

HUSBANDRY MANUAL
For
SWAMP WALLABY
Wallabia bicolor



Picture: Swamp Wallaby (Geo-societies, 2003)

Mammalia: Macropodidae

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1 INTRODUCTION

The Swamp Wallaby was first described by Anselme Desmarest in 1804. The scientific name given to *Wallabia bicolor* refers to the contrast between the species' dark brown upper parts and reddish orange under parts. The common name pertains to its favoured habitat of moist surroundings however it generally does not live in swamps (Morris, 1998).

A combination of genetic, reproductive, dental and behavioural characteristics set the Swamp Wallaby so far apart from other wallabies that it is classified as the sole living member of the genus *Wallabia* (Strahan, 1992).

A medium sized macropod, the Swamp Wallaby is a nocturnal, herbivorous marsupial which is essentially solitary but will amass in small numbers at night to feed. Found along the eastern coast of Australia and southern regions of Victoria in dense vegetation, the Swamp Wallaby feeds on browse, shrubbery, bracken and other small plant life. Differing from other wallabies by its exceptionally dark colouring, *Wallabia bicolor* exhibits a pointed face and appears uncoordinated when displaying slow movements.

This wallaby is a distinctive individual in the family Macropodidae as a result of the species unique chromosome number. While wallabies in the genus *Macropus* all have 16 chromosomes, *Wallabia bicolor* has 11 in the male and 10 in the female (Ellis, 2000).

In Australia zoos have had an extensive history of viewing Swamp Wallabies in captivity. Adelaide Zoo, for example, has held *Wallabia bicolor* since at least 1884-1885. At present most zoos and fauna parks are holding the species in various exhibits (Jarman, 1990). It is known as being one of the most commonly held macropods on display in Australia although throughout worldwide enclosures the species does not seem as abundant in number.

Captive populations of *Wallabia bicolor* serve as educational tools and as subjects for research and display in zoological institutions. Holding Swamp Wallabies in their natural surroundings helps educate the public in the plight against habitation loss and the conservation of the species' environment, two contributing factors to the recent decline in *Wallabia bicolor* population. Displayed Swamp Wallabies provides to the every day man an increased appreciation for the native wildlife of Australia and promotes active participation in the care and conservation of the animal's habitat. Viewing the species amongst their wild settings can inspire and facilitate in highlighting the ongoing need to preserve the animal's habitat, along with supplying detailed information on animal plaque cards. A broader spectrum benefit would not only aid Swamp Wallabies but would also draw attention to the issue for relating endangered species and their greater needs. Endangered wallabies such as the Rufous-Hare Wallaby, Bridled Nail Tail Wallaby and Banded-Hare Wallaby would also profit from Swamp Wallaby exposure.

As *Wallabia bicolor*, at present, is of such an abundant number the species is able to educate by holding a certain number in captivity without affecting wild wallaby population.

Once more, common numbers of Swamp Wallabies will not only assist towards conservation and education efforts for them and additional native wildlife, the species are also a major asset to experimental research.

In 2000 an investigation conducted at Western Plains Zoo examined the permeability of sperm cell membrane of macropods to develop improved techniques for successful preservation of macropod semen. This research focus is of significant importance to all endangered macropods of Australia. By using *Wallabia bicolor* as the subject of this study, the species is playing a vital role in the ability to transport undamaged semen to assist in insemination efforts of endangered macropods in distant areas of Australia.

An extensive study involving the use of the Swamp Wallaby was also conducted in 2000 by D. Cooper and K. Anderson at Macquarie University, New South Wales. The focal point of the research involved the trial of a new humane contraceptive for the use in mammals. The investigation analyzed the response of Swamp Wallabies, Red-Necked Wallabies and Quokkas to the device. The research would allow improved contraception management of captive population size and sex ratio in exhibited mammal enclosures, particularly macropod exhibits. It allowed steps to be taken to control the fertility of captive populations of mammals in order to maintain sustainable populations with a sex ratio consistent with the objectives of the enclosed population (Reedman, 2000). Employing fertility control methods has also permitted long term population control rather than the necessary culling of surplus animals.

