HUSBANDRY MANUAL
FOR THE

Common Wombat
Vombatus ursinus

Northern hairy-nosed wombat
Lasiorhinus krefftii

and

Southern hairy-nosed wombat
Lasiorhinus latifrons

MAMMALIA: VOMBATIDAE

In partial fulfilment for the degree of
Master of Philosophy

Donna Treby
University of Queensland
2005

TABLE OF CONTENTS

1. INTRODUCTION:

There are three species of wombat within the Vombatidae: the Common Wombat (*Vombatus ursinus)*, the Southern Hairy-nosed Wombat (*Lasiorhinus latifrons)* and the Northern Hairy-nosed Wombat (*Lasiorhinus krefftii).* Common wombats and southern hairy-nosed wombats are relatively plentiful; many are killed by cars and shot under permit each year in New South Wales, Victoria and South Australia; as they are considered a pest by pastoralists. The northern hairy-nosed wombat is one of the most critically endangered animals in the world with an estimated population of 90 individuals in Epping Forest National Park (Scientific) located in the Central Queensland Highlands.

Wombats are primarily grazers, the upper incisors work against the lower pair as efficient cutters of grass and forbs with the molars being broad with grinding ridges. They are largely nocturnal, however can be found in the open foraging on days of low light or when food is scarce and they are hungry. Wombats are the largest of all burrowing herbivores; their semi fossorial lifestyle offers protection from predation, as well as microclimate stability.

Common and southern hairy-nosed wombats have been held in numerous zoos throughout Australia (table 1) and the world. The first common wombats to be held in a zoo were kept in the zoological gardens attached to the Natural History Museum in Paris in 1803. London Zoo also had common and southern hairy-nosed wombats well before 1863.

Table 1. ARAZPA institutions that currently hold Common and Southern hairy-nosed wombats.

Common wombat	Southern hairy-nosed wombat
Western Plains Zoo	Westerns Plains Zoo
Taronga Zoo	Taronga Zoo
Melbourne Zoo	Melbourne Zoo
Australia Zoo	Australia Zoo
Dreamworld	Dreamworld
The ACT National Zoo & Aquarium	Currumbin Wildlife Sanctuary
Healsville Sanctuary	Rockhampton Botanical Gardens & Zoo
Featherdale Wildlife Park	Adelaide Zoo
Halls Gap Wildlife Park	Monarto Zoo
Ballarat Wildlife Park	Perth Zoo
Alma Park Zoo	
Australian Reptile Park	
Lone Pine Koala Sanctuary	
Wild World	
Cleland wildlife Park	
Crocodylus Park	

The northern hairy-nosed wombat was briefly held in captivity at Western Plains Zoo in Dubbo and also by the Dennis family from Epping Forest Station up until the late 1990's. No northern hairy-nosed wombats are currently held in captivity.

2. TAXONOMY:

Wombats belong to the Vombatidae. There are two genera and three extant species of wombats within this family. The first species to be described was the common wombat (Shaw 1800), later the southern hairy - nosed wombat was described by (Owen 1845) and the northern hairy-nosed wombat by (Owen 1872) (Strahan 2000).

Common Wombat Status

ASMP Management level 3
Planned Husbandry Research Program
IUCN N/A
OH&S Hazardous
Studbook Keeper: Fiona Cameron, Western Plains Zoo.

Southern Hairy-nosed Wombat Status

ASMP Management level currently 3, proposed 1b
Institutions holding this species are requested to assist the critically endangered northern hairy-nosed wombat, as an analogue species.

IUCN N/A
OH&S Hazardous
Studbook Keeper: Donna Treby

Northern Hairy–nosed Wombat Status

ASMP None in captivity not managed

IUCN Critically endangered (B2ab(iii) – single population occupying <10 km^2 , declining habitat quality).

2.1 Nomenclature

Class: Mammalia
Supercohort: Marsupialia
Cohort: Australidephia
Order: Diprotodontia
Suborder: Vombatiformes
Superfamily: Vombatoidea
Family: Vombatidae
Genus: *Lasiorhinus*
Species: *Lasiorhinus krefftii* Northern Hairy-Nosed Wombat

Lasiorhinus latifrons Southern Hairy – Nosed Wombat
Genus: *Vombatus*
Species: *Vombatus ursinus* Common Wombat

Etymology

Lasiorhinus	Hairy nose
krefftii	After Gerrard Krefft who was a curator at the Australian Museum
latifrons	Broad forehead. Refers to the wide nose
Vombatus	Derived from Aboriginal names used for the wombat
ursinus	Bear like

(Jackson 2003)

2.2 Subspecies

The hairy-nosed wombats do not have any subspecies, however the common wombat has three subspecies, which include *Vombatus ursinus ursinus* from Flinders Island, *Vombatus ursinus hirsutus* from the south-eastern mainland and *Vombatus ursinus tasmaniensis* from Tasmania (Strahan 2000).

2.3 Other Common Names

- Common wombat; naked nose wombat, coarse haired wombat, island wombat, Tasmanian wombat, forest wombat.
- Southern hairy - nosed wombat; hairy-nosed wombat.
- Northern hairy-nosed wombat: Queensland wombat, Queensland hairy-nosed wombat, Moonie River wombat. Yaminon – Indigenous name.

(Strahan 2000)

3. NATURAL HISTORY:

3.1 Morphometrics

Depending on the species wild adult wombats range in body weight from 19 to 40 kg and are approximately 900 to 1150 mm in body length. This is dependant on the species (table 2.) The common wombat displays a variety of coat colors from almost black to white, while the southern hairy - nosed wombats coat is silver-grey. However, white animals that are not albino are known to occur. The northern hairy-nosed wombat is dark grey almost black in coloration. Both the hairy-nosed wombat species have silky fur while the common wombat has a very wiry coat (Strahan 2000).

The female northern hairy-nosed wombat tends to be larger than males, significantly so for body length, head and body length and weight. Despite the slightly smaller size of adult males they tend to have thicker necks than adult females. Body measurements for the southern hairy-nosed wombat reveal no significant differences between the sexes, except in foot length, which is slightly longer in males. Adult female common wombats tend to be larger than males, but the differences are not significant (Johnson and Crossman 1990).

Table 2. Body weight and head-body length for the different species of wombats (Strahan 2000).

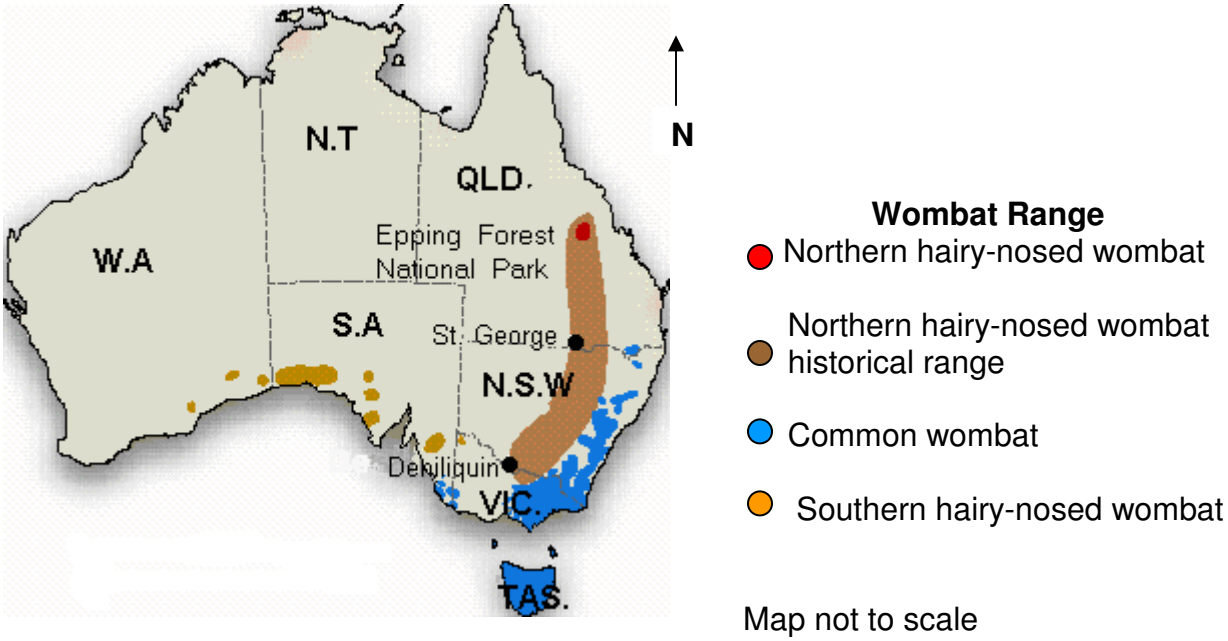
Species	Mean Weight range (kg)	Head & body length range (mm)
Lasiorhinus krefftii	27 - 40	970 - 1110
Lasiorhinus latifrons	19 - 32	772 – 934
Vombatus ursinus	22 - 40	900 – 1150

3.2 Distribution and Habitat

The main habitat of the common wombat is the forest-covered, often mountainous areas of south-eastern Australia (Map1). Its requirements include a temperate, humid microclimate, suitable burrowing conditions and native grasses for food. In southern Queensland and northern New South Wales, it occurs only in sclerophyll forest above 600m but, further south, particularly in Tasmania, it also occurs at lower altitudes and in more open vegetation such as woodland, coastal scrub and heathland (Strahan 2000).

The southern hairy-nosed wombat has a patchy distribution in semi-arid shrubland and mallee in southern South Australia and south-eastern Western Australia (Strahan 2000). The southern hairy- nosed wombat is also found in north-western Victoria and in 1996 was discovered in the south-west of New South Wales near Wentworth (Ayers *et al.* 1996). However this population has since become extinct.

The northern hairy-nosed wombat is reduced to a single population confined to Epping Forest National Park (Scientific) in the Central Queensland Highlands where it occupies temperate savannah grasslands (Horsup 2001).



Map 1. Map of Australia showing present and historical distribution of the northern hairy-nosed wombat and current distribution of the southern hairy-nosed and common wombats adapted from Australian Geographic (2004).

3.3 Diet in the wild

Wombats are strict herbivores and are hindgut fermenters (Booth 1999). The natural diet of all three wombat species is primarily made up of perennial native grasses, which are of low nutritive value (Hume 1999). When foraging, southern hairy-nosed wombats graze closely in a circular pattern around the burrow complex to produce a 'lawn' or grazing halo of green shoots, and home ranges are small, about 4 ha. Wombats have a split upper lip, which allows them to use their two upper and lower incisors to crop pasture close to the ground. All wombats have continuously growing incisors, premolars and molars, a feature not found in any other marsupial. Consequently, tough grasses are reduced to minute particles. The fact that wombats are able to reduce their food to small particles is an important feature in its ability to obtain maximum benefit from its diet. Perennial grasses, especially *Stipa nida,* are the main component of the diet of southern hairy-nosed wombat , however, more forbs, dicots and woody shrubs are eaten during severe drought (Hume 1999).

Common wombats usually forage in forest clearings or on pasture some distance from their burrows, and consequently they have larger home ranges, about 14 ha.(Triggs 1996). In the highlands of New South Wales the wombats select the leaves and roots of perennial grasses', especially *Poa, Danthonia* and *Themeda* spp., as well as cultivated oat crops. In periods of seasonal shortage or in areas where grasses are scarce, common wombats will feed on sedges (*Carex* spp.) and rushes (*Lomandra* spp.) and will also scratch the soil surface for small roots of grasses and other plants (Hume 1999).

The northern hairy-nosed wombat only occurs on deep alluvial sands supporting open eucalypt woodland with a grassy understorey. The main components of their diet appear to be the tough perennial grasses *Heteropogen contortus* (black spear grass), *Enneapogon lindleyanus* (wiry nineawn) *Fimbristylis dichotoma, Chrysopogon fallax, Brachiaria* spp, *Erogrostis lacunaria* and *Aristida* spp. (Woolnough 1998; Stenke 2000). The introduced *Cenchris ciliaris* (buffel grass) is rapidly becoming a dominant grass species in Epping Forest, and will therefore feature more prominantly in the diet of the northern hairy-nosed wombat (Horsup 2003).

3.4. Longevity

3.4.1 Wild

In the wild the southern hairy-nosed wombat have been known to live for 14 to15 years (Wells 1989). There is little information on longevity of common wombats in the wild. However, it appears that they can live for more than 15 years (Triggs 1996). Trapping data of the northern hairy-nosed wombat has shown that some individuals have lived for at least 17 years in the wild (Horsup *pers. comm.*).

3.4.2 Captivity

Common wombats typically live 12 to15 years in captivity. However, there are records of one living to 26 years of age at London Zoo (MacCallum 2003). The longevity of southern hairy-nosed wombats is similar to common wombats and are expected to live 10 to 15 years in captivity. Brookfield Zoo had a wild caught female live to the known age of 27 years and similarly Melbourne Zoo had a wild caught male live for 25 years (Treby 2003).

There had been four known instances of captive northern hairy-nosed wombats. Three were held by the Dennis family who originally owned Epping Forest as part of their leasehold land. “Darby” was an aged male when found and survived for approximately 8 years before dying from what was thought to be old age. Their second wombat “Joan” was collected as a young adult, and survived for 27 years. Another female was found on the fence line between Epping Forest National Park and Epping Station, and was taken back to the homestead, but escaped soon after and was not seen again (Dennis 2004). In 1997 an adult male was transported to Western Plains Zoo where he died soon after from and intersusseption of the bowel, thought to be associated with stress and dietary changes.

3.4.3 Techniques to determine the age of adults

Once wombats mature, there is no reliable technique for aging. It is not possible to study patterns of tooth wear as all of the teeth grow continuously (Jackson 2003).

4. HOUSING REQUIREMENTS:

4.1 Exhibit Design

The minimum enclosure sizes for exhibiting wombats as directed by the Exhibited Animals Protection Act (EAPA)(*Standards for exhibiting mammals in New South Wales* 2002) are as follows;

Minimum Surface area for one wombat is $23m^2$
Minimum Surface area for two wombats is $30m^2$
Additional Floor area for each extra animal is $9m^2$

The EAPA state that the exhibit structure for wombats needs to be only a basic design as wombats are highly destructive due to their very powerful build and digging habits. Most plants will be up-rooted, logs and other furnishings will be dug around. A natural dirt/sand substrate floor should be provided to allow the animal to express natural digging behaviour. A mesh underlay approximately 1 to 1.5 m below the surface is required to prevent them from escaping under the fence. The perimeter fence should be smooth as wombats are quite capable of climbing mesh fences. Chewing or digging at fences which may also result in damage to teeth, gums and feet of the wombat. Fencing types such as corrugated iron are not suitable because of the reflective heat in summer (Jackson 2003; MacCallum 2003). Wombats are capable of jumping at least a meter in height, therefore surrounding walls need to be a minimum 1.5m high (Jackson 2003).

