Australia
Ph: +61746617066
Fax: +61746619179
* Animal capture and handling equipment

State and Other Wildlife Agencies

Environment Australia
John Gorton Building, Cnr. King Edward Terrace and Parkes Place ACT 2600, Australia
GPO Box 787, Canberra ACT 2601, Australia
Ph: +61262741111
Fax: + 61262741666
Email: ciu@ea.gov.au
Internet: www.ea.gov.au

New South Wales
National Parks and Wildlife Service
PO Box 1967 or 43 Bridge Street
Hurstville, NSW 2220, Australia
Ph: +61295856444
Fax: +61295856555
Email: info@npws.nsw.gov.au
Internet: www.npws.nse.gov.au

Northern Territory
Parks and Wildlife Commission of the Northern Territory
PO Box 496 or Goyder Centre, 25 Chung Wah Terrace
Palmerston Northern Territory 0831, Australia
Ph: +61889995511
Fax: +61889323849
Internet: www.nt.gov.au/paw

Queensland
Queensland Parks and Wildlife Service
PO Box 155 or Albert Street Brisbane, Queensland 4002, Australia
Ph: +61732020200
Fax: +61732026844
Email: nqic@env.qld.gov.au
Internet: www.env.qld.gov.au

South Australia
Department for Environment and Heritage
GPO Box 1047
Adelaide South Australia 5001, Australia
Ph: +61882048888
Fax: +61882048889
Email: environmentshop@sau.gov.sa.gov.au

Internet: www.deh.sa.gov.au

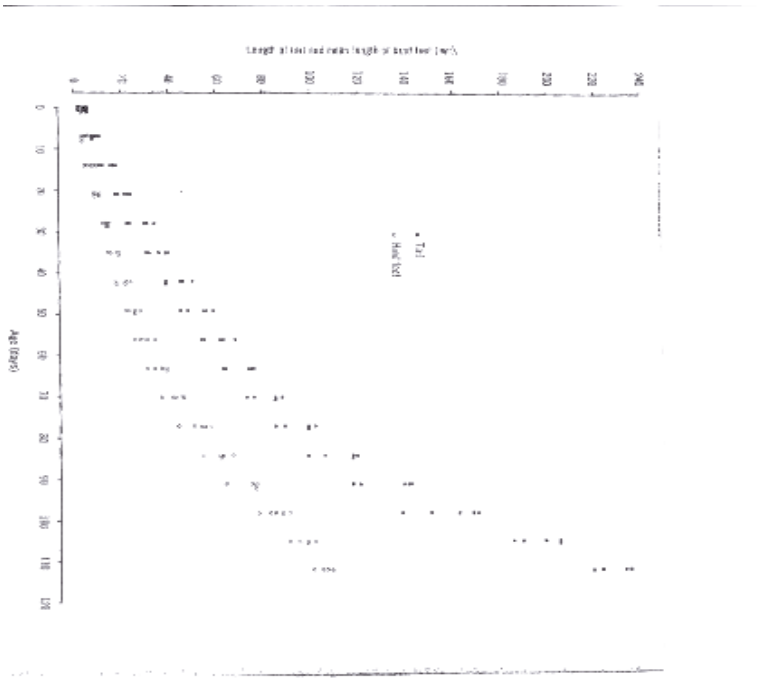
Tasmania
Parks and Wildlife Service, Tasmania
GPO Box 44A or 134 Macquarie Street
Hobart, Tasmania 7001, Australia
Ph: +61362336556 or +611300135513
Fax: +61362333477
Email: interps@dpiwe.tas.gov.au
Internet: www.parks.tas.gov.au

Victoria
Department of Sustainability and Environment
PO Box 500
East Melbourne, Victoria 3002, Australia
Ph: +61394124011
Fax: +61396378100
Email: customer.service@nre.vic.gov.au
Internet: www.nre.vic.gov.au

Western Australia
Department of Conservation and Land Management
Locked Bag 104
Bentley Delivery Centre, Western Australia 6983, Australia or
17 Dick Perry Ave.
Western Precinct, Technology Park, Kensington, WA 6151, Australia
Ph: +61893340333
Fax: +61893340498
Email: info@calm.wa.gov.au
Internet: www.calm.wa.gov.au