Because *Wallabia bicolor* are natural browsers, they will occasionally damage agricultural crops. As a result, they are often shot by farmers who view them as pests. Hunting and culling of this species has lead to *Wallabia bicolor's* skins to be sold throughout Australia, especially in Queensland and all through Asian provinces. Approximately 1,500 skins are marketed each year in Queensland. These acts can be either seen as a positive economic importance to humans or unnecessary killing of this beautiful species. Whatever the stance Swamp Wallaby populations now rely on the protection of humans to sustain their surrounds and populations and must be preserved if future societies wish to observe *Wallabia bicolor* in the wild.

OH&S RATING: LOW RISK

- Possible threat to safety during capture: Employ correct handling and restraint techniques to avoid impairment. Refer to Section 7.3.
- Potential transferal of zoonotic diseases:
 - Tetanus
 - Toxoplasmosis
 - Trycophyton Dermatormycosis (Ringworm)
 - Salmonellosis

Maintain high standards of personal and workplace hygiene, constantly update tetanus vaccinations as well as consistently wearing all designated Personal Protective Equipment (PPE). Refer to Section 8.4.

2 TAXONOMY

Nomenclature

Class: Mammalia

Order: Diprotodontia

Family: Macropodidae

Genus: *Wallabia*

Species: *bicolor*

Subspecies

Wallabia bicolor bicolor, New South Wales, Victoria

Wallabia bicolor apicalis, Cape York, Queensland

Wallabia bicolor mastersii, Cairns region, Queensland

Wallabia bicolor ingrami, Queensland, south of Cairns

Wallabia bicolor welsbyi, Stradbroke Island, Queensland

Recent Synonyms

Protemnodon bicolor

Other Common Names

- Black Stinker (New South Wales)
- Stinker (Queensland)
- Black Wallaby
- Black-tailed Wallaby
- Fern Wallaby
- Black Pademelon
- Two-coloured wallaby

(Strahan, 1992)

3 NATURAL HISTORY

3.1 MORPHOMETRICS

3.1.1 Mass and Basic Body Measurements

Weight: 12.3-20.5 (17) kg (males)
10.3-15.4 (13) kg (females)

Head-body length: 723-847 (756) mm (males)
665-750 (697) mm (females)

Tail length: 690-862 (761) mm (males)
640-728 (692) mm (females)

Total height: Swamp Wallabies stand at 70cm on average (Strahan, 1992).

3.1.2 Sexual Dimorphism

The form of sexual dimorphism exhibited by the Swamp Wallaby is heteromorphic. In heteromorphic species the sexes grow at different rates. Both sexes continue to grow strongly throughout life with both males and females showing significant increases in size during adult life. Males of heteromorphic species are more than just a larger version of females. The relative exaggeration in forearm muscularity is greatest in *Wallabia bicolor*. Male Swamp Wallabies are also usually heavier than the female of the species (Grigg, Jarman, Hume, 1989).

Dimorphism in the general appearance of Swamp Wallabies occurs when areas of red/orange fur are more emphatically coloured in males than females. Copious brown secretions on the chests and necks of large male *Wallabia bicolor* are also apparent yet not fully visible due to its disguise against their dark chest fur.

- *W. bicolor mastersii*: generally smaller than the southern Swamp Wallabies averaging 15kg (males) and 10kg (females), has shorter, grey fur and will stand at approximately 60cm.
- *W. bicolor apicalis*: more typical of the southern race of Swamp Wallabies and will frequently have a white tip on the end of the tail. Weight and size of this subspecies will average the same as *Wallabia bicolor bicolor*.
- *W. bicolor bicolor* weight and size: 17kg (male) and 13kg (female). Stand tall at 70cm.
- *W. bicolor ingrami*: similar body mass and size as *W. bicolor mastersii*.
- *W. bicolor welsbyi*: similar body mass and size as *W. bicolor bicolor*.
- New Guinea Swamp Wallaby: smaller in comparison to the majority of Australian *Wallabia bicolor* and will reflect similar values of mass and height to that of *W. bicolor mastersii*.
- New Zealand Swamp Wallaby: originating from the New South Wales strand of *W. bicolor bicolor*, the Swamp Wallaby of N.Z., as a result, has inherited the same mean body weight and size of their Australian counterparts (Strahan, 1992).