Although wombats can live in environments where the temperature can reach 35˚C to 45˚C with relative humidity of 2 to 5%, the corresponding temperature in the burrow of southern hairy-nosed wombats is about 10 to 27˚C with 60 to 70% humidity (Shimmin *et al.* 2002). If captive animals are kept outdoors and are unable to construct burrows, they must be given the ability to behaviorally thermoregulate (Jackson 2003). Provision of a burrow or the means to construct one will make them feel secure and also provide them with the ability to shelter from the environment. Burrows can be constructed using mock rock caves, pipes or hollow tree trunks (Photograph 1). Overstorey planting will provide shade and should be included (Gaughwin 1982; Jackson 2003). The use of eucalypt branches (old koala browse), placed over mounds and tunnels has been employed by many institutions in an attempt to keep burrow temperatures down. Sprinklers and adequate shading during warm weather should always be provided. Water can be provided in a large stainless steel, ceramic bowl or by an automatic filling device. Water features or wet moats should be avoided as wombats have been known to drown in them (Treby 2003).

Wombats have also been successfully housed indoors, which has the advantage of allowing better control of temperature and humidity. In these enclosures, soil or sand to a depth of 0.5-1 m should be provided over the concrete floor to allow for natural digging behaviour. Indoor enclosures also allow the use of reverse lighting to display

them when they are generally most active (normally at night). Brookfield Zoo in Chicago has successfully used this technique to display and breed southern hairy - nosed wombats in the past (Jackson 2003).

4.2 Holding area design

The holding area is of a very similar design to the exhibit and only needs to be quite basic.

4.3 Spatial requirements

A pair of wombats requires at least 30 m^2 as well as a shaded nesting area. Larger enclosures are preferable and enclosures up to 400 m^2 have been suggested to reduce the likelihood of pacing, climbing and other attempts to dig out of the enclosure (Booth 1999). Although common wombats are usually not kept with more than two individuals together, southern hairy - nosed wombats have been readily held in groups. If held in groups, an additional area of at least 9 m^2 should be provided for each additional animal (Jackson 2003).

4.4 Position of enclosure

The enclosure should be situated in an area that is well drained, has plenty of shade during hot weather and provides sunny areas during cooler weather, as wombats like to bask when it is cold.

4.5 Weather protection

The enclosure can be open, semi enclosed or fully enclosed. If open they need to have adequate shade and sprinkler systems for cooling.

4.6 Heating requirements

Heating is not required for the display of wombats. However, Dr. Glenn Shimmin from the Department of Environment and Heritage, Adelaide suggested “that the wombats may need to experience a seasonally varying den of 14˚C to 25˚C, held constant throughout any one day to induce reproductive behaviour” (Shimmin *pers. comm*. 12.10.2000). Therefore the inclusion of a heating system may be of benefit for reproduction.

4.7 Substrate

The substrate should be soil or sand that is well drained. Care should be taken when using leaf litter as southern hairy-nosed wombats have been known to suffer from fungal infections of the feet when kept on leaf litter that was damp. Apart from allowing activity and other natural behaviours, the provision of substrates to allow digging enables the wombats to wear down their claws. If kept on a cement floor where there is

no provision for digging, nails may grow excessively. The provision of sand or soil will also allow the wombats the opportunity to dust bath a behaviour which they enjoy.

4.8 Nest boxes

To best cater for wombats psychological needs an artificial burrow should be provided to stimulate natural behaviour and a feeling of security. Nest boxes/dens should be approximately 1m x 1m x 1m with a hinged lid, narrow tunnel like entrance/passage, lined with straw or hay, and positioned in the shade where possible in outdoor enclosures. Artificial mock rock, concrete and brick sleeping dens have been used at several institutions (MacCallum 2003). Straw or hay can be used as bedding. However, quite often in the summer months it may well be pushed out of the den and discarded by the wombats (MacCallum 2003). Hessian bags filled with straw are often accepted, the wombats sleep between the bags, which provided additional insulation during winter (Presidente 1982).

4.9 Enclosure Furnishings

The enclosure requires very few furnishings as wombats are destructive by nature. Large hollow logs, branches, large rocks and pipes that are buried in the soil and large enough for them to sleep in are ideal (Photograph 1). If large rocks are used in the enclosure they will need to be checked regularly as wombats can destabilize their foundations by constant digging. The risk of rocks falling or rolling onto animals should be taken into consideration when landscaping the exhibit. If difficulties are encountered in getting plants established inside the enclosure, then plants may need to be planted around the outside of the exhibit to provide shading. Large tussocks of *Lomandra logifolia* have been successfully used in the southern hairy-nosed wombat exhibit at Currumbin Wildlife Sanctuary, the wombats there do not seem to be interested in eating them. Branches and rocks are used by wombats as scratching posts to reach places on their body that they cannot otherwise reach (MacCallum 2003).


Photograph 1: Enclosure furnishings

4.10 Wombat breeding facilities

4.10.1 Western Plains Zoo

Western Plains Zoo has the largest captive population of common wombats in Australia and has constructed a purpose built complex to facilitate reproductive research. The new facility is a “State of the Art design” was built in 1997 (MacCallum 2003) (Photograph 2). The design mainly focuses on the thermoregulation requirements of wombats. The complex is a series of interconnecting tunnels packed in soil and

surrounded by a retaining wall to prevent digging with the soil acting as a natural insulation. Burrow temperatures range between 14˚C to 24˚C. Access to wombats is by hinged lidded sleeping boxes which are lined with hay/straw bedding. The wombats' movements are controlled by a series of sliding doors. This design also makes it easy to restrain and handle wombats (MacCallum 2003).

Photograph 2: Wombat Breeding Facility at Western Plains Zoo

4.10.2 Rockhampton Zoo

The "Wombat Breeding and Research Facility", overseen by Dr. Alan Horsup of the northern hairy-nosed wombat recovery team, is located within the grounds of the Rockhampton Botanical Gardens and Zoo and is a replica of the Western Plains Zoo enclosure. This facility is dedicated to reproductive research on the southern hairy-nosed wombat as an analogue species for the northern hairy-nosed wombat. The facility is air conditioned to provide optimal temperatures for the wombats. The inclusion of humidifiers may also be required to replicate burrow conditions and stimulate natural breeding behaviours (Horsup *pers. comm*. March 2004).

4.10.3 Melbourne Zoo

Melbourne Zoo have incorporated a heating system into the tunnels of their wombat exhibit as well as into the floor of one of the boxes in the off limits area. This heating system can be controlled via thermostats.

4.10.4 Taronga Zoo

Taronga Zoo's 'Backyard to Bush' exhibit contains a custom made wombat facility which consists of a series of six burrows, of varying sizes on display and two outdoor off exhibit areas. The exhibit has the capability of being opened up for access to all areas, or being sectioned off into two indoor/outdoor exhibits or two indoor and two outdoor areas. Thermal stability can be obtained through altering the floor heating in the six burrows.

4.10.5 Perth Zoo

Perth Zoo's wombat exhibit is split in half to form two enclosures, with an off limits area located between the two exhibits. One half of the exhibit contains an underground tunnel system with viewing area in the front (Photographs 3a & 3b).

Photograph 3a: Perth Wombat Exhibit

Photograph 3b: Underground tunnel with viewing area

5. GENERAL HUSBANDRY:

5.1 Hygiene and cleaning

Wombats should be maintained with high standards of hygiene. All enclosures should be cleaned daily to remove faecal matter and uneaten food. Drinking water containers should also be cleaned and refilled daily.

5.2 Record keeping

Health, condition and reproductive status of captive wombats should be routinely monitored. Animals should be checked daily and the following records kept.

- Identification numbers;
- Veterinary examination conducted;
- Treatments provided;
- Behavioural changes or problems;
- Reproductive behaviour or condition;
- Weights or measurements;
- Changes in diet;
- Movements of individuals between enclosures or institutions; and
- Births & deaths.

(Jackson 2003).

The collection of information on individual physical and behavioural patterns can contribute greatly to the knowledge of the husbandry of these species. Individual programs such as ARKS (for general information on birth, transfers and deaths),

SPARKS (breeding studbook for a species) and MedARKS (veterinary information), are used by zoological institutions to record the above information. Developed by the International Species Information System (ISIS), these programs operate as a means of data transference between institutions (Jackson 2003).

5.3 Methods of identification

5.3.1 Microchip transponders

Microchips (Trovan, Microchips Australia), implanted subcutaneously between the scapulae of individuals, provide a permanent method of identification. Microchip implants do require the animal to be caught to confirm identification with a Microchip scanner.

5.3.2 Tattoos

Tattooing has been successfully used on the inside of the ear. However, tattoos cannot be read from a distance and may fade with time (Rice and Kalk 1996). This technique again requires the animal to be manually restrained to confirm identification.

5.3.3 Visual identification

All wombats show a degree of anatomical and behavioural variation therefore visual identification can often be used. However, this technique requires an intimate knowledge of individual animals.

5.3.4 Ear tags

Ear tags are not recommended, as they are highly likely to be torn out. Ear tags that have been used include self piercing, nylon disc swivel tags similar to that used for cattle, pigs and sheep, however although highly visible, these are sometimes lost, become entangled or are ripped out by other wombats (Jackson 2003).

5.3.5 Hair bleaching

Rockhampton and Taronga zoos, have experimented with bleaching. This technique is highly visible although only temporary and may be difficult to see if the animal is lying on its back or side where the bleach mark is located.

5.3.6 Ear notching

Ear notching by cutting U or wedge-shaped notches out of the ear margins are permanent, but may be obscured by subsequent injuries. Ear notching may also be objectionable on humane grounds (Rice and Kalk 1996).

5.3.7 Freeze marking

Freeze marking or cryobanding has not had widespread use. This could be due to the brand detracting from the look of the animal. Freeze marking has the potential to meet many of the ideal marking criteria. It is permanent, can be legible at a distance, and is thought to be painless; the rapid freezing of the skin acts as a local anaesthetic. It has been used on mammals ranging in size from neonatal mice to African elephants (Rice and Kalk 1996).

6. FEEDING REQUIREMENTS:

6.1 Captive diet

The Basal Metabolic Rate (BMR) of the southern hairy-nosed wombat is one of the lowest recorded for any marsupial and the maintenance energy requirements of wombats is also the lowest recorded for any marsupial. The low metabolism and rate of digestion provide wombats with advantages in terms of their ability to survive long periods of food shortage under adverse environmental conditions (Hume 1999). Given wombats low BMR and energy requirements they have a tendency to become obese in captive situations, so a low energy low protein diet primarily based on grass and or palatable but low quality food is essential.

Fruits and green leafy vegetables ferment more rapidly than grasses which could lead to digestive disorders, therefore wombats with their low metabolic rate and slow digesta passages rates can not efficiently make use of these food types. Dry dog food should not be fed to wombats; due to its high protein, low fiber content and a mineral balance designed for carnivores. There may be a link between feeding inappropriate diets and systematic calcification seen occasionally in captive wombats.

In 1995, “Ridley Agriproducts produced a “wombat pellet” and offers a high fibre (15%) low crude protein (12.5%) pellet with Vitamin D reduced to 2400 IU/kg.” (Booth 1999). However, this product has been discontinued due to lack of demand.
Maintenance energy requirements for a southern hairy - nosed wombat weighing 23.1 kg are 140 KJ/kg daily (Hume 1999).

Therefore the recommended captive diet for an adult wombat is;

- 200 gm of commercially produced feed;
- meadow hay ad libitum; and during the breeding season
- fresh native grass daily.

Below is a list of diets fed by a variety of institutions. Amounts given are daily rations per animal. Rations need to be measured to ensure animals are not overfed.

Western Plains Zoo (Common wombat)

- 300g kangaroo pellets
- 1 corn cob
- 400g sweet potato

- 1-2 clumps of native or exotic fresh grasses, supplemented with meadow hay if not available

Currumbin Wildlife Sanctuary (Southern Hairy-nosed wombat)
- 200 g macropod pellets
- 10g lucerne hay
- clumps of fresh native grasses 1-2 times per week
- ¼ corn cob or sweet potato given once per week

Perth Zoo (Southern Hairy- nosed wombat)
- 150g kangaroo pellets
- 80g silverbeet
- 150 g pumpkin
- 150 g carrot
- 150 g beetroot
- 150g ½ corn cob or 1 sweet potato 3 x weekly
- Access to lucerne hay at all times
- Fresh cut grass daily - fed Pm

Melbourne Zoo (Southern hairy–nosed wombat)
This diet changes on a weekly basis and is offered A.M.
Week 1
- 1 cup of macropod pellets Daily
- ½ handful of grass Daily
- 2 chunks of vegetable Sunday
- ¼ cup of maize Tuesday
- browse Monday, Wednesday and Friday
- ad libitum meadow hay Daily

Week 2
- 1 cup of pellets Daily
- ½ handful of grass Daily
- browse Monday, Wednesday and Friday
- meadow hay ad libitum Daily

Weeks 3
- 1 cup of pellets Daily
- browse Monday, Wednesday and Friday
- meadow hay ad libitum Daily

During lactation the female wombats are given 2 cups of pellets daily until her joey is fully weaned.

Western Plains Zoo (Northern Hairy-nosed wombat)
Oaten Hay
Fresh cut grass (species unknown)
- carrot
- apple
- sweet potato +<u>These items would only be eaten when proffered by hand</u>

- roo cubes
- portagen lapped from a hand held bowl

Dennis Family Epping Forest Station (Northern Hairy-nosed Wombat)
Queensland Blue couch grass *Digitoria didactyla* daily
Pollard – warm mash daily

6.2 Supplements

No specific supplements are required due to wombat's low metabolic rate and energy requirements.

6.3 Presentation of food

It is recommended that food be provided in strong stainless steel or ceramic bowls (minimum 30cm diameter) or hoppers 20 cm above the ground to prevent the wombats from soiling or walking on their food. One bowl per animal is required.

7. HANDLING AND TRANSPORT

7.1 Timing of capture and restraint

Wombats are best caught first thing in the morning when they are less active.

7.2 Catching bags

Strong hessian bags or wooden boxes are generally used to transport wombats (see Box Design 7.6.1)

7.3 Capture and restraint techniques

Juvenile wombats are generally easily picked up under the armpits, placed in a large hessian bag (with end tied closed), if required and carried away. Adult wombats can be highly aggressive, and will readily attack and can cause severe injury. Some animals will retreat into the nest box, pipe or log and face their rear towards you. In this case, care needs to be taken as the wombat will make an effort to crush your arm against the side or roof of the box or log (MacCallum 2003).

If manual restraint is required the animal is approached from behind and held in position by placing a foot against the rump so it cannot reverse, and placing a hand on each shoulder so that it cannot turn or go forward (MacCallum 2003). Alternatively if the wombat is in a box with a hinged lid, throw a blanket over the animals head; this seems to quieten them considerably. The hands then firmly hold the shoulders in place and

move back towards the armpits, where one arm slides under the armpit and slides across the chest. The animal is then picked up one arm now under both armpits. You can place your hand under the rump of the wombat, however, be cautious as this may reduce the affect of your grip on the wombat if they are struggling (Photgraph 4). Highly aggressive animals may put their head back and try to bite or head butt, so keep your head tilted back and away.
Chemical restraint, such as darting or hand injection is another alternative for capturing/retraining highly aggressive wombats and will require veterinary assistance.

Photograph 4: Manual restraint

7.4 Weighing and examining

Wombats are generally best weighed by holding them, and then weighing yourself with the wombat and then subtracting your weight. At Currumbin Wildlife Sanctuary with a particularly aggressive male southern hairy–nosed wombat, he was crate trained and the same weighing principle as above applied. Wombats can also be conditioned to walk onto a weighing platform.

7.5 Release

The release of the wombat needs to be done with care, as aggressive individuals can turn and attack. If releasing an aggressive animal this should be done over a wall approximately 1 m high.