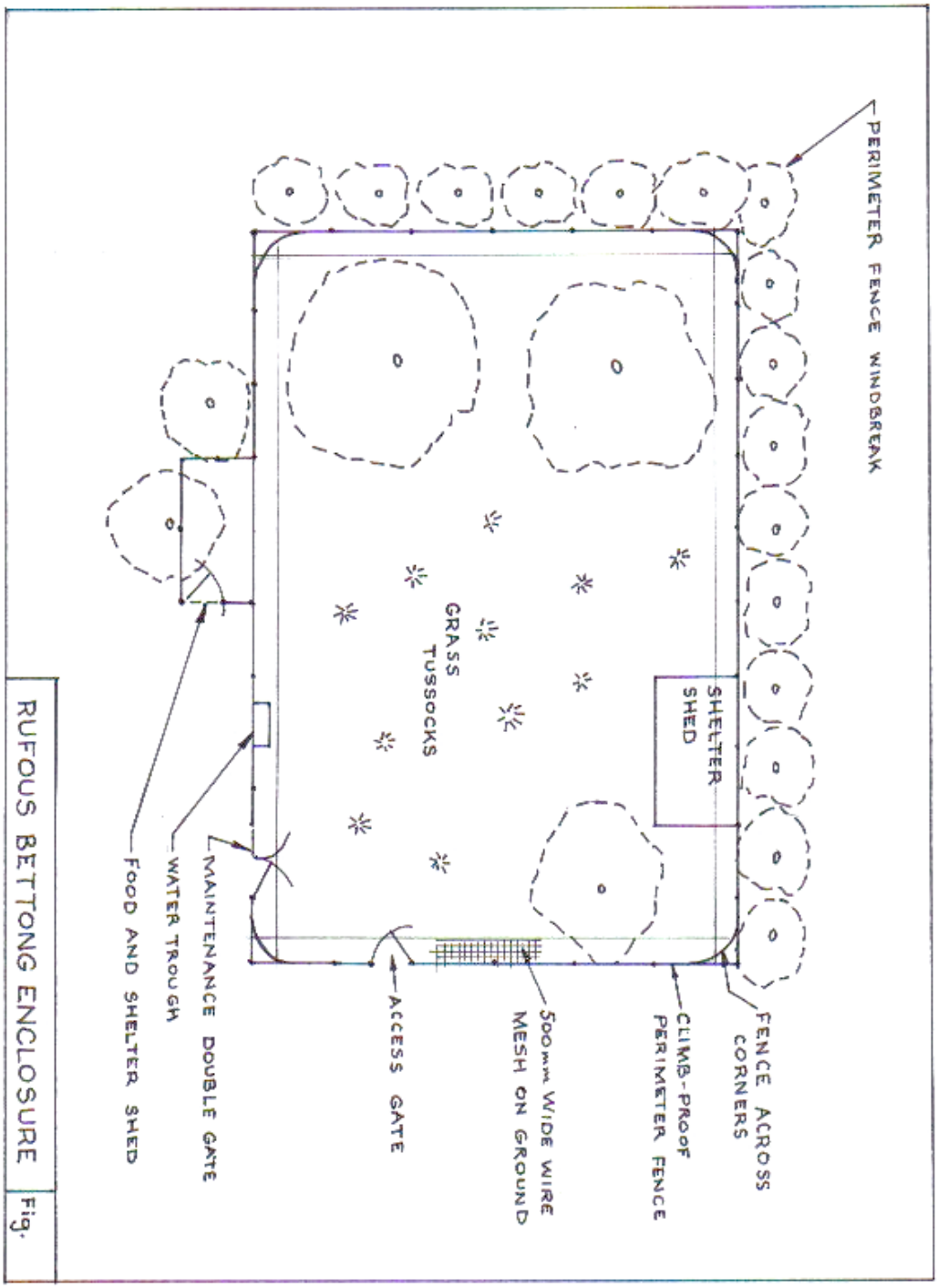
Marsupial Society of Australia
GPO Box 2462
Adelaide South Australia, 5001, Australia
Ph: +61882527800
Email: msa@iweb.net.au
Internet: www.marsupialsociety.org.au

Appendix 2.



Pouch young of the rufous rat-kangaroo: length of tail and mean length of hind feet plotted against age. Mean duration of pouch life, 114 days (Johnson, 1978).

Appendix 3.


PERIMETER FENCE WINDBREAK
SHELTER SHED
GRASS TUSSOCKS
FENCE ACROSS CORNERS
CLIMB-PROOF PERIMETER FENCE
500mm WIDE WIRE MESH ON GROUND
ACCESS GATE
MAINTENANCE DOUBLE GATE
WATER TROUGH
FOOD AND SHELTER SHED
RUFOUS BETTONG ENCLOSURE
Fig.

Appendix 4.

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.

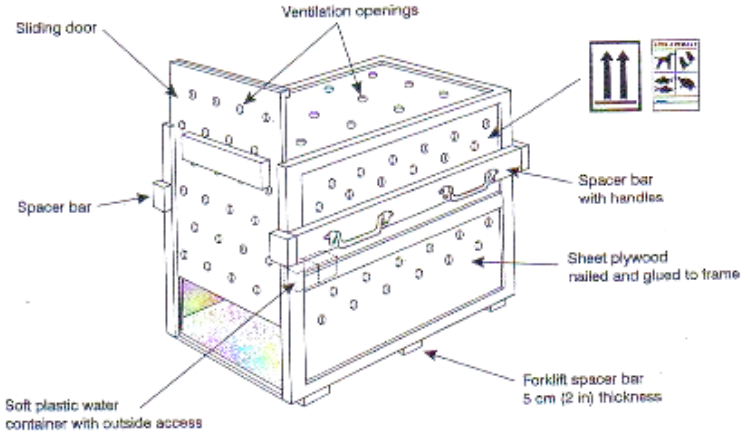
Roof

The ventilated plywood (or similar) roof must be 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 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:



8

83

CONTAINER REQUIREMENT 83

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