Figure 1.1 illustrates growth in weight with age (or molar index) of *Wallabia bicolor bicolor* (Grigg, Jarman, Hume, 1989).

Figure 1.2 indicates skull length comparison of male and female *Wallabia bicolor bicolor* against molar index (Grigg, Jarman, Hume, 1989).

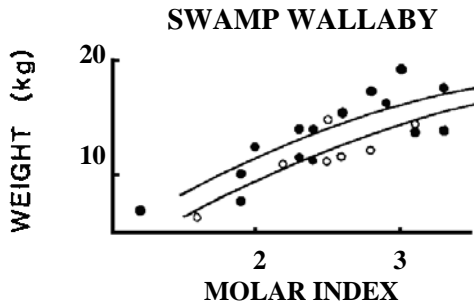
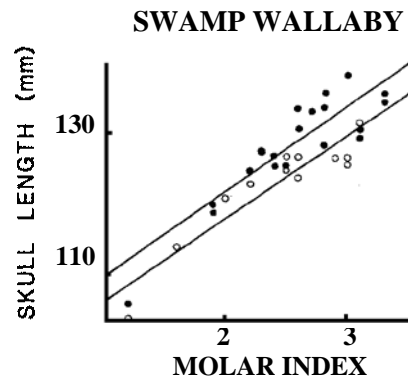


Fig 1.1- Individual weight plotted against molar index for male (black dots) and females (open circles) *Wallabia bicolor*. The sample was taken from northeastern New South Wales.

Fig. 1.2- Individual skull lengths for male and female (open circles) *Wallabia bicolor*, plotted against molar index. Sampled animals came from northeastern New South Wales.



3.1.3 Distinguishing Features

The Swamp Wallaby is a diprotodont marsupial (pouched mammal). Females have pouches that open anteriorly and contain four mammae. The forelimbs, which are significantly smaller than the hind limbs, contain five digits and are used to manipulate their food. The hallux is absent in the hind limbs which are syndactylous and elongated for use in rapid bipedal motion. The fourth toe is the longest and the most specialized digit of the hind foot. This, along with the loss of the hallux, has adapted this species for hopping (Ellis, 2000). *Wallabia bicolor* is distinguished from other wallabies by its very dark colouring. It has long, coarse fur that is generally dark brown to black above and light yellow to strong rufous-orange below. The Swamp Wallaby also has a light yellow to light brown cheek-stripe (conspicuous in northern part of range, slight in the south). Extremities are usually darker but the tip of the tail is occasionally white, especially in Queensland. The gait of the wallaby differs from other wallabies with its head remaining low and tail straight out behind (Ellis, 2000).

3.2 Distribution and Habitat

The Swamp Wallaby can be found on the eastern coast of Australia from southeastern South Australia, Victoria, eastern Queensland and eastern New South Wales. Local distribution of each area is determined by the availability of adequate dense vegetation for shelter. (Strahan, 1992)

In New Zealand *Wallabia bicolor bicolor* has been introduced on the southern island of Kuwau. It has since successfully established feral populations and now has spread throughout small, southern regions of New Zealand.

A New Guinea strain of *Wallabia bicolor* has also inhabited southern regions of New Guinea forests and has since flourished on native vegetation.

The Swamp Wallaby has also accustomed itself on adjoining Australian islands such as Stradbroke (island south-east of Moreton Bay, Queensland) in which the species flourish on native environment. Consequently a subspecies has arisen from the group's separation from other *Wallabia bicolor* on mainland Australia and given way to *Wallabia bicolor welsbyi* (Jackson, 2004).