7.6 Transport requirements

7.6.1 Box design

The box must be very strongly built, otherwise they are likely to chew or dig their way out of the box during transit. Further specific details of the box can be found in IATA (IATA. 2002). Photograph 5 shows transport boxes used at Currumbin Wildlife Sanctuary with dimensions of 90 cm high x 90 cm long x 60 cm wide.

Photograph 5: Transport Box

7.6.2 Furnishings

When transporting southern hairy-nosed wombat's Currumbin Wildlife Sanctuary packs the box with straw. The wombats burrow into the straw, which acts as support and cushioning, is absorbent and quietens the wombats. Some institutions transport wombats within hessian bags. With this method the wombats are quiet; however, death due to heat stress has been recorded.

7.6.3 Water and food

Due to the low metabolic rate and slow digestion times, wombats do not need to be fed for trips less than several hours (though they probably could manage not feeding for considerably longer than this) (Gaughwin 1982). For longer journeys, food and water should be provided in a deep dish (Jackson 2003).

7.6.4 Animals per box

One animal per box. Females with pouch young should not be transferred unless the young is still attached to the teat (Jackson 2003).

7.6.5 Timing of transport

As wombats do not tolerate high temperatures (>33˚C), transportations should be overnight or during the morning in the cooler months.

7.6.6 Release from the box

Place the box in enclosure, open the door and allow the wombat to exit in its own time. Remove the box when the wombat has chosen another site as its den.

8. HEALTH REQUIREMENTS:

8.1 Daily health checks

Each wombat should be observed daily for any signs of injury or illness. This is generally done during cleaning of the enclosure ie in the morning or in the afternoon when food is presented. This is when wombats are most likely to be active. Each wombat should be checked for:

- Condition of coat;
- Discharge from the nose, eyes or cloaca;
- Changes in appetite;
- Behaviour changes – depressed, aggressive;
- Injuries;
- Faecal quality; and
- Presence and development of pouch young by observation of the bulge in the pouch.

(Jackson 2003)

8.2 Detailed physical examination

8.2.1 Chemical restraint

Pre-anaesthesia fasting is not required for adult wombats as they are not prone to regurgitation. If hand-reared they should not be fed for at least one hour before anaesthesia. Sedation can be undertaken using Diazapam, (Valium®) 0.5 – 1.0 mg/kg, by an intramuscular (IM) injection in the thigh muscle. Wombats can be anaesthetized using injectable agents such as tiletamine/zolazepam (Zoletil®) at 3 – 8 mg/kg IM, with lower doses being adequate for minor procedures (Vogelnest 1999).

Studies on tiletamine and zolazepam on all three species of wombats has found that most animals displayed mechanical chewing and 'paddling' movement of the front limbs, particularly when recovering. Chewing and paddling seemed to be more prevalent in animals which had been stressed before anaesthesia (Evans *et al.* 1998).

Inhalation anaesthetic agents such as isoflurane or halothane in oxygen are frequently used for induction and/or maintenance of anaesthesia, however isoflurane is preferred since there is a greater relaxation of the muscles. Intubation is difficult and not usually attempted or required (Vogelnest 1999). However, if intubation is necessary, the wombat is intubated by extending the head, retracting the tongue and placing a 7.5

gauge endotracheal tube 'blind'. Once intubated, adult wombats are maintained on 1 to 2 % isofluorane delivered by a circle anaesthetic system (MacCallum 2003).

The vital signs recorded for wombats under Zoletil and isoflurane anaesthesia are:

- Body temperature 35.4 – 36.7˚C
- Heart Rate 90 – 120 beats/minute
- Respiratory Rate 20 breaths/minute

(Booth 1999)

8.2.2 Physical examination

A thorough physical examination should be conducted once per year with the wombat under anaesthetic. The following should be included and recorded in the health check process (Jackson 2003).

- Body Condition – various body condition indices have been used to examine the condition of wombats. A subjective condition index provides a score of one to five.
  1. Ribs visible, backbone and pelvis
  2. Ribs covered but easily felt, backbone still visible, and the rump is sunken
  3. Pelvis, backbone and ribs covered
  4. Pelvis, backbone and ribs well covered
  5. Wombat in excellent/fat condition

- Weight – is recorded and compared to the previous weights recorded. Trends in body weight give a good general indication of the animal's state of health. Age and sex should also be considered when weighing animals. Animals in captivity should be weighed monthly to monitor developments in body weight.

- Temperature – Normally 32– 36.7˚C. Body temperature can be measured rectally; by placing a thermometer gently in the rectum of the wombat.

- Pulse rate – Normally 40-45 beats per minute (BPM) at rest and 55-60 BPM when active. Taken over the femoral artery, or by auscultation of the heart.

- Respiration rate – Normally 12-16 BPM in deep sleep and 26-32 BPM whilst dozing.

- Fur – Check for alopecia, ectoparasites, fungal infections or trauma.

- Eyes – Should be clear, bright and alert
  Normal bilateral papillary light response
  Normal corneal reflex and no discharge should be present

- Nose & nostrils – should be clean. If discharge is present swab for pathogens.

- Ears – check pinnae for signs of fighting; use otiscope to check external ear down to external acoustic meatus.

- Mouth- check lips and cheek pouches, check for abnormal swellings, mucous membrane color.

- Teeth – check for tooth wear and make sure that teeth are wearing properly and not over grown.

- Cloaca – should be clean, check for faeces around the cloaca.

- Also check for the presence of lumps over body and auscultation of lungs.

- Females – condition of the pouch. Check whether lactating.
  If pouch young is present; record sex, stage of development, weight if detached from the teat and measure to determine age from growth curves if necessary.
- Males – Check testes – size (length, width, depth) and consistency (firm, not soft). Extrude penis and assess. Measure accessory gland bulge if present (length and width). If bulge is present this is an indicator of reproductive readiness.

- Faecal sample – perform a qualitative faecal float to test for parasites.

- Urine sample - test using multi sticks and a refractometer for specific gravity.

- Blood sampling – Blood can be collected from the cephalic, radial, caudal tibial femoral or jugular veins. As the skin is thick, a tourniquet helps to visualize the peripheral veins on the shaved limb (Appendix 1) (Booth 1999).

8.3 Routine treatments/ vaccinations

None required.

8.4 Known health problems

Wombats suffer few problems in captivity, apart from superficial bite wounds to rump and ears from other wombats. However, parasites and diseases that occur in wombats are described below. The following information is taken from Jackson (2003) unless otherwise stated.

8.4.1 Ectoparasites

8.4.1.1 Mange, ticks & fleas

Cause – The mite *Sarcoptes scabei*, burrows into the deeper parts of the stratum corneum resulting in infestations on the skin. More commonly known as ‘mange’ it is

often seen in wild populations of Common wombats and kills many individuals. Sarcoptic mange was once less commonly seen in southern hairy - nosed wombat populations. However, a severe outbreak was recorded in 2004 which could have a catastrophic affect on drought affected populations of the Murraylands (Shimmin *pers. comm.*2004). Sarcoptic mange has not yet been seen in the northern hairy-nosed wombat.

Most wild wombats will have infestations of ticks and several genera of fleas are known to occur as well such as *Lycopsylla nova* and *Echidnophaga cornuta* (Skerratt 1998; Gerhardt *et al.* 2000). Ticks such as *Ambylomma triguttatum, Aponomma auruginans, Ixodes cornuatus, Ixodes victoriensis* and *Ixodes tasmani occur* (Skerratt 1998; Gerhardt *et al.* 2000) more commonly on the ventral areas and on the ears. Severe infestation can cause anemia.

Signs - Fur loss, the presence of thick scaly crusts on the body, and in severe cases, large open sores with secondary bacterial infection and the presence of maggots. Movement, vision and mastication may be impaired by the severity of the skin changes and death through starvation or misadventure is likely to occur in wild animals.

Diagnosis – Visual observations or a skin scraping and microscope examination to identify the parasites. Identification of sarcoptic mange is made by taking skin scrapings and confirming the presence of mites or their ova.

Treatment – In mild cases a topical acaricide may be effective such as 3-4 treatments of 1.25% solution of Amitraz at weekly intervals. Other treatments such as Ivermectin pour-on can be applied to the body or given subcutaneously at a dose of 200-300mg/kg. Treatment should be repeated after 10 days; a total of four treatments are required. Soaking in keratolytic solutions first to remove crusts may be necessary. In advanced cases euthanasia is the most humane approach. Care should also be taken that re-infestation does not occur from old bedding and nest boxes.

Ticks and fleas can be treated with an insecticidal was such as Malawash for dogs and given 14 days apart, or treatments such as 'Frontline' (Fiprenil) spray or 'Spot On' applied as recommended for dogs.

Prevention – Maintaining good hygiene and addressing the first signs of an infestation.

8.4.2 Endoparasitic worms

8.4.2.1 Cestodes

Cause – Various species of cestode have been identified from common wombats, however three species infect common wombats as metacestodes (immature tapeworms), two of which, *Echinocooccus granulosus* and *Anoplotaenia dasyuri,* occur rarely. Several Cestodes appear pathogenic as *Progamotaenia festiva* has been associated with mild cholangitis or fibrosis of the bile-ducts and *Taenia hydatigena,*

metacestode stage, with hepatic granulomata in common wombats. *Phascolotaenia comani* has been commonly reported and *Paramonezia johnstoni* occasionally reported in common wombats. *Progamotaenia diaphana, Paramoniezia johnstoni* have been recorded in southern hairy - nosed wombats and *Paramonzia suis* in the northern hairy-nosed wombat (Smales 1998).

Signs – Signs of cestode infections are not obvious unless metacestodes cause severe damage to internal organs such as the liver.

Diagnosis – Faecal flotation which is a simple laboratory test to determine the presence of internal parasites; and presence of eggs or segments. Only infection with adult cestodes can be diagnosed in this way since the metacestode stage of the cestode life cycle occurs within internal organs and does not produce eggs or shed segments.

Treatment – Treatment with anthelmintics such as Droncit (praziquantel). One tablet per 10 kg, check for presence of eggs or segments again within 14 days and retreat if necessary.

Prevention – Generally not required but would be covered by routine treatment with anthelmintics. It is also important to remove faeces from the enclosure.

8.4.2.2 Nematodes

Cause – Several species of nematodes are known to live in the colon of wild common wombats such as; *Oesophagostromoides giltneri, O. eppingensis* and *O. longispicularis.* Larvae of *Baylisascaris tasmaniensis* have also been identified in granulomatous lesions in several organs, as well as the lungworm *Marsupostrongylus coulsoni. Stongyloides* has also been found as well as several sub species of roundworm within the colon usually with no signs of disease.

Macropstrongyloides lasiorhini and *Oesophagostomoides stirtoni* in the southern hairy - nosed wombat and *Oesophagostomoides eppingensis* in the northern hairy-nosed wombat (Smales 1998).

Signs – Infection with *Strongyloides* and roundworm sub species can result in mild enteritis in some wombats,while others wombats appear to show no or few problems. *Marsupostrongylus coulsoni* is the only nematode known to cause gross pathological changes in common wombats, with infections being associated with mild interstitial pneumonia.

Diagnosis – Faecal floatation.

Treatment – Where thought to be a concern, nematodes are treated with an appropriate anthelmintic such as benzimadozole or ivermectin 0.2 mg/kg injections under the skin (sub-cutaneous) twice at 10 day intervals.

Prevention – Good hygiene and surveillance by faecal float.

8.4.2.3 Trematodes

Cause – The liver fluke *Fasciola hepatica* has been commonly found in wild common wombats in swampy areas or along creeks that are suitable for the snail *Lmnaea tomentosa* and L. columella as the intermediate host.

Signs – Although it appears that common wombats are generally resistant to Fasciola hepatica, it can result in jaundice and ascites due to extensive hepatic fibrosis and marked fibrosis of the bile ducts.

Diagnosis – Detection of eggs by faecal floatation.

Treatment – Triclabendazole is used for the treatment of *Fasciola hepatica* in sheep and is given at a dosage of 10mg/kg.

Prevention – Good hygiene and surveillance by faecal floatation.

8.4.3 Protozoans

8.4.3.1 Coccidia

Cause – Is due to the parasites *Eimeria spp.* and is often associated with enteritis in sub-adult and hand-reared wombats.

Signs – Often associated with the onset of grazing in juvenile wombats. Coccidia can occur at approximately 10 months of age or sometimes earlier in hand-raised animals. In severe cases the wombat may develop mucoid to liquid green diarrhoea, progressively loose weight and become bloated. Although generally not considered to be pathogenic, deaths are known to occur.

Diagnosis –Faecal floatation.

Treatment – Once clinical signs of enteritis have developed, treatment becomes very difficult, as fluid therapy is hard to deliver and anti-coccidial therapies that are used in other species are often ineffective.

Prevention - Frequent faecal flotation tests for the presence of coccidial oocytes.

8.4.3.2 Toxoplasmosis

Cause – Is often associated with hand reared animals, and occurs when wombats have access to cat's faeces, with the protozoan *Toxoplasmo gondii*, in the house or yard.

Signs – Neurological signs including ataxia, circling and blindness, respiratory symptoms or poor growth and death often associated with interstitial pneumonia and or focal encephalitis.
Diagnosis – Visual signs and serological tests.

Treatment – If treatment begins as soon as clinical signs are apparent, it is possible to successfully treat, so do not wait until diagnosis is confirmed as this may take several days. Nonetheless this disease is usually fatal in wombats.
Prevention- Avoiding all access to cats, cat faeces and hay that may have been contaminated with cat faeces.

8.4.4 Fungus

Cause – Fungal lesions of *Chrysosporium spp*. have been found in the lungs of wombats in Tasmania and Victoria. Infection is common in wild southern hairy - nosed wombats and has been found in captive animals.

Signs – Appears to show no visible signs of disease.

Diagnosis – As incidental findings on autopsy.

Treatment – Not required.

Prevention – Not required.

8.5 Quarantine requirements

As part of a preventative health program all new wombat arrivals must be quarantined, despite being considered free of transmissible diseases by the previous holding facility. Wombats should be housed in a separate facility for 30 days and cared for by keepers who are not in contact with other animals outside of the quarantine facility (Van Drimmlen 2000).

On arrival new wombats must undergo;
- Physical examination for obvious abnormalities;
- Dental examination for abnormalities;
- Record body weight;
- Record or apply ID;
- Collection of blood sample; and
- Faecal float – to check for parasites.

Three consecutive negative faecal and blood tests are required before wombats are released from quarantine (Van Drimmlen 2000).

9. BEHAVIOUR:

9.1 Activity

Wombats are generally nocturnal and display little activity during daylight hours. They may spend up to 16 hours each day asleep in their burrows in order to conserve energy; which is behaviour adapted to their low energy diet. Southern hairy-nosed wombats are known to bask and feed during the day in autumn, winter and spring (Wells 1978).

Wombats have adapted their behaviour to their semi fossorial lifestyles due to their inability to regulate their body temperature when temperatures rise above 25˚C (Shimmin *et al.* 2002).

In summer wombats are more active from midnight to early morning before the temperature gets too hot, while in winter they are more active in late afternoon to early evening before temperatures have dropped. The only time in which wombats appear to be diurnal is when they sometimes bask in the sun during the cooler months especially after cold nights (Wells 1978).

Research on the northern hairy-nosed wombat found an important relationship between temperature and activity. Activity increased with temperature until 20˚C was reached, after which further increases in temperature result in a decrease in activity. The northern hairy-nosed wombat spends only two to six hours above ground with a significant relationship between the time of year (and hence temperature and food availability) and activity in the warmer months and more during the cooler months especially in late winter and early spring (Johnson 1991).

9.2 Social behaviour

Social and reproductive strategies are not well understood in the southern hairy - nosed wombat, there is little information upon which to base husbandry techniques and group sex ratios in captivity (Finlayson, work in progress). However, the focus of social organization of the southern hairy - nosed wombat is the warren, which can have from one to thirty burrows. There can be ten or more wombats using them though not necessarily at the same time. Typically a wombat colony uses 10 to 20 warrens in a cluster, which can be spread over an area up to 1 km^2. Females show greater preference for burrows than males, but there appears to be no evidence of burrow ownership among warren occupants (Jackson 2003). In the wild adult male southern hairy-nosed wombats are dominant to adult females; in captivity in some cases the female is dominant over the male (Gaughwin 1982).

Fighting in wombats consists of bites to the face, ears, rump and flanks. Aggression is generally undertaken by a series of vocalizations that include a flat ‘chicker chicker’ and a rasping chur that can be a prelude to chasing and fighting. Fights that do occur can result in head to head attacks or with one defending itself by pushing its rump toward the attacker (MacCallum 2003).

9.3 Reproductive behaviour

In many mammals the function of the selected pheromones that are voided with the urine is to signal the reproductive status of the females. Flehman has been observed in both common and southern hairy-nosed wombats, it is typically made by the wombat standing with its head stretching up and its mouth open while it retracts the lip, baring the gum and wrinkling the nose. Sometimes the wombats make rapid licking and mouthing movements during or after showing flehman (Gaughwin 1979; Triggs 1996).
Activity levels are noticed to increase during the breeding season. The male's aggression levels increase towards the females by chasing and exhibiting dominance over them. Both males and females display an increase in vocalization during this time.

9.3.1 Common wombat

At Western Plains Zoo, a few days prior to mating, females exhibited oestrous behaviour associated with courtship. The females were observed to stop at right angles to the males, present themselves, and make grunting noises. Behaviour by the males also indicated that they were aware that the females were in oestrous. Males were seen sniffing the faeces of the females, and showing flehman.

9.3.2 Southern hairy-nosed wombat

In the wild copulation probably occurs in the burrow (Gaughwin 1982). Consequently, to copulate effectively the male may have to prevent the female escaping by forcing her to the blind end of a tunnel or burrow. The implications of this observation for the design of enclosures for the southern hairy-nosed wombat are obvious; in that a burrow of some type must be provided (Gaughwin 1982). At Currumbin Wildlife Sanctuary, copulation had been observed at the entrance to a hollow log however, no young were produced. Crowcroft & Soderlund (1977) also noted that on some occasions southern hairy-nosed wombats have failed to give birth after intromission.

One problem observed with captive breeding of southern hairy-nosed wombats is the failure of the male to copulate with the female. The concentrations of androgens in the plasma of breeding wild southern hairy-nosed wombats (3 to15 ng/mL) were higher than those of some captive animals (0.5 to 4.0 ng/mL), (time of year and age of animals was not supplied). Androgen or gonadtrophin therapy may possibly stimulate sexual behaviour in apparently inhibited male southern hairy-nosed wombats (Gaughwin 1982).

9.3.3 Northern hairy-nosed wombat

Little is known on the reproductive behaviours of the northern hairy-nosed wombat. During the months proceeding summer rains persistent approach-retreat and extended bouts of vocalization have been noted and were recorded more or less continuously throughout nightly observation sessions (4 to 4.5 hours) over 10 consecutive nights (Stenke 2000). This may be an indication that the occurrence of such behavioural activities could have been influenced by the female oestrus cycle (Stenke 2000).

9.4 Bathing

Although wombats can swim, they usually do not bathe in water. However, wombats will dust bath in sand or dusty soil (Triggs 1996).

9.5 Behavioural problems

Adult wombats in captivity generally do not tolerate the presence of keepers in their enclosures. The degree of aggression towards handlers depends on the individual wombat.

9.6 Signs of stress

Stress in wombats can be associated with very loud vocalizations and teeth gnashing. Chronic stress may result in alopecia that is usually symmetrical and immunosuppressed, excessive drinking and eating or anorexia (Jackson 2003).

When a wild caught female southern hairy-nosed wombat arrived at Currumbin Wildlife Sanctuary, she constructed a burrow and then proceeded to block the entrance with an earth plug. This was observed to be a stress related behaviour .

9.7 Behavioural enrichment

Although wombats do not seem to require an intensive behavioural enrichment program, several activities can be provided for them as they tend to display inquisitive personalities when presented with unusual items (Photograph 6 and 7).

Photograph 6: Cardboard box food dispenser

Photograph 7: Scratching brush

Table 2 below is a list of behavioural enrichment devices utilized at Currumbin Wildlife Sanctuary; and are scaled from 1 to 5.

1. ignored item
2. approached item and interest lasted less than10 seconds.
3. interacted with item for greater than 60 seconds
4. interacted with item for up to 5 minutes
5. interacted with item for over 5 minutes

Enrichment device	Scale 1-5
Cardboard box food dispenser	5
Grass tussocks	5
Soil substrate that allows for digging	5
Wheel barrow	5
Scatter feed	5
Scatter seed and leave to sprout in enclosure after rain=green pick	5
Scratching brush on tree	4
Garbage bin to climb in and on	4
Placing logs or large rocks in the path or entrance to sleeping dens	3
Tractor tire; wombats like to hide in the tire rim.	3
Mulch piles	2
Large logs to climb in or on	2
Browse	1

Table 2: Environmental Enrichment Devices at Currumbin Wildlife Sanctuary

Staff at Taronga Zoo have designed a maze for the wombats which can be used for either enrichment or breeding. The box is made from ply, has a hinged roof for each section and is placed directly on the ground to encourage digging (Figure 1 & Photograph 8). Dimensions are 2.4 m long x 1.2 m wide.

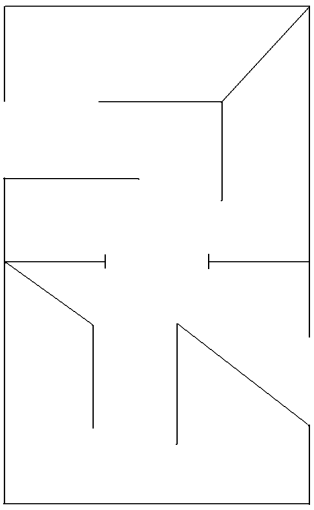


Figure 1 and Photograph 8: Wombat Enrichment/Breeding Maze

9.8 Introductions and removals

Generally when a female and a male are to be kept as a pair, the male should be released first to the enclosure so that he can establish territory before the female is introduced. If a male is placed into an enclosure with an established female, the female may be dominant over the male and they may not breed. One animal from the established pair can usually be removed and then returned with few social problems (Jackson 2003).

With the common wombat much patience and time is required to introduce two sexually mature wombats, and should be preceded by a familiarization period, where the female is given the opportunity to select her preferred male. For example: a female situated between two males, in adjoining yards on either side, will usually favour one of the males. Vocalisations by males and females, dust bathing, digging faecal deposits and urination along side the boundary fences are all indicators of preference. Faecal pellets from each animal are also placed in each others enclosures before allowing any physical contact. Wombats are then introduced for short supervised intervals over a period of time. Levels of aggression between the paired wombats and any signs of oestrus behaviour, such as increased vocalizing by both animals and flehman by the male are to be closely monitored. At Westerns Plains Zoo, depending on compatibility males are left with females for a period of four to six months, from September to February (MacCallum 2003).

9.9 Intraspecific compatibility

Most common wombats are held as solitary animals or as pairs if compatible, which can be a male and female, two females or two juvenile males (less than 18 months of age). Southern hairy-nosed wombats can be held as solitary animals but preferably should be held as pairs or in small groups.

Little is known on the captive requirements of the northern hairy-nosed wombat. The Dennis family attempted to house their pair together on many occasions, all attempts resulted in the animals constantly fighting with each other resulting in separation (Dennis 2004). The animal that was sent to Western Plains Zoo was kept as solitary animal due to its circumstances.

Burrow sharing however, has been reported to occur with the northern hairy-nosed wombat (Johnson 1991; McGill 2003). Simultaneous sharing of burrows was rare and only occurred in burrows with multiple entrances. Given the architectural complexity of a burrow, this observation indicates that wombats who shared burrows may have settled in different sections of the burrow (Johnson 1991).

9.10 Interspecific compatibility

Because of their aggressive nature, wombats are not recommended to be housed with other species.

9.11 Suitability to captivity

Juvenile wild caught common wombats adjust to captivity better than adult common wombats. Most eat fresh grass within 2 to 5 days and commercial food after 7 to14 days (Presidente 1982).

The southern hairy - nosed wombat, on the other hand when wild caught as adults have been known to not eat for up to 4 weeks when brought into captivity. However, they can generally be encouraged to eat after 2 to 3 weeks if provided with fresh grass and left undisturbed (Gaughwin 1982). (See Appendix 2 wombat translocations).

A similar problem occurred when an adult male northern hairy-nosed wombat was brought into captivity at Western Plains Zoo. This animal refused to eat for 6 weeks and had to be force fed. He lost one-third of his body weight and died after seven months from an intersusseption of the bowel, which is thought to be associated with stress and dietary changes (Bryant 1996).

10. BREEDING

With the growing body of knowledge on marsupial reproduction it is clear that marsupials have physiological complexities that control reproduction. Seasonal factors, such as photoperiod, weather patterns that, in turn, affect pasture growth can influence the annual cycle of reproduction in marsupials (Renfree 1988; Taggart *et al.* 2004).

Therefore in a species such as the southern hairy-nosed wombat where females breed seasonally but in response to variable environmental conditions, such as rainfall, the exact timing of reproduction may vary from year to year (Taggart *et al.* 2004).

10.1 Mating system

It has been proposed that in the three species of wombat, that males are polygnous, whereas females may be monogamous (Taggart *et al.* 1998). In addition, histological analysis has shown that the female common wombat is monovular with ovulations alternating between ovaries (Paris *et al.* 2002).

Western Plains Zoos breeding pairs of common wombats were introduced in early spring and separated at the end of summer, which resulted in reproductive success with a pair of twins being born to one female and a male joey to a second female. It has been suggested that inter-oestrus separation of animals may be necessary for the normal enactment of reproductive behavioural cues. Pairs housed together permanently at Western Plains Zoo were found to become complacent; although compatible, no breeding activity was observed. Data gathered from this research indicates that female common wombats are actually fertile all year round (MacCallum 2003).

The present data indicates that the reproduction season for the southern hairy - nosed wombat is restricted to winter and spring. It appears that breeding by most of the adult

wombats only occurs in years in which rainfall is plentiful and, by implication pasture growth is abundant (Gaughwin *et al.* 1998).

Courtship and breeding behaviour in the northern hairy-nosed wombat as observed by Stenke (2000) was noted to occur in the months of October through December and April through August. These patterns indicate that the northern hairy-nosed wombat may be poly-oestrus. The greater part of the birth period coincides with the wet season (November-March) (Woolnough 2000).

Captivity does not appear to suppress progesterone secretion and excretion during the oestrus cycle whether the animal is held in a solitary situation or with another animal. It is suggested that failure to mate might instead be due to a lack of behavioural stimulation (MacCallum 2003).

10.2 Ease of breeding

Common and southern hairy-nosed wombats have not bred regularly in captivity. One reason for this may be to the ease of acquiring young from the wild. Orphans of both species are routinely brought into captivity for handraising; which may have lead to complacency in the establishment of captive breeding programs. Zoos in Australia and overseas have bred wombats with some success. During 2002 Perth, Rockhampton and Melbourne Zoo produced southern hairy - nosed wombat young.

Southern hairy-nosed wombats do not show mating behaviour within the first three years or until they reach sexual maturity (Gaughwin 1982). Even after a successful mating female southern hairy-nosed wombats may not produce young (Crowcroft and Soderlund 1977).

Western Plains Zoo produced three common wombats in 2003, and has been conducting reproductive research on common wombats over the last five years ((MacCallum 2003). Australia Zoo had success in breeding common wombats during 2003.

The opportunity for a captive breeding program for the critically endangered northern hairy-nosed wombat has to date not been available.

10.3 Fertility assessment

10.3.1 Females

In order to asses the fertility of the female common wombats at Western Plains Zoo the oestrous cycle of the wombats were monitored by changes in urogenital cytology,

plasma (blood) progesterone concentrations, and faecal progesterone metabolic measurements. Wombats were manually caught three times per week, weighed and placed under gaseous sevoflurane anaesthesia via a modified mask and maintained by mask on sevoflurane, in oxygen. After the completion of the health check, blood was taken for a full blood count biochemistry, serum and plasma; animals were weighed, pouch checked, a urogenital swab taken for cytology, and faecal samples collected. The entire procedure took 8 minutes and the wombat recovered within 20 minutes (MacCallum 2003).

No hormone assays have been carried out on northern hairy-nosed wombats to date.

10.3.2 Males

To determine the reproductive status of male common wombat's at Western Plains Zoo both testicular measurements were recorded and semen was collected by electro ejaculation (EJ), on a monthly basis for a period of 12 months. The semen was then evaluated for sperm concentration, percentage of live and motile and the rate of sperm movement. Wombats were caught manually, restrained and initially sedated with 180 to 200 mg (depending on animal's weight) of Zoletil IM by injection. Wombats were then weighed and placed under gaseous isoflurane anaesthesia. Wombats were intubated using a 7.5 gauge endotracheal tube and maintained by mask on isoflurane in oxygen. The entire procedure took 30 minutes and the animal recovered within 2 hours. (MacCallum 2003).

Electroejaculations carried out on male southern hairy-nosed wombats showed that collection carried out from September to March, encompassing the breeding season 94% contained sperm. During March and May the penis was very difficult to evert from its pre-pubertal sac in almost every male examined and 92% of ejaculates did not contain sperm (Taggart *et al.* 1998).

Recent research has found that males with a peri-cloacal measurement (accessory gland measurement) of greater than or equal to 5.2 cm were generally considered reproductively active and those with a measurement of less than or equal to 4.0 cm were considered to be inactive. Semen analysis data support this conclusion with ejaculates of small volumes (<1 ml) collected from males with small peri-cloacal gland widths. Therefore accessory gland size can be used as an indicator that hormone levels may be high enough for successful breeding to occur (Taggart *et al.* 2004).

10.4 Breeding management

There does not appear to be a problem with sperm production in captive males as male southern hairy-nosed and common wombats are known to produce spermatozoa during the breeding season. If there are reproductive problems with the females then it is either one of a behavioural nature, associated with the manner in which the animals are housed in captivity, or else, that captivity is affecting reproduction through some other mechanism in females. If the problem is one of a behavioural nature this may be overcome using semen collection, cryopreservation and AI techniques. If it involves the

female reproductive cycle then methods will need to be developed to artificially induce oestrous and ovulation (Taggart *et al.* 1998).

Staff at Perth and Melbourne zoo use nest boxes with small entrances which the female can retreat too and block the opening to inhibit entrance by the male. When she is receptive she can then allow the male into the nest box (Photograph 9 and figure 2).