The Swamp Wallaby lives in thick undergrowth of sclerophyll forests, woodland, densely vegetated gullies and heath in eastern and southern Australia from Cape York to south-western Victoria. Areas of thick grass or ferns, occasionally in damp allocations on hillsides of open eucalypt forest, provide day time shelter from which it emerges to feed at night. In Queensland, brigalow scrub is particularly favoured and in the brigalow belt of southern inland Queensland it is a common species. Moist thickets in swamp surroundings are another general habitat of *Wallabia bicolor*. They are known to venture into more open areas, but only if there are nearby provinces of dense brush. A Swamp Wallaby will acquire a home range of approximately 2-6 hectares of their surrounding habitation.

Distribution of the Swamp Wallaby rates at 300 000 per 1 million km² (Armbrust, 1998).



Picture: Australian distribution (Strahan, 1992)

3.3 Conservation Status

Common, secure.

A decrease in the abundance of Swamp Wallabies has occurred due to habitat destruction and, to a lesser extent, culling by farmers and car related accidents on roads (Ellis, 2000). However, *Wallabia bicolor* is still plentiful in population and these issues are not currently considered threats to the species' survival.

3.4 Diet in the Wild

Swamp Wallabies are strictly herbivorous and regarded as the classic 'browser' among all macropodids. *Wallabia bicolor* is a generalist feeder with a preference for dicotyledons. These dicots include both forbs and woody shrubs and trees. A fondness for forbs is seen in all seasons, while that for shrubs is favoured in winter.

Research suggests that food plants include both pasture and bush species. In Queensland, agricultural crops adjacent to suitable shelter are readily grazed especially during winter and throughout dry periods. In Victoria, the Swamp Wallaby eats a wide range of native and exotic vegetation including pine tree seedlings, Mountain Ash seedlings and reeds. Apical shoots of any plantation eucalypts that are below 60cm are also divulged with their consumption occurring mainly in winter. Although preference is shown for the coarse browse supplied by hedges and small bushes, seasonal variation shows that *Wallabia bicolor's* dietary intake demonstrates a significant proportion of grass during summer months. Molasses grass, *Melinus minutiflora*, green couch, *Cynodon dactylon* and sedges and *Cyperus* species are chief grass varieties consumed by the Swamp Wallaby. Occasional high ingestion of above ground fungi, bearing fruiting bodies, also occurs throughout the species, more than any other macropodid (Strahan, 1992).

The largest of the browsing macropods, among the plants eaten are Bracken fern, Pouched Coral fern and the introduced hemlock (which is highly poisonous to man and stock). The water content of browse exerts a major influence on the water and energy balance of Swamp Wallabies. When high levels of water are present in vegetation there is no requirement for supplementary drinking water; however during severe droughts and hot, dry periods water is consumed with most individuals visiting waterholes every night.

It had been suggested that the browsing habit may be reflected in the shape of the molars, which differs from that of other wallabies. Like the Agile Wallaby, the Swamp Wallaby has a broad fourth premolar which is never shed and is used for cutting coarse plant material (Armbrust, 1998).

A Swamp Wallaby will select dietary plants of high nitrogen content, low fibre and low yet abundant in structural carbohydrates for their average wild diet, which would include the following:

- Grasses
- Sedges
- Forbs
- Shrubs
- Vines
- Ferns
- Fungus
- Seeds

3.5 LONGEVITY

3.5.1 *In the Wild*

Longevity of the Swamp Wallaby in the wild is not well documented, but it is generally accepted as being:

Maximum: 16.8 years

Average: 15 years

(Longevity of Mammals in Captivity; from the Living Collections of the World, 2005)