One problem observed with captive breeding of southern hairy-nosed wombats is the failure of the male to copulate with the female. The concentrations of androgens in the plasma of breeding wild southern hairy-nosed wombats (3 to15 ng/mL) were higher than those of some captive animals (0.5 to 4.0 ng/mL). Androgen or gonadtrophin therapy may possibly stimulate sexual behaviour in apparently inhibited male southern hairy-nosed wombats (Gaughwin *et al.* 1998).

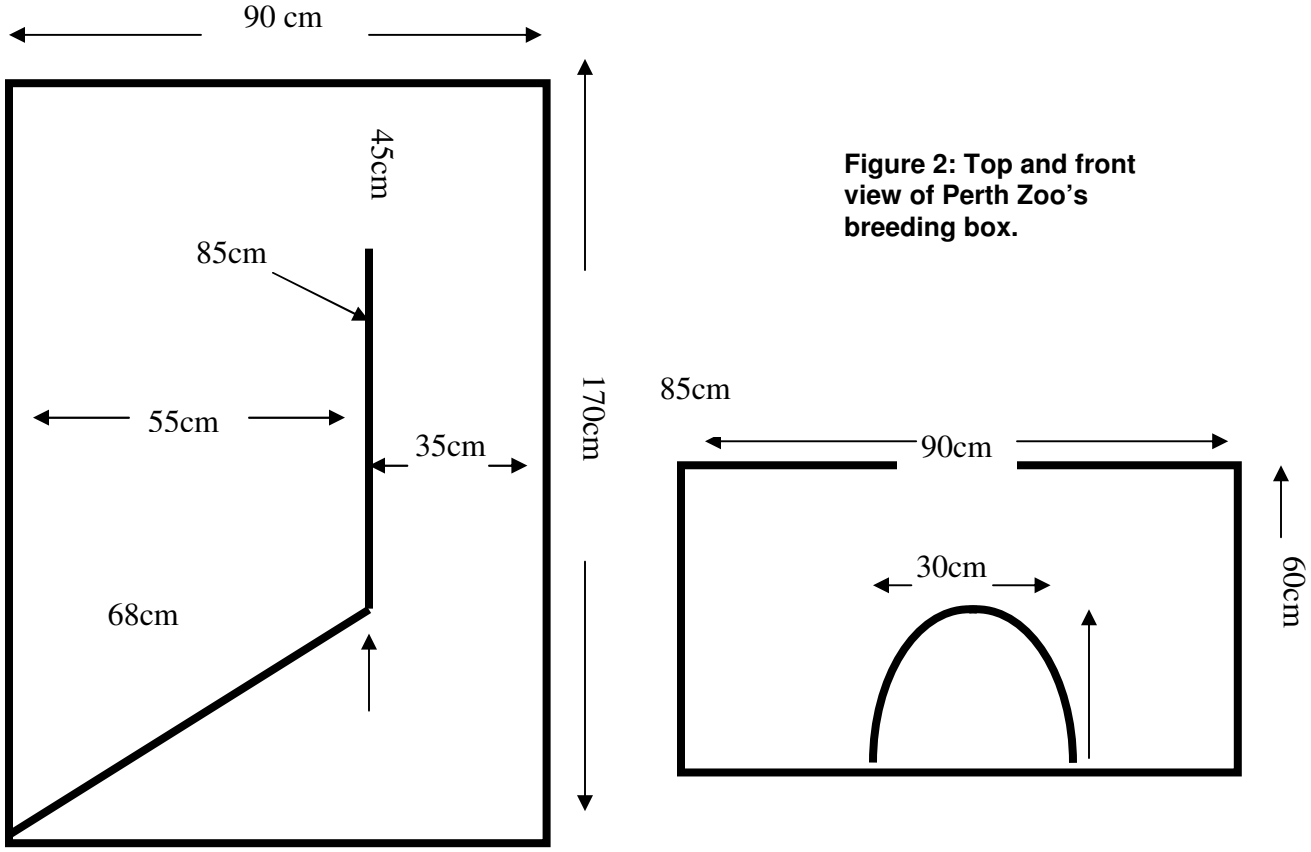


Figure 2: Top and front view of Perth Zoo's breeding box.

Photograph 9: Southern Hairy-nosed wombat breeding box (Perth Zoo)

10.4.1 Common wombats

At Western Plains Zoo, male and female common wombats were housed separately and paired in July or August in both 2000 and 2001. Pairs were chosen on compatibility, behavioural observations, and on other studies where optimal breeding time was reported to be between the months of September to March (breeding season) which resulted in pouch young (MacCallum 2003).

10.4.2 Southern Hairy-nosed wombats

There is no established or tested optimal ratio for the housing of southern hairy-nosed wombats for reproduction. The housing ratios for southern hairy-nosed wombats employed by individual institutions outside of breeding season is given below in Table 3.

Institutions	Exhibit #1	Exhibit #2	Exhibit #3	Exhibit #4
Perth Zoo	1:0	0:1		
Taronga Zoo	1:0	0:4	0:1	
Currumbin Sanctuary	1:3	1:0		
Melbourne Zoo	1:0	2:1	2:0	1:2
Rockhampton Zoo	2:5	0:3	1:2	1:2
Adelaide	1:1			

Table 3: Housing sex ratio of southern hairy-nosed wombats at zoos.

At Melbourne Zoo prior to the breeding season, all wombats are separated (in March), so that bonds were broken and new territories established, with the females occupying two enclosures and the males housed separately with no visual contact. Males were then re-introduced to the females one to two months later for breeding, with the ideal time for introductions in late July/August. If no mating behaviours were noted in this time, the males were then rotated through the enclosures.

Once the animals have been introduced there should be minimal disturbance to the wombats, therefore all conditioning training was ceased and cleaning was also kept to a minimum.

Melbourne Zoos recent success with breeding occurred in an on display enclosure with off limits area attached. The female with pouch young was then separated from the group due to aggression from other wombats.

Perth Zoo permanently house their pair of wombats separately and introduce them prior to the breeding season, with breeding occurring in an on display enclosure.

Perth and Melbourne Zoos are also the only ARAZPA institutions to have second generation captive bred stock.

Below is a check list of recommendations for the successful captive breeding of southern hairy-nosed wombats. Not all of the steps in the list are being used by all institutions at one time. However, each institution that has been successful has included most of these recommendations into their captive breeding management plan.

- House males and females separately, but allow visual contact.
- Rotate wombats in July to break old territories and to stimulate breeding activity.
- Introduce fresh green grass daily at this time.
- Pair animals from August.
- Provide tunnels and access to digging.
- Each wombat should have a separate box/burrow.
- Have more than one male in the collection so they can stimulate each other via competition.
- Female is checked for seminal plug if mating is suspected.
- Remove male from females exhibit no later than 20 days after first seminal plug is observed

10.5 Courtship/mating behaviour

An ethogram for the common wombat by Böer (1998) lists 44 patterns of social and territorial behaviour of which 13 (29.5%) are clearly sexual in behaviour. During the time of this research the two animals that Böer studied occupied 21% of their total social activity devoted to reproductive behaviour which can readily be divided into five phases. (Figure 3).

1. Attraction phase: The female followed the male, often matching her speed to his, and made nose-to nose contact with him when they passed one another. The female frequently stopped in front of the male with her body axis set at right angles to the male and turned her eye, ears and nose towards the males face. In addition she presented her urogenital region be maximally stretching her hindlimbs. The male performed frequent digging displays in front of the female. This phase usually lasted 3-4 minutes, and never extended beyond 10 minutes.

2. Interim phase: During this phase one partner uttered arousal grunts which were answered by the other wombat. The grunts of the second animal were then answered by the first and the new grunts of the first wombat were answered in turn by the second and so on. It was evident that the pair of wombats had synchronized their sexual moods. This phase lasted from 2-3 minutes.
3. Chasing phase: The male chased after the females which bounded away from him. While running behind he often tried to bite her on the back. The chasing phase sometimes continued for 30 minutes.
4. Copulation phase: The male approached the female from behind and attempted to grasp the female around the hips with his forelimbs. When he secured a grip on the female he would roll on to one side and endeavor to pull her hindquarters in the same direction. Attempts by the female to drag herself away using her fore limbs were thwarted by the male who maintained his grip around her pelvic region. In the latter part of the copulation phase both animals lay quietly in the copulatory position for about 30 minutes. Presumably ejaculation occurred at this time.
5. Postcopulatory phase: Following copulation the wombats separated and slept. About 30 minute's post-coitum the female deposited 1 -2 ml of ejaculate. Despite daily examination of the enclosure, copulation plugs, were not detected.

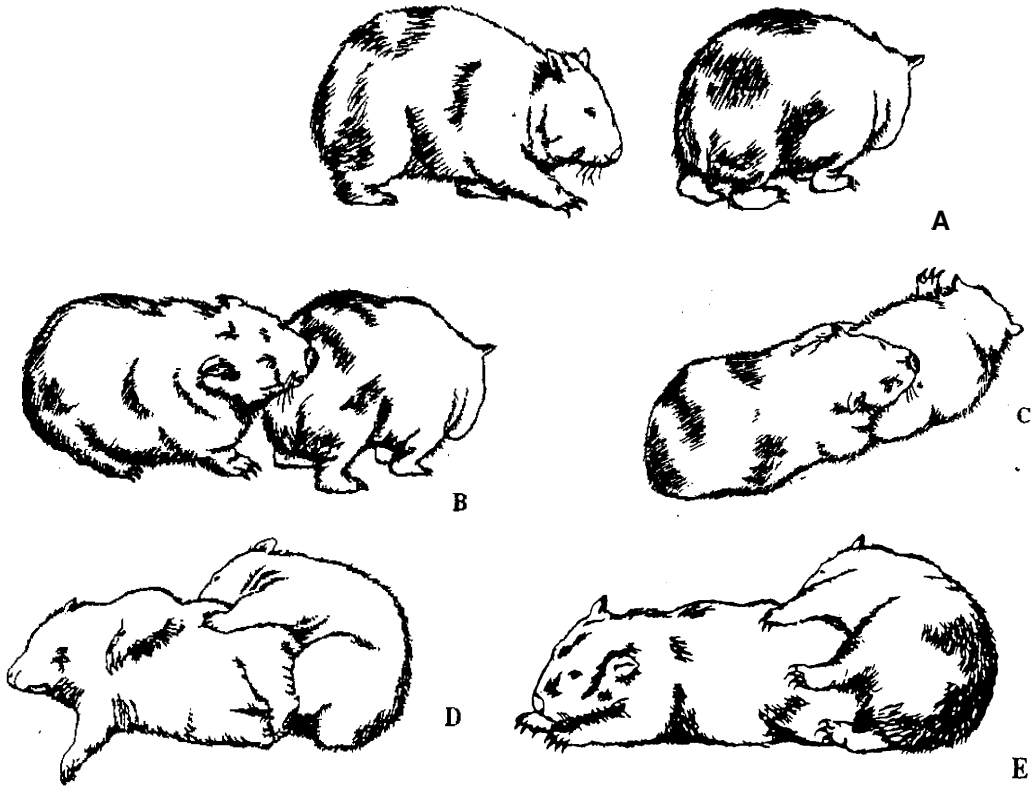


Figure 3: Courtship and Mating behaviour in Common Wombats (Marks 1998)

Böer (1998, p. 133), described an account given by a keeper at Hanover Zoo. "A female wombat was observed squatting on her hindquarters with her body partly borne by her forelimbs (Figure 4.) During periods of tremor of her entire body, lasting between

5 and 10 seconds, the female extend and flexed hindlimbs. In between these phases the female once rolled on to her side and grasped with one forelimb the area between her urogenital and pouch opening. The female common wombat was positioned with her body bent in such a way that the neonate had to ascend an inclination of 45%."

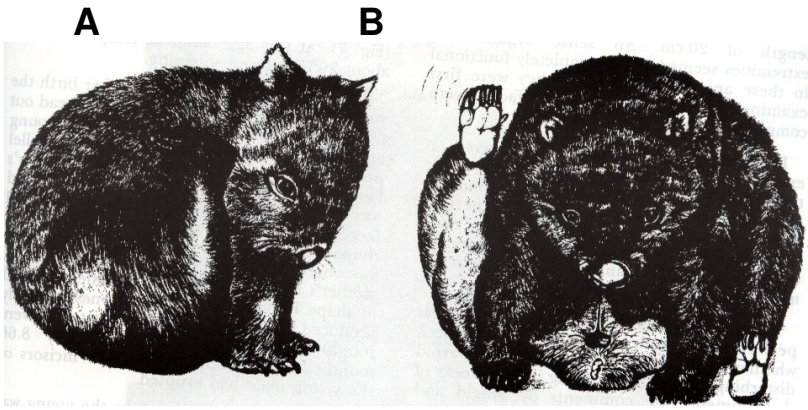


Figure 4: A: Lateral View B: Antero-ventral view (Böer 1998)

At Currumbin Wildlife Sanctuary copulation had been observed at the entrance to a hollow log, however, no young were produced. Crowcroft and Sunderland (1977), also noted that southern hairy-nosed wombats have failed to give birth after successful intromission.

10.6 Reproductive condition

Wombats are generally placed in several categories depending on their reproductive status. For females these include (Jackson 2003):

1. Juvenile non-breeding (non-parous) – pouch clean and dry teats very small.
2. Adult non-breeding (parous) – pouch dry and dirty (Photograph 10)
3. Pregnant – pouch pink in colour and glandular in appearance.
4. Pouch young present- pouch deep, very moist and young attached to teat. (Photograph11)
5. Lactating (young absent from pouch but still suckling) – pouch area large, teats enlarged.
6. Post lactation – teats are still enlarged, expressing only clear liquid and regressing in size.

Photograph 10: Adult non breeding pouch

Photograph 11: Re-productive pouch with young present (K. Payne).

10.7 Pouch checks and birth of pouch young

At Western Plains Zoo, after mating was observed, a month of two later the females pouches were checked for the presence of a joey. On confirmation of pouch young males were separated immediately from females (MacCallum 2003).

Below are the developmental stages of pouch young that need to be recorded:

- Sex distinguishable
- Tips of ears free
- Papillae of facial vibrissae evident
- Eyelashes visible
- Eyes open
- Fur visible
- Eyes open
- Fur visible – slight tinge, medium or well developed
- Tips of first incisors through the gums
- At foot
- Eating solids
- Self feeding
- Independent

Measurements of the pouch young that need to be recorded are (Jackson 2003):

- Crown rump length (mm) – primarily for very small neonates when other measurements are difficult to record
- Weight (g) – if detached from the teat (do not detatch)
- Head length (mm) from the occiput to snout tip
- Head width (mm) maximum width across the zygomatic arches
- Snout next to length (mm)
- Tail length (mm) – from the cloaca to the end of the last vertebrate of the tail tip
- Length of right tibia (mm) – from the stifle to the heel
- Pes length (mm) – from the heel to the base of the longest toe, not including the claw

10.8 Techniques to control breeding

As wombats do not bred well in captivity, the potential of breeding in excess to requirements has not yet become an issue. Separation of the animals would be all that is required if breeding was not desired.

10.9 Occurrence of hybrids

None are known to occur.

10.10 Timing of breeding

Breeding in the common wombat appears to be influenced by both latitude and elevation such that the maximum growth rate of young corresponds with the maximum potential growth period of temperate grasses. The timing of breeding in common wombats is different in different locations in Australia with breeding occurring in December to March in the highlands of New South Wales and eastern Victoria, and from March to July in northern Victoria (Strahan 2000).

Wild southern hairy - nosed wombats have a defined breeding season, with most births from late July to September and some in October and November, which correlates with the growth and germination of native pastures. Weaning occurs in spring or early summer, or almost six months out of phase with common wombats as these growth periods are associated with the winter rainfall patterns of the arid and semi-arid zones of South Australia. When there is little rain, body weight and reproduction activity is decreased in both males and females (Gaughwin *et al.* 1998). In captivity births have been recorded in all months of the year with 18% of births occurring in July and April followed by 14% in February and 11% in June (Treby 2003).

The breeding cycle of most female northern hairy-nosed wombats begins prior to the summer rains (Stenke 2000; Woolnough and Foley 2002).

10.11 Age at first and last breeding

Common and southern hairy-nosed wombats do not begin to demonstrate reproductive behaviour until at least three years of age (Gaughwin 1982; Triggs 1996).

Data recorded in the southern hairy-nosed wombat stud book show that the youngest female to have produced pouch young was 3.5 years and the oldest female to have bred was almost 18 years of age. The average age of females at first reproduction was 7.5 years, with the average age of females to reproduce being 10 years. The youngest male recorded to have successfully inseminated a female that subsequently produced pouch young was 4 years, with the oldest being 18 years of age. The average age of males at first reproduction was 6.11 years, with the average age of males to successfully inseminate females was 9.9 years (Treby 2003).

10.12 Ability to breed every year

Common wombats appear to breed annually, however the two species of hairy-nosed wombats appear to coincide breeding with rainfall so that in years of low rainfall, they often do not breed. The shortest interbirth interval recorded for the southern hairy - nosed wombat in captivity was 36 days, which shows that once a female looses her pouch young she can return to oestrous and breed again. However, the shortest interval between births of young which gained independence was 219 days (Treby 2003).

10.13 Ability to breed more than once per year

Wombats can breed more than once per year. However, this is unlikely to occur in the wild due to the length of time required to raise their young.

10.14 Nesting requirements

Female wombats should be provided with a well built nest box, a large hollow log, an artificial burrow or ideally an area of earth in which they can dig their own burrow. Nesting material such as straw, hay or soil should be provided in artificial burrows and nest boxes.

10.15 Breeding diet

Births in hairy-nosed wombats appear to be correlated with rains and associated grass growth after rain when forage is maximal, so the provision of large amounts of fresh grass at the beginning of the breeding season is recommended for these species. Staff at Melbourne Zoo put their wombats on a dry diet and then just prior to introductions other food sources will be offered ie. grass, browse and root vegetables. Melbourne and Perth Zoos also increased the amount of pellets and root vegetables fed to their lactating female.

Western Plains Zoos diet for female common wombats carrying pouch young has been modified to provide them with as much nutrition to assist them while feeding young. They are fed the same quantities as under normal circumstances but instead of once are fed twice a day; morning and afternoon, clumps of grass, kangaroo pellets, corn and sweet potato (MacCallum 2003).

10.16 Oestrous cycle and gestation period

Common wombats are monovular and polyoestrous and have an oestrous cycle of approximately 47.2 days (Finlayson 2004), with oestrous lasting 24 to 81 hours (Boer 1998), and a gestation period lasting 21 days (Wells 1989). The southern hairy - nosed wombat is also monovular and polyoestrous and has an oestrous cycle of 35 days and

a gestation period of 20 to 22 days (Moritz *et al.* 1998). Oestrous cycles and gestation periods for the northern hairy-nosed wombat are not known.

10.17 Artificial breeding techniques

Assisted reproductive technology is well established in wildlife conservation programs in eutherian mammals. The development and application of this technology in marsupials, however, is a relatively new field and until recently had not been applied in a direct effort to help conserve any threatened marsupial species (Taggart *et al.* 2002).

- **Artificial Insemination (AI) –** can increase breeding the potential of genetically superior animals, expand gene pools without risk and expense of maintaining/transporting sires, is more efficient, disease free, allows movement and distribution of genetic material, and the utilization of males unable to breed naturally due to physical or behavioural problems.

- **Embryo Transfer** – is an efficient method of introducing superior genetics into populations that are suffering from a loss of genetic diversity.

- **Embryo splitting** – is the ability to predict the embryo's sex which is an important demographic management tool. For example, a reduction in the number of males allows more space for females in a captive breeding program

- **IVF –** this approach has many advantages including:
  - making use of animals with certain types of infertility;
  - reduction in the numbers of viable sperm needed as compared with AI or natural breeding;
  - the potential for salvaging genetic material from animals after death for oocytes maturation and IVF; and
  - increased use of potential males being crossed to one female.

- **Semen collection, cryopreservation & storage**

- **Hormone analysis**

- **Genome Resource Banks** – Allow interactive movement of biological material between living animal populations, thereby maximizing genetic vigor/heterozygosity. Genome resource banks offer opportunities for improving the efficiency of captive breeding programs, especially when linked to techniques such as AI, IVF and ET. Genetic resource banks provide a high level of insurance against the loss of diversity of an entire species.

(Johnston 1997).

10.18 Litter size

Usually only one young is produced, however Western Plains Zoo recently produced twin common wombats.

10.19 Weaning

The young begin leaving the pouch and eating solid foods at about nine months of age and more than double their weight in the next three to eight months under favourable environmental conditions. They reach adult body weight at two years of age at which time they generally disperse (Wells 1971). The time in the pouch varies with species and ranges from 10 to 11 months in the northern hairy-nosed wombat (Strahan 2000) and 9 to10 months in the southern hairy-nosed and common wombats (Jackson 2003).

Weaning occurs at approximately 12 to 16 months for common and southern hairy - nosed wombats (Gaughwin 1982; Triggs 1996; Boer 1998). At Western Plains Zoo hair loss was observed on the rumps of the joeys due to biting by the female. This was though to be an indication of the female weaning her young. Joeys were 18 months and 16 months at the time. Weaning occurred over approximately 3 weeks. Young were separated from their mothers during the day, then overnight, before being permanently separated.

The wombats were weighted prior to separation from their mothers, and weighed every two days after that, where possible. They were provided with water, vegetables, pellets and grasses ad lib. Changes in faecal pellet size, consistency and colour were observed closely throughout the weaning period. Initially the wombats weighed approximately 10 kg. During weaning weight losses between 25 and 420 g were observed (MacCallum 2003).

10.20 Age at removal from parents

Removal of the young is dependant on when the female returns to oestrous. In general females become increasingly aggressive towards their young. Therefore they should be removed from their mothers several months before, when approximately 20-28 months old. Chasing of young by females and severe biting are often observed at this stage (Boer 1998).

11. ARTIFICIAL REARING:

11.1 Housing

When bringing native animals into care, reducing stress is the first priority. The choice of suitable housing can help create a stress-free environment. To achieve this, several factors should be considered including: (Jackson 2003).

- Securing the area from children and other animals;
- Maintaining the area in a hygienic manner;
- Making the area secure;

- Clearing the area of obstacles and hazards; and
- Ensuring the area offers shelter from the weather and noise

Southern hairy-nosed and common wombats are frequently hand-reared. Unfurred or finely furred young that weigh less than two kilograms should be placed in a soft cotton pouch. The pouch plus joey is placed inside a bag made from sheep skin with the fleece attached, or some other thick woolen surround. A locked cat carry cage or laundry basket lined with clothing, blankets and an inner cotton-lined bag can be used (Figure 5). Do not use synthetic fiber as these are either too hot or too cold and rub on the joey's skin, producing pressure areas. Never house young wombats so that they have direct contact with fur or fleece or artificial fibers , as the joeys suck these fibers and they form large balls (like fur balls) which may block the gut (George *et al.* 1995). Joeys should never share a pouch with others. Enforced sharing may cause significant stress (McCracken 1990).

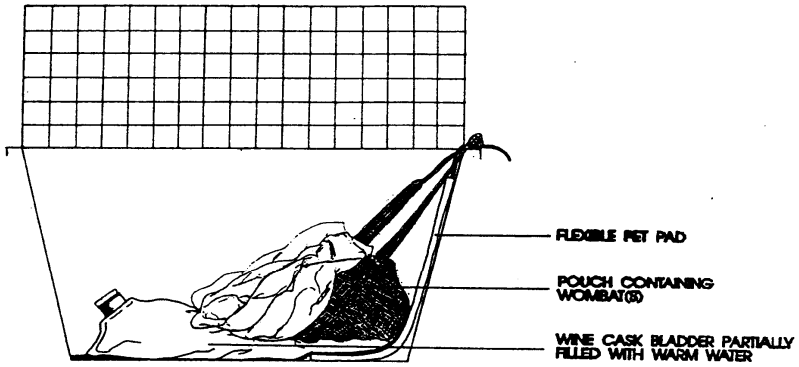


Figure 5: housing for orphaned joeys

11.2 Temperature requirements

Unfurred wombats require extra warmth. A constant temperature in the pouch is important and should be monitored carefully. A thermometer (Figure 5) with a probe is recommended for monitoring pouch temperatures. The temperature should be taken inside the pouch and it is the temperature of the air surrounding the joey not the joey's temperature that is required (George *et al.* 1995).

- **Unfurred** wombats less than 600 gm 28-30˚C no higher. If the wombat's feet are bright pink it is probably too hot.
- **Furred** wombats greater than 600 gm 28˚C no higher

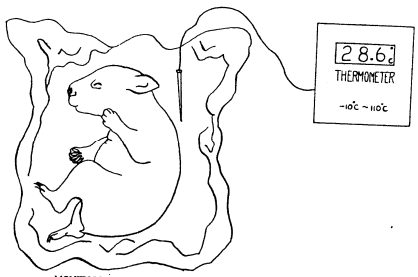


Figure 6: Temperature probe (George *et al.* 1995)

An electric blanket, hot water bed, wheat bag or hot water bottle (that is reheated every four hours) can be used for heating. Hot water bottles should be well wrapped up inside towels or other fabric and not be placed too close to the wombat so that over heating or dehydration occurs (MacCallum 2003).

11.3 Diet and feeding routine

11.3.1 Natural Milk

Common wombat milk increases in total solids during lactation from 22% in early lactation to 51% in late lactation, while lipids increase from 6 to 28% and proteins from 4% to 9%. In contrast, the concentration of carbohydrates decreases from 12% in early lactation to only 4% in late lactation (Table 4) (Jackson 2003).

Table 4. Concentrations of major constituents of common wombat milk.

Total Solids (%)	**Carbohydrates** (%)	**Lipids** (%)	**Protein** (%)	**Calcium** (mg/l)	**Iron** (mg/l)
22.0-51.0	4.0-12.0	6.0-28.0	4.0-9.0	4200	22

11.3.2 .Milk Formulas

The three main low-lactose formulas used for hand-rearing wombats are:

1. Wombaroo Wombat Milk Replacer (see Appendix 6). The three formulas range from <4 for joeys with less than 40% of their pouch life completer; a 0.4 formula for joeys with 40% of their pouch life completed that have fine fur, eyes open and erect ears; and a >0.6 formula for joeys with greater than 60% of their pouch life completed, that have short dense fur and spend a lot of time out of the pouch. Wombaroo wombat formula gives the best growth rate and hair quality than other milk formulas (Booth 1999).

2. Di-Vetelact: Is a widely used, low lactose milk formula. Due to its low energy concentration when prepared as directed, some groups advise the addition of mono and polyunsaturated fats such as canola oil with Wombaroo diets. Adding saturated fats in the form of cream is not recommended as it is too highly saturated and can lead to the malabsorption of calcium. Di-Vetelact should be fed at approximately 20% body weight (Jackson 2003).

3. Biolac: has three formulations – M100 with 2-5ml of canola oil per 100ml for furless joeys; M150, a transitional milk to use when dense fur has developed;

and M200, which is used when the animal produces solid dark pellet droppings, as it contains elevated lipid in the form of canola oil. When the joey is nearing weaning, 2-5 ml of canola oil is added per 100ml of formula. Mixing the formulas is the way to make the transition from one formula to another. The young animal should be fed 10-15% of its body weight per day (Jackson 2003).

Wombats need to establish normal gut flora to break sown the vegetable matter in the diet. This can be achieved by several methods including offering dry dirt (pica), which they may eat. It can also be assisted by adding half a teaspoon of natural yoghurt to the formula daily. An alternative method to inoculate with bacteria is by choosing several fresh droppings from a healthy adult wombat, preferably of the same species, grinding them up, adding warm water, straining and adding 5 ml or one teaspoon to the joeys bottle containing milk and mixing it up or giving it directly into the mouth by squirting it in (Austin 1979).

When six months of age, Farex or Heinz Rice Cereal can be added to the Di-Vetelact formula by adding half to one teaspoon to every 200 ml and letting is stand for a few minutes before feeding (Austin 1979).

11.3.3 Feeding apparatus

Very small joeys can be fed using a syringe fitted with a short length (1cm) of infant gastric feeding tube as a teat or plastic intravenous catheter. Most wombat joeys will be large enough to be fed with a plastic feeder bottle (50 or 100 ml) and a wombat teat (Figure 7).

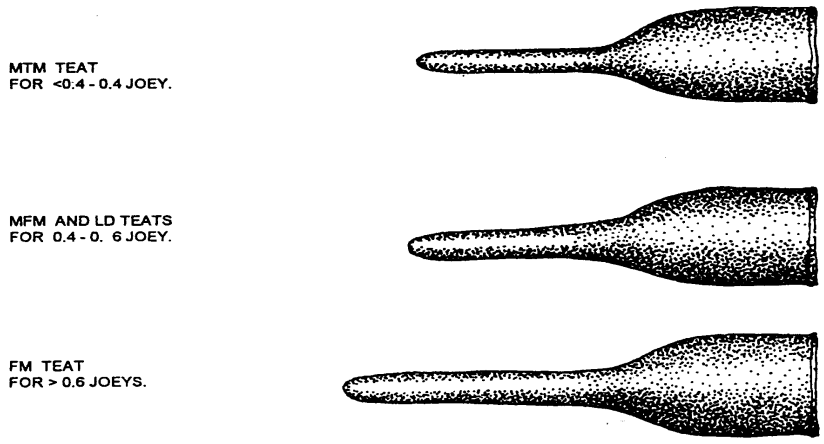


Figure 7: Wombat teats (George *et al.* 1995)

11.3.4 Feeding routine

When first brought in for hand rearing, the joey will be stressed and dehydrated, administer orally 100 ml plain boiled water with 5g (1 teaspoon) of glucose or 1g of electrolyte replacer such as Vytrate (McCracken 1990; George *et al.* 1995; MacCallum 2003). The joey should be wrapped up in a towel and a hand placed over its eyes for at least the first few feeds to prevent it being distracted or stressed by its surroundings (Figure 8) (Austin 1979).

The temperature of the milk should be approximately 36˚C. Young wombats should be fed approximately 15% to 20% of their body weight daily, depending on the formula given. The demand for milk will decrease with the introduction of solid food (Booth 1999). When feeding it is important not to feed the milk formula too quickly, as it can accumulate in the pharynx and be passed into the lungs where it can result in pneumonia and death (Presidente 1982).