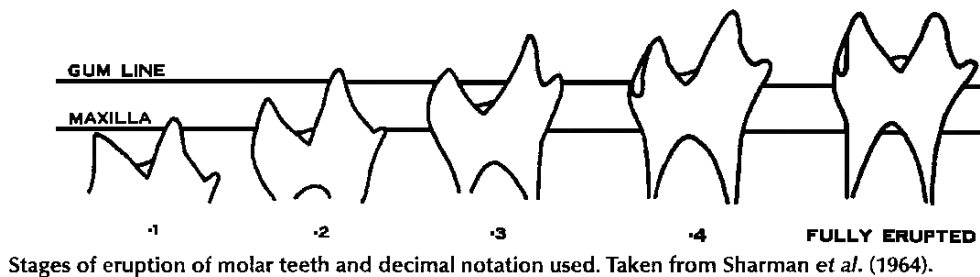
3.5.2 *In Captivity*

Maximum: 15.4 years (recorded at Healesville Sanctuary, 1997) (R. Matkovics-pers. comm.).

Average: 12.4-15 years

3.5.3 *Techniques Used to Determine Age in Adults*

The appropriate age of the Swamp Wallaby, once they have achieved adult body size can be determined through the examination of molar eruption (when the molar breaks through the gum line in jaw) (Jarman, 1990). Molar eruption is estimated by observing the proportion of the molar teeth that have erupted from the gum line. This method of age determination has the added advantage of not requiring the use of x-ray equipment (Hocking, 1997). The following diagram illustrates the process by which the molar breaks the gum line and age is able to be identified.



4 Housing Requirements

4.1 Exhibit/Enclosure Design

Enclosures must be designed and constructed to ensure the physiological and behavioural needs of Swamp Wallabies are addressed whilst protecting them from predators, harassment, temperature extremes and precipitation.

As *Wallabia bicolor* are considered to be predominantly nocturnal, they may be exhibited in a reversed lighting enclosure (EAPA, 1995).

The size and shape of enclosures for macropods shall provide freedom horizontally and should not fall below the minimum requirements set forth under the Exhibited Animal Protection Act (EAPA, 1995) (Measurements provided in the following section 4.3).

Feed stations should be covered, protected from the wind, and concreted to prevent parasite and bacterial build-up and to allow easy cleaning and disinfection.

The enclosure shall be well drained and the accumulation of faeces and urine in or on substrate around watering and feeding points shall be prevented by at least one of the following:

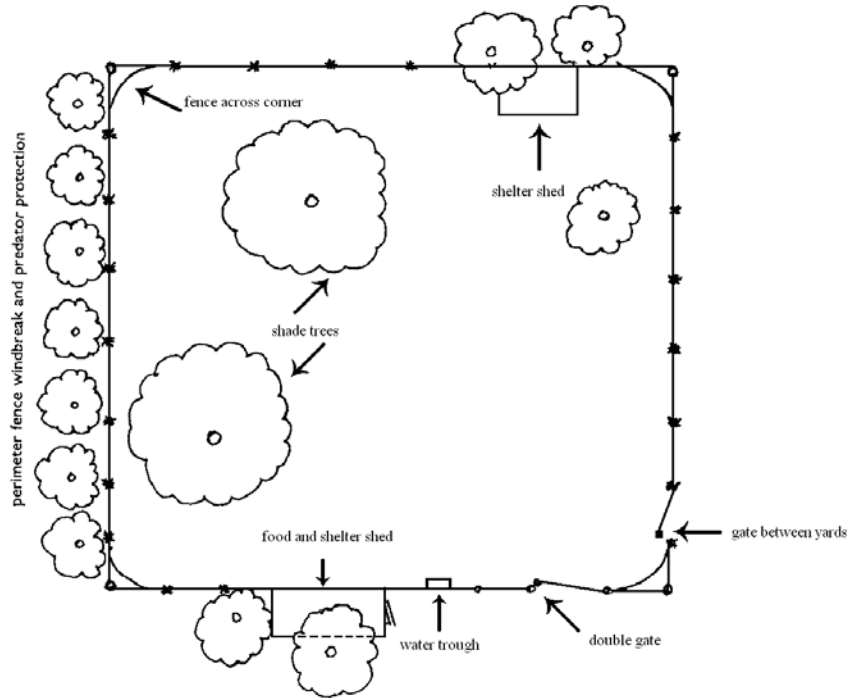
- Providing readily cleanable substrate around fixed watering/feeding points
- Providing a readily replaceable substrate around watering/feeding points which are fixed;
or
- Providing feeding/watering points which can be readily moved.