It is important to feed a joey in an upright position or lying on its side. Never feed a young wombat lying on its back as milk may be inhaled. Joeys from 600gm onwards tend to lie on their sides to feed (George *et al.* 1995).

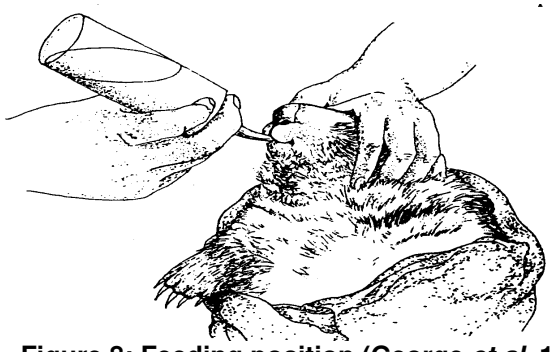


Figure 8: Feeding position (George *et al.* 1995)

The number of daily feeds decreases as the joey develops. Unfurred joeys should be fed every 2-3 hours night and day. When furred the number of feeds can be reduced to five and the volume increased per feed. Once the joey is fully emerged the number of feeds is reduced to two or three per day and they should be given access to grass and introduced to a pelleted feed (Presidente 1982).

Joeys should be offered 100 to 200 ml of fresh water daily in a large solid bowl as they can easily dehydrate during warm weather. Water is especially important once the joey begins to leave the pouch and eat solids (George *et al.* 1995).

11.4 Specific requirements

In the mother's pouch humidity is high and the unfurred joey is naturally lubricated so that it does not dehydrate. In an artificial pouch, it is not feasible to keep the humidity high, nor is it desirable, as bacterial infections increase with humidity. The joey will need to be lubricated several times a day with Sorbelene cream (not with added glycerine) so that its skin does not become dry and cracked. Baby oil is not suitable as

it is not absorbed, tending to stay on the skin surface where it rubs off. Sometimes, unfurred joeys develop flaky skin, but this usually disappears as the fur comes through (George *et al.* 1995).

11.5 Data recording

When an animal is initially presented for hand-rearing, details such as its sex and approximate age, using growth charts, should be noted. During hand rearing the information listed below should be recorded on a daily basis. This information provides background data, such as food consumption which will assist when making comparisons with growth curves, to assess progress and to seek veterinary attention if required (Jackson 2003).

The following information should be recorded on a daily basis:

- Date;
- Time when the information is recorded;
- Body weight to the nearest 1g if possible;
- General activity and demeanor;
- Characteristics and frequency of defecation and urination;
- Amount in grams of different food types offered;
- Food consumption at each feed; and
- Veterinary examinations and outcomes.

(Jackson 2003)

The developmental stages and measurements outlined in Appendix 4 should also be recorded on a weekly basis where possible

11.6 Identification methods

Generally not required but a Microchip can be implanted beneath the skin in the shoulder region once furred.

11.7 Hygiene

Maintaining a high standard of hygiene is critical to the survival of a wombat joey. Emphasis should be placed on the following:

- Maintain a clean pouch lining at all times. Older joeys can be trained to urinate on newspaper by keeping a piece of newspaper with urine on it.

- Maintain personal hygiene by washing and disinfecting hands before and after handling the joey. Use antibacterial solution for washing hands with furless joeys, as their immune system is not well developed.
- Wash hands between feeding different joeys.
- Use boiled water when making up formulas for very young joeys.
- Clean spilt milk formula, faeces and urine from the joey's skin as soon as possible, and then dry the animal.
- Wash all feeding equipment in warm soapy water and sterilize in a suitable antibacterial solution such as Halasept or Milton, or boil it for ten minutes. Once sterilized, the equipment should be rinsed in cold water.
- When not in use store feeding equipment in the fridge.
- Only heat up milk once and discard leftovers.
- Avoid contact with other animals unless you are sure they pose no health risk.
- Toileting can be done by the application of warm water to the cloaca using cotton wool to stimulate urination and defecation before and after feeding.
- If furless cover the joey's body with Sorbelene cream after each feed until fur appears.
- Once fully emerged from the pouch, they should be allowed to socialize with other joeys to avoid human imprinting and encourage normal social behaviour.

(Jackson 2003)

11.8 Behavioural considerations

Once a wombat reaches approximately 18 months of age, it naturally becomes increasingly independent of its carer and becomes quite aggressive. Aggression is a normal behaviour soon after emergence from the pouch (Jackson 2003).

11.9 Use of foster species

Fostering within wombat species has been conducted successfully, with 100% success rates being observed in southern hairy - nosed wombats, provided the pouch young is transferred to another female with a young of equivalent or greater size. Young as small as 1.5g have been transferred successfully to foster mothers using this process and the growth rates are unaffected (Jackson 2003). There may be advantages in having the ability to cross-foster from the northern hairy-nosed wombat which may reduce reproductive stress on the mother. This could then enable female northern hairy-nosed wombats to breed every year (Backhouse 2001).

No interspecies fostering is known to have been used to date and the poor breeding success of wombats in captivity means that fostering between wombat species is presently unable to be used (Jackson 2003).

11.10 Weaning

The wombat can be introduced to solid foods by providing pelleted food and freshly cut grass with roots and dirt attached. Weaning usually occurs by 14 to 15 months of age and sometimes as early as 12 months (Booth 1999). The number of bottle feeds can be slowly reduced as the wombat develops and its solid food intake increases. As often wombats wean themselves and refuse to drink formula, it is important to make sure that this does not occur at less than 12 months of age (Austin 1979).

11.11 Rehabilitation and release procedures.

If common wombats are to be released, preparation should begin once the wombat begins to leave the pouch. It should gradually be weaned from the carer into an enclosure with adequate soil depth that allows burrowing, and be fed on increasing amounts of grasses. By 18 months of age, the young wombat in the wild is usually driven away by the mother. Ideally the wombat should be soft released where it can come and go from the carer's home to the wild and then disperse permanently when it is ready. Wombats released as pairs appear to do better than those released on their own, though this bond quickly breaks down after release (George *et al.* 1995).

The release of common wombats in NSW and the ACT is governed by The National Parks and Wildlife act of 1974 No: 80. In Part 9 Division 2 Section 127, a license will be issued to liberate animals anywhere or in a specific locality within NSW.

In Tasmania the Wildlife Regulation Act of 1999, Part 2 Division 2, states that the common wombat is an unprotected species and no permits are required to take from the wild and to date no regulation exists for their release.

The Victorian Flora and Fauna Act of 1988: Act No: 47/1988, Part 5, Division 2, Section 48, states that no animal is to be released without the appropriate permit.

The National Parks and Wildlife Act 1972, Department of Environment and Heritage, South Australia, states in section 3.7 of the Standard Operating Procedures; Native Species-Rescue and Release, specific guidelines to cover the release of native wildlife. All animals must be self sustainable and released within 48 hours of rescue, after 48 hours special criteria must be met. If the animal is hand raised or habituated to humans it is not to be released unless it is in accordance with a threatened species recovery program.

Dr. Peter Mawson, senior zoologist for the Department of Conservation and Land Management in Western Australia (*pers. comm*. 01.05.04), stated, "that there is only one small area of the state that contains a wild population of southern hairy-nosed wombats; this area is approximately 120 km west of the South Australian border. Southern hairy-nosed wombats are allowed to be released at this site under regulation 28A in consultation with the Department of Conservation and Land Management."

12. ACKNOWLEDGEMENTS:

Currumbin Wildlife Sanctuary: - Jenny Lunney
Dreamworld: - Dr Vere Nicholson
Dr. Alan Horsup: - Queensland Parks and Wildlife Service
Melbourne Zoo: - Peter Courtney, Deb Dyson
Perth Zoo: - Dr. Helen Robertson, Arthur Ferguson and Karen Payne
Rockhampton Botanical Gardens and Zoo: - Clinton O'Brian
Dr. Glenn Shimmin: - Department of Environment and Heritage
Dr David Taggart: - School of Earth & Environmental Science, Adelaide University
Taronga Zoo: - Erna Walraven, Mikaylie Wilson and Vicki Hudnall
Western Plains Zoo: - Jodie Lardner-Smith

13. REFERENCES

Austin, M.A. 1979, *A practical guide to the successful hand rearing of Tasmanian marsupials*, Regal Publications, Melbourne.

Ayers, D., Nash, S. & Baggett, K. 1996, *Threatened Species of Western New South Wales*, National Parks and Wildlife Service of New South Wales, Sydney.

Backhouse, G. 2001, *Major Project Review of the Northern Hairy-nosed Wombat Recovery Program*, Department of Natural Resources and Environment, Melbourne.

Boer, M. 1998, 'Observations on reproduction in the Common wombat (*Vombatus ursinus)* in captivity', in R. T. Wells & P. A. Pridmore (eds), *Wombats*, Surrey, Beatty & Sons, Sydney. 129-146.

Booth, R. 1999, 'Wombats: care and treatment of sick, injured and orphaned animals', in PGFoV Science (ed.), *Wildlife in Australia: Healthcare and Management*, Post Graduate Foundation of Veterinary Science, University of Sydney, Sydney. 1-11.

Bryant, B. 1996, *Northern Hairy-nosed Wombat Recovery Project. Captive Veterinary Management, June-August, 1996*, Western Plains Zoo, Dubbo.

Crowcroft, P. & Soderlund, R. 1977, 'Breeding of wombat *(Lasiorhinus latifrons)* in captivity', *Zoologische Garten*, vol. 47. 313-322.

Dennis, J. 2004, Captive Northern Hairy-Nosed Wombats at Epping Forest Station, 08/12/04.

Evans, M., Atkinson, S. & Horsup, A. 1998, 'Combination of zolazepam and tiletamine as a sedative and anaesthetic for wombats', *Australian Veterinary Journal*, vol. 76, no. 5. 355-356.

Finlayson, G.R. 2004, *Proposal to study reproductive behaviour and hormone assessments of southern hairy nosed wombats in captivity*, Adelaide University, Adelaide.

Gaughwin, M.D. 1979, 'The occurence of flehmen in a marsupial-the hairy-nosed wombat (*Lasiorhinus latifrons)*', *Animal Behaviour*, vol. 27. 1063-1965.

---- 1982, 'Southern hairy-nosed wombats *Lasiorhinus latifrons:* its maintenance, behaviour and reproduction in captivity', paper presented to Scientific Meting of the Australian Mammal Society, Healesville.

Gaughwin, M.D., Breed, W.G. & Wells, R.T. 1998, 'Seasonal reproduction in a population of southern hairy-nosed wombats *Lasiorhinus latifrons* in the Blanchetown region of South Australia', in R.T. Wells & P. A. Pridmore (eds), *Wombats*, Surrey Beatty & Sons, Chipping Norton, Sydney. 109-112.

Geographic, A. 2004, *Wombat distribution map*, Australian Geographic.

George, H., Parker, G. & Coote, P. 1995, *Common wombats: Rescue, Rehabilitation, and Release.*
Gerhardt, K., Smales, L.R. & McKillup, S.C. 2000, 'Parasites of the Northern Hairy-nosed wombat Lasiorhinus krefftii: Implications for Conservation', *Australian Mammalogy*, vol. 22. 17-22.
Hakof.D 2005, *Developmental Notes for Southern Hairy-Nosed Wombats*, Adelaide Zoo, Adelaide.
Horsup, A. 2001, *Annual Report on the Northern Hairy-nosed Wombat Recovery Program*, Queensland Parks and Wildlife Service, Rockhampton.
---- 2003, *Annual Report on the Northern Hairy-nosed Wombat Recovery Program*, Queensland Parks and Wildlife Service, Rockhampton.
Hume, I.D. 1999, *Marsupial Nutrition*, Cambridge University Press, Cambridge.
IATA. 2002, *Live Animal Regulations. International Air Transport Association*, Montreal.
Jackson, S. 2003, *Australian Mammals Biology and Captive Management*, CSIRO Publishing, Melbourne.
Johnson, C.N. 1991, 'Utilization of habitat by the northern hairy-nosed wombat *Lasiorhinus krefftii*', *Journal of Zoology*, vol. 225. 495-507.
Johnson, C.N. & Crossman, D.G. 1990, 'Sexual dimorphism in the Northern Hairy-nosed Wombat lasiorhinus krefftii (Marsupialia; Vombatidae)', *Australian Mammalogy*, vol. 14. 145-146.
Johnston, S.D. 1997, *Reproduction tools for captive breeding.*, University of Queensland, Brisbane.
MacCallum, C. 2003, *Common Wombat (Vombatus ursinus) Husbandry Manual*, Western Plains Zoo, Dubbo.
Marks, C. 1998, 'Courtship and mating behaviour in a pair of free ranging Common wombats (*Vombatus ursinus)*', in R. T. Wells & P. A. Pridmore (eds), *Wombat*, Surrey, Beatty & Sons, Sydney. 125-128.
McCracken, H. 1990, *Husbandry and Veterinary Care of Orphaned Marsupial Pouch Young.*, Melbourne.
McGill, J.M. 2003, 'Burrow Architecture and its Relationship to Activity Schedules of the Northern Hairy-nosed Wombat (*Lasiorhinus krefftii)*', Honours thesis, James Cook University.
Moritz, K., Green, R.H. & Selwood, L. 1998, 'A historical analysis of the reproductive cycle of the common wombat. *Vombatus ursinus*.' in RT Wells & PA Pridmore (eds), *Wombats*, Surrey Beatty & Sons, Sydney. 75-85.
Paris, M.C.J., White, A., Reiss, A., West, M. & Schwarzenberger, F. 2002, 'Faecal progesterone metabolites and behavioural observations for the non-invasive assessment of oestrous cycles in the common wombat *Vombatus ursinus* and the southern hairy-nosed wombat *Lasiorhinus latifrons*', *Animal Reproduction Science*, vol. 72. 245-257.
Presidente, P.J.A. 1982, 'Common Wombat *Vombatus ursinus*: maintenance in captivity, blood values, infectious and parasitic diseases', in D.D. Evans (ed.), *The Management of Australian Mammals in Captivity*, The Zoological Board of Victoria, Melbourne. 133-143.
Renfree, M.B. 1988, *Reproductive physiology on marsupials. In Australian wildlife, the John Keep refresher course for veterinarians.*, Sydney.

Rice, C.G. & Kalk, P. 1996, 'Identification and Marking Techniques', in D. G. Klieman, M. E. Allen, K. V. Thompson, S. Lumpkin & H. Harris (eds), *Wild Mammals in Captivity Principles and Techniques*, University of Chicago, Chicago. 56-66.

Saunders.A 2003, *Southern Hairy-nosed Wombat Developmental Notes*, Environmental Protection Agency, Rockhampton.

Shimmin, G. & Taggart, D. 2002, 'Development of Translocation Procedures in the Southern Hairy-Nosed Wombat for Application to the Northern Hairy-Nosed Wombat'.

Shimmin, G.A., Skinner, J. & Baudinette, R.V. 2002, 'The warren architecture and environment of the Southern Hairy-nosed Wombat (*Lasiorhinus latifrons)*', *Journal of Zoology London*, vol. 258. 469-477.

Skerratt, L.F. 1998, 'Diseases and parasites of the Common Wombat Vombaus ursinus in the Healsville area of Victoria', in RT Wells & PA Pridmore (eds), *Wombats*, Surrey Beatty and Sons, Chipping Norton. 317-328.