Captive Swamp Wallabies must be kept in conditions which ensure freedom from natural predators (dingoes and large domestic dogs, cats and foxes). Establishments exhibiting this wallaby shall have a dog and fox-proof perimeter fence. (Min. 2m high, 0.5m beneath ground and 0.5m overhang at 45 degrees outward). If not constructed from smooth unclimbable panel, other appropriate alternatives will be considered (EAPA, 1995).

Fences which incorporate obstacles protruding out from the fence line into the enclosure shall not be used to enclose *Wallabia bicolor*. Straining wires for fences shall be on the outside of the enclosure only (Williams, 1999).

Enclosures shall be constructed of such materials stated above and be maintained in sufficiently good repair to ensure that they will contain the animals at all times and are to be safe for the animals, for the staff attending them, and for the public.

The ideal enclosure is circular, as there are no corners for the animals to trap themselves in if they become agitated or frightened. Any fence angle change should be clearly visible to the captive Swamp Wallaby. Where there is dense planting behind changes in the angle of wire mesh fences, the fence shall be of more visible construction. Bushes may be planted inside the enclosure, or loosely fitted wire mesh may be placed across corners to reduce the impact of the Swamp Wallaby encountering sharply angled corners (Williams, 1999). Mesh size of wire fences should be sufficiently small to ensure that the enclosed wallabies cannot get their heads caught. Square enclosures should be built with round steel posts or star pickets on the outside of chain link mesh or wire netting. Corner posts should be of 10cm round galvanized steel pipe with angle supports. Additional wire netting can be put across the corners to make more of an inner curve to the fence (EAPA, 1995).



Picture: Macropod enclosure (Williams, 1999).

4.2 Holding Area Design

Wallabia bicolor enclosures shall incorporate an adjoining holding yard(s). A number of display enclosures may make use of the same holding yard. The size of holding yards should not fall below one third of the minimum requirements for display enclosures (EAPA, 1995).

Facilities shall be available for the isolation and treatment of sick animals. Reverse cycle lighting shall be available in these facilities for sick animals which are normally housed in a nocturnal house. These areas are to be built using concrete flooring that is slightly roughened and sloped so that cleaning water runs into outside drains or grease traps. Adequate drainage should also be provided so that they can be thoroughly cleaned and disinfected. A water trough is to be installed at the front of the cage, which can be cleaned easily without the need to enter the holding area.

4.3 Spatial Requirements

Minimum Floor Area of Enclosure: (m² per pair)

Swamp Wallaby

Wallabia bicolor

=60m² (EAPA, 1995).

- An additional 25% of the area listed previous shall be added to the enclosure size for each extra adult female (EAPA, 1995).
- An additional 50% of the area listed previous shall be added to the enclosure size for each extra adult male (EAPA, 1995).
- Where visitors are permitted to go into an enclosure with *Wallabia bicolor*, there shall be an area, which at least meets the minimum size requirements for holding yards and which is designated off limits to the visitors so the enclosed *Wallabia bicolor* may escape unwanted visitor attention (EAPA, 1995).

4.4 Position of Enclosures

As a general principle in housing macropods, enclosures are to be designed to face in a north easterly direction to deflect precipitation, allow winter sunlight to enter enclosure and reduce heat exposure during summer months.

4.5 Weather Protection

All *Wallabia bicolor* shall be provided with a means of sheltering from wind, rain and extremes of temperature and sunlight. (This requirement may be fulfilled by providing a combination of ground cover and external plantings). Swamp Wallabies captive in enclosed open spaces must have access to shelter and shade to prevent cold stress and heat stress caused by weather extremes. Shrubs, trees or other shelter can minimize climatic stress. If natural shelter is not available, alternatives such as two shelter sheds with open front ends must be provided. One shall be facing north, the other facing south to give the enclosed animal a choice during inclement weather. Sheds are to be made of corrugated iron covered in half logs to keep them cooler in summer and warmer in winter (Williams, 1999). Shadecloth stretched over wire netting and suspended a few centimetres above the roof helps reduce rain and hail noise on corrugated iron roofs. These sheds will also provide a dry area for the provision of food. Shelter should be sited to provide maximum protection from the prevailing weather conditions (wind, rain) and maximum shade in the summer months (EAPA, 1995).

4.6 Temperature Requirements

Captive *Wallabia bicolor* shall have adequate exposure to heat and warmth provided by sunlight and allowed to shield from such elements using provided shelter. In moderate environments, 20-30°C, *Wallabia bicolor* maintain a stable body temperature by licking forearms, shin area of hind legs, chest, pouch and scrotum. When the Swamp Wallaby becomes overheated they will pant. This is the major form of heat dissipation. The major physiological responses to cold are increased insulation and increased heat production within the body. The Swamp Wallaby will do this by shivering (Jarman, 1990).

As environmental temperatures rise toward body temperature at 33°C-36°C wallabies must resort to water-based enrichment. Swamp Wallabies in captivity have been observed to dangle their arms in water troughs to cool down, or walk through standing water if not deep (Williams, 1999). This practice is an exception to most macropods as they are generally repelled by water. Because of this it is advised to provide artificial water supplies inside the enclosure (such as a stream or pond) to allow the wallaby to exhibit its natural temperature regulation behaviour.

4.7 Substrate

There shall be sufficient soft substrate/bedding to allow all Swamp Wallabies to create a hip-hole for comfortable resting (EAPA, 1995).

The substrate should consist predominantly of compacted inert material which is non-abrasive to macropod feet. Natural earth, leaf litter and soil are the ideal ground surfaces for macropods to be housed in. Concrete is only acceptable for short term holding/hospital enclosures. The animal's feet and tail can be damaged by constant abrasion from a rough surface; conversely, if the surface is too smooth, *Wallabia bicolor* is in danger of slipping over and harming themselves if the surface gets wet.

4.8 Nestboxes and/or Bedding Material

Ideal bedding material includes the use of dense bedding straw (EAPA, 1995). This material is not only comfortable and restricts the incidence of disease but is a non-edible option for the use in a Swamp Wallaby enclosure.

4.9 Enclosure Furnishings

A sufficient number and forms of exhibit furnishings should be provided to allow activity for the species and limit stereotypic behaviour.

Enclosure furniture and fittings shall be of such style and position as to prevent the likelihood of injury and, in particular, shall not be placed so as to provide an obstacle which will injure the Swamp Wallaby when running a fence line. A range of enclosure furnishing suggestions includes:

- Suitable ground cover and/or other sight barriers shall be provided so that individuals can isolate themselves visually from the viewing public and other macropods sharing the enclosure. Ground cover shall be arranged so as to provide numerous pathways and hiding locations which serve to prevent stereotypic behaviour (EAPA, 1995).
- As the species has adapted to live in well-covered habitation they need to be supplied with large quantities of grass tussocks, shrubs or spinefex hummocks so they are able to hide and feel secure (Williams, 1999).
- Where a perimeter fence is made of wire netting it is advisable to plant fast growing, thick low native shrubs close together outside the fence to provide a windbreak as well as a visual deterrent to predators.
- Established, large shade trees within the enclosure along with shrubbery and small ground trees over shelter sheds provide the ideal arrangement for warm summers. Supplementary natural cover provided by small shrubs and grass bushes should be planted in small clusters along the inside of the internal fence.
- Protective tree guards should be used to prevent the animal's ring-barking live trees (Williams, 1999).
- Logs and leafy branches, particularly from stringybarks and other rough-barked trees, can be placed in the exhibit as sources of extra roughage.
- Rock formations may also be provided but only for the purpose of aesthetic appeal.
- Continuously self-filling aluminum water troughs, fitted with ball valves, should be positioned near the front of the exhibit for convenience of cleaning and to lessen disturbances.
- Food pans placed 4-5 feet off the ground shall be dispersed evenly throughout enclosure with enough pans to avoid territorial defence of feeding stations (EAPA, 1995).