Smales, L.R. 1998, 'Helminth parasites in wombats', in R. T. Wells & P. A. Pridmore (eds), *Wombats*, Surrey, Beatty & Sons, Sydney. 312-316.

Standards for exhibiting mammals in New South Wales, 2002, NSW, Department of Agriculture, viewed 05.02.2004 2004.

Stenke, R. 2000, *Study of the Behaviour and the Ecology of the Northern Hairy-nosed Wombat (Lasiorhinus krefftii) at Epping Forest National Park*, Zoological Society for the Conservation of Species and Population Germany, Munich.

Strahan, R. 2000, *The Mammals of Australia*, 2nd edn, Reed New Holland, Sydney.

Taggart, D., Shimmin, G., Underwood, G. & Phillips, K. 2002, 'Survival of very small macropod pouch young following short-term isolation from the pouch at various environmental temperatures', *The Zoological Society of London*, vol. 5. 275-282.

Taggart, D., Shimmin, G., Ratcliff, J., Steele, V., Dibben, R., Dibben, J., White, C. & Temple-Smith, P. 2004, 'Seasonal changes in the testis, accessory glands and ejaculate characteristics of the southern hairy-nosed wombat, *Lasiorhinus latifrons,* (Marsupialia: Vombatidae).' *sub-mitted*.

Taggart, D.A., Steele, V.R., Schultz, D., Dibben, R., Dibben, J. & Temple Smith, P.D. 1998, 'Semen collection and cryopreservation in the southern hairy-nosed wombat *Lasiorhinus latifrons* : implications for conservation of the northern hairy-nosed wombat *Lasiorhinus krefftii*', in R. T. Wells & P. A. Pridmore (eds), *Wombats*, Surrey Beatty & Sons, Chipping Norton. 180-191.

Treby, D. 2003, *Southern Hairy-nosed Wombat Studbook Data*, Australasian and Regional Association of Zoological Parks and Aquaria, Melbourne.

Triggs, B. 1996, *The Wombat-Common Wombats in Australia*, revised 2nd edn, University of New South Wales, Sydney.

Van Drimmlen, S. 2000, 'Quarantine Procedures', in *Veterinary Procedures for Zookeepers at Currumbin Wildlife Sanctuary*, Currumbin Wildlife Sanctuary, Gold Coast, p. 10.

Vogelnest, L. 1999, 'Chemical restraint of Australian native fauna', Sydney.

Wells, R.T. 1971, 'Maintenance of the hairy-nosed wombat *Lasiorhinus latifrons* in captivity', *Zoo International Year Book*, vol. 11. 30-31.

---- 1978, 'Field observations of the Hairy-nosed Wombat *lasiorhinus latifrons* (Owen)', *Australian Wildlife Research*, vol. 5. 299-303.

---- 1989, 'Vombatidae', in D. W. Dalton & B. J. Richardson (eds), *Fauna of Australia. Mammalia*, Australian Government Publishing Service, Canberra, vol. 1b. 755-768.

Wilson, M. 2004, 'Quarantine of Southern Hairy-Nosed Wombats (*Lasiorhinus latifrons*) at Taronga Zoo's Veterinary and Quarantine Centre', paper presented to 10th Annual Veterinary Nurse Conference, Melbourne.
Wombaroo 1996, *Wombaroo: Food for wildlife*, Adelaide.
Woolnough, A. 1998, 'The Feeding Ecology of the Northern Hairy-nosed Wombat, *Lasiorhinus krefftii,* (Marsupialia: Vombatidae)', PhD thesis, James Cook University.
Woolnough, A.P. 2000, 'Reproductive strategies of female northern hairy-nosed wombats', *Australian Mammalogy*, vol. 21. 257-258.
Woolnough, A.P. & Foley, W.J. 2002, 'Rapid evaluation of pasture quality for a critically endangered mammal, the northern hairy-nose wombat (*Lasiorhinus krefftii)*', *Wildlife Research*, vol. 29. 91-100.

14. APPENDIX:

Appendix 1: Haematology and serum biochemistry of southern hairy-nosed wombats (Booth 1999).

Component	Units	*Lasiorhinus latifrons* n=22**
RBC	x 10^{12}/L	4.68 ± 0.51
Hb	gm/L	128 ± 15
PCV	%	39.7 ± 4.5
MCH	µµg	
MCHC	gm/L	324 ± 14
MCV	fl	85 ± 3
Platelets	x 10^{9}/L	
WBC	x 10^{9}/L	10.0 ± 4.0
Segmented Neutrophils	x 10^{9}/L	5.43 ± 2.38
Lymphocytes	x 10^{9}/L	4.96 ± 2.65
Monocytes	x 10^{9}/L	0.01 ± 0.03
Eosinophils	x 10^{9}/L	0.55 ± 0.68
Basophils	x 10^{9}/L	0.0
Sodium	mmol/L	143 ± 10
Potassium	mmol/L	5.7 ± 1.2
Chloride	mmol/L	101 ± 6
Bicarbonate	mmol/L	24 ± 6
Glucose	mmol/L	6.4 ± 1.4
BUN	mmol/L	13.± 1.8
Creatine	mmol/L	0.15 ± 0.03
Calcium	mmol/L	2.65 ± 0.30
Phosphorous	mmol/L	1.55 ± 0.45
Cholesterol	mmol/L	3.1 ± 0.6
Total Protein	gm/L	70 ± 9
Albumin	gm/L	
Globulin	gm/L	
Total Bilirubin	µmol/L	2.2 ± 1.1
Alanine Aminotransferase	U/L	
Alkaline Phosphatase	U/L	101 ± 46
Lactat Dehydrogenase	U/L	355 ± 137
Aspartate Aminotransferase	U/L	65 ± 35
Creatine Phosphokinase	U/L	376 ± 240

*From captive and free ranging wombats at Healsville Sanctuary and Melbourne Zoo. Obvious outliers removed.
** From Gaughwin and Judson 1980, data from free ranging wombats

Appendix 2: Translocation Trial: Extract from a summary report to the northern hairy-nosed wombat recovery team by: Dr. G. Shimmin and Dr. David Taggart (Shimmin and Taggart 2002).

The first trial translocation to develop techniques for northern hairy-nosed wombats was undertaken in 2002. Four southern hairy - nosed wombats (two males, two females) were translocated from a wild population at Swan Reach in the Murraylands of South Australia to Monarto Zoological Park in South Australia. The release site, a 4ha fenced enclosure at Monarto Zoo, was known wombat habitat. In addition, ground and tree cover within the enclosure were compared to areas adjacent to wombat warrens at the capture site at Swan Reach to ensure that the habitats were similar. Artificial burrows were constructed by digging trenches and laying two 2.5m and 200 mm diameter concrete pipes end to end. One end was at ground level and the other end at approximately 2.5 m below ground level. Burrow temperature were found to be within the range of natural burrow temperatures at the capture site at Swan Reach. Lengths of 50 mm PVC pipe were placed at the end of each tunnel to allow a porthole camera to be inserted into the burrow to monitor wombat activity.

Translocation was undertaken in June to coincide with maximum pasture growth at the end of the adjustment period. A range of supplementary foods, including Lucerne and oaten hay a concentrated mix (Complete-O and oats), were provided near the entrance to all artificial burrows. All wombats were fitted with radio-collars that contained radio-transmitters and data loggers that recorded activity.

Weight loss of up to 20% of initial capture weight were considered acceptable, based on experience with captive populations of southern hairy - nosed wombats at Adelaide University, Rockhampton Zoo and Melbourne University. Wombats of at least 2.5 condition score (on a score from 0 to 5.0) were selected for translocation.

Monitoring indicated that translocated animals were spending an average of 2.5 hours above ground to nearly 7 hours of the day for control animals at Swan Reach. In September one wombat was found dead in its burrow and two others had lost more than 25% of body weight and were taken into captivity. The fourth animal had lost 17% of its capture weight and was also removed from the experiment. All three surviving wombats have been kept in captivity and have recovered their lost weight and are doing well.

It became apparent that the artificial burrows restricted monitoring and that when concern for the wombats health necessitated capture in the burrow, this was very intrusive and destructive to the burrow. It has been proposed that in future translocation trials, animals are habituated to a captive diet before being released into a new site. Artificial burrows will need to have several points of access and observations so that animals can be more easily monitored and captured if necessary.

Appendix 3: Quarantine of Southern Hairy-Nosed Wombats (*Lasiorhinus latifrons)* at Taronga Zoo's Veterinary and Quarantine Centre (Wilson 2004).

Six wild caught southern hairy - nosed wombats were brought into captivity in November 2002. On arrival, the animals were underweight, in poor body condition, with dull and poor coat condition.

The wombats were paired up in large dens, as there was inadequate space to house them individually. They were then shuffled around until compatible pairs were found. During this time the smallest wombat kept dropping in weight and was separated for close observation, to assess her appetite and feacal output. Two weeks into quarantine, one of the male wombats died of severe pneumonia. Erna Walraven, Senior Curator of Taronga Zoo, noted that this particular wombat was constantly found with his face in his water bowl (*pers.comm* 25.05.04), suggesting a highly stressed individual.

Dens consisted of a simple layout for ease of cleaning, to minimize disturbance and reduce stress on the wombats. Wooden boxes (length 106 cm long x 60 cm high x 54 cm wide) with one entrance and a lift up lid were provided for each animal. The concrete floors were covered with oaten hay which provided food and bedding and provided an opportunity for wombats to become habituated to a captive diet, as food was every where. This also allowed for easy spot cleaning. Water containers were attached to the walls to prevent the animals from tipping them over.

Each morning the animals were checked and cleaned at the same time to minimise disturbance. This was the only time the lights were on, other wise they were kept with subdued lighting provided through skylights. For the first two weeks of quarantine fresh feaces were left in the enclosures and only a few day old feaces and left over food were removed with spot cleaning and water replaced. After the wombats had settled in more intensive cleaning was carried out. They were then checked again in the afternoon but not disturbed. At this time weekly weighing and body condition scoring started to monitor their adaptation to captivity and new diet.

The diet was observed closely, due to the fact that they were wild caught and in poor condition. Oaten hay and native grass clumps were offered during the first 10 days. The wombats did not adapt well to the new diet and continued to loose weight. Feed consumption was measured by monitoring feacal output.

After 10 days, high concentrate feed such as kangaroo pellets and stud mix were introduced for 7 days in an attempt to reduce further weight loss. Carrots, maize sweet potato and sweet corn were slowly introduced. During the 32 day quarantine period, the wombats displayed a preference for oaten hay, the introduction of pellets, stud mix and vegetables took approximately six weeks.

Appendix 4: Weights and Development Notes (Boer 1998; Saunders.A 2003; Hakof.D 2005).

	Vombatus ursinus			***Lasiorhinus latifrons***		
Age Months	**Mean Weight (g)**	**Total body length**	**Characteristic ontogenetic events(s)**	**Mean Weight (g)**	**Total body length**	**Characteristic ontogenetic events.**

		(mm)				(mm)	
birth	0.5	15	Unfurred; frontlimbs with nails; hindlimbs: tissue buds.	0.5	20	As in *V.ursinus*
1.0	5	50	Firmly attached to teat; hindlimbs	6-10	50-60	Nails on hindlimbs; sex determinable.
2.5	25	60	Rhinarium open; hindlimbs still without nails			
3.0	70	110	Vibrissae and eyelashes developed: Skin pigmentation begins	53-83	11-13	Vibrissae developed Body hair develops
3.5	150	115	Eyelashes more fully developed; fur on maxillary and temporal regions of head			
4.0	220	130	Eyes and auditory canals open; still firmly attached to teat	306	176	2 incisors erupted
4.5	300	150	Detached from teat; lips fully separated: nails on hind limbs	424	210	Eyes open, pushing onto front legs,ears lifting, vocalisations.
5.0	380	170	Lower incisors erupting; thin fur on head, forearms and shoulders	750	200	
5.5	500	175	Genitals, pouch and teats visible			Incisors erupted,walking
6.0	650	180	Upper incisors erupted	1400	300	Fine fur over entire body
6.5	800	190	Thick fur over anterior of body			First emergence from pouch
7.0	950	200	Molars erupted; sweat glands active			Completely furred, starting to eat grass
7.5	1200	215	Head out of pouch; fur on posterior half sparsely developed			
8.0	1500	230	First emergence from pouch in shelter box; ingestion of maternal faeces	1400 -3400	330	Descensus testiculorum; molars erupted
8.5	1800	245	First emergence from pouch above ground; ingestion of plants			
9.0	2200	265	Fur complete; resting position with head and anterior body inside pouch			Permanently out of pouch
9.5	2600	285	Thermoregulation completely functional			
10	3200	310	Permanent emergence from pouch			
12-15	12-19kg		Weaned	5.5-7.5kg	480-550	Weaned
18	17-24kg		Usually independent	15-20kg	600-800	Independent

Appendix 5: Hairy-nosed wombat; Wombaroo Growth & Feed Estimates (Wombaroo 1996)

Milk	Age Days	Arm mm	Leg mm	Weight g	Feed ml/day
	20	**33**	**22**	**2**	**2**

	40	36	37	14	6	
<0.4	60	39	32	42	14	
	80	42	37	93	25	
	90	44	40	129	30	
	100	46	43	173	40	
Transition	101 to 103		30ml <0.4 + 10ml 0.4		40	
From	104 to 106		20ml <0.4 + 20ml 0.4			40
<0.4 to 0.4	107 to 109		10ml <0.4 + 30ml 0.4		40	
	110	48	46	225	40	
	120	50	49	287	45	
	130	52	53	358	50	
0.4	140	54	56	439	55	
	150	56	59	532	60	
	160	58	63	636	65	
Transition	161 to 163		40ml 0.4 + 20ml > 0.6		60	
From	164 to 166		30ml 0.4 + 30ml > 0.6			60
0.4 to > 0.6	167 to 169		20ml 0.4 + 40ml > 0.6		60	
	170	60	67	753	60	
	180	62	71	882	65	
	190	64	74	1024	70	
	200	66	78	1181	75	
Emerging from	210	68	83	1352	80	
pouch	220	70	87	1592	85	
	230	73	91	1882	105	
	240	75	96	2212	120	
>0.6	250	77	100	2562	135	
	260	80	105	2912	145	
Fully out of pouch	270	82	110	3262[A]	160[B]	

A. Average growth rate from now is about 35g per day

B. Milk volume now depends on other food consumed. If uncertain about what to feed or when to commence weaning consult your Wombaroo supplier.

Appendix 6: List of Suppliers

Biolac
Geoff and Christine Smith
P.O. Box 93
Bonnyrigg Plaza
New South Wales 2177
Ph: 02 98239874

Fax: 02 98239874

Central Animal Records
22 Fiveways Boulevard
Keysborough
Victoria 3173
Ph: 03 97063100
Fax: 03 97063198
Email: info@car.com.au
* PIT tags and scanners

Sharpe Laboratories Pty Ltd
12 Hope Street
Ermington
New South Wales 2115
Ph: 02 98585622
Fax: 02 98585957
Email: sharpe@myoffice.net.au
* Di-Vetalact

Wombaroo Food Products
P.O. Box 151 Glen Osmond
South Australia 5064
Ph: 08 83791339
Fax: 08 83791339
Email: Wombaroo@adelaide.on.net
* Wombat Hand Raising Formula and Equipment