5 General Husbandry

5.1 *Hygiene and Cleaning*

Cleaning routines must be developed and followed to ensure the preservation of exhibit environments. Exhibit flora must be cared for and maintained in an appropriate condition by upholding regular pruning sessions and removal of excess weeds. Consideration must always be given to the aesthetic appearance of the enclosure as well as animal visibility and security (EAPA, 1995).

Substrate and nesting material inside enclosures shall be kept constantly clean. The substrate, any enclosure furniture, food and water containers and other components of the enclosure shall be sustained in a clean and hygienic condition, free from the accumulation of faeces and urine.

Without limiting the generality of the above statement, particular attention shall be paid to removing faeces from around feeding stations, watering points and resting areas.

Contaminated substrate material shall be removed and replaced weekly with grassed areas to be spot raked daily. Sheds should also be thoroughly raked and cleaned out daily. Provided enclosure furnishings shall be monitored and changed when necessary or on a monthly basis to decrease likelihood of disease and bacterial transmission.

Enclosures and holding areas with asphalt or concrete should be thoroughly swept daily and, ideally, hosed at least every second day. When animals have been moved from exhibits containing these substrates, the floors should be bleached in preparation for new arrivals at a dilution which is non-toxic or harmful to macropods (recommended dilution ratio-H₂O:bleach, 20:1). Refer to page 81, Appendix E for bleach MSDS (Material Safety Data Sheet).

All enclosures which are potential sources of disease or parasites should be regularly spelled for periods necessary to minimise the possibility of re-infection. In enclosures with moist, shaded areas, this may be for 2-3 months under summer conditions and 4-6 months under winter conditions.

All articles which are likely to be dangerous if ingested shall be removed from the enclosure (EAPA, 1995). At any time there shall be no rubbish or foreign material left by the public in enclosures.

Public feeding of the animals shall also be controlled by supervision or appropriate signage (EAPA, 1995).

Control of potential pests such as wild rodents, foxes, feral cats, birds and snakes shall preferably be under professional guidance; however preventive measures and control methods are able to be put into place to avert pest infestations occurring.

One of the major pest problems associated with the health of macropods is that of feral cats and their ability to transfer fatal diseases such as Toxoplasmosis to Swamp Wallabies held in captivity. Cat access into enclosures therefore must be prevented at all times with constant observation of exhibit perimeters undertaken to monitor entrance points/holes in the fenceline that allow cats to enter the enclosure and defecate on feed. Electric fencing may also be implemented as well as installation of tree guards around base of exterior tree trunks to ensure that cats are unable to climb over perimeter fencing. Traps are also able to be laid with eradication by on-sight shooting and ground irritants that aggravate cats feet when felines come into contact with the substance being further control techniques of pest cats.

In the instance of foreign rat and mouse infestations preventative measures can only be carried out after detection of rodents is confirmed. Smell of urine, signs of rodent faeces, sight of burrows and holes, broad food consumption, gnawing indentations evident in mesh wiring and actual rodent

sightings are ways in which rats and mice are easily discovered. As rodents are not only pests within themselves but are able to attract other dangerous predators that will cause further harm to Swamp Wallabies such as snakes (snake bite and death and consumption by venomous snake) it is vital that this pest species is controlled and eradicated to maintain health and sustain hygiene within the Swamp Wallaby exhibit. This is able to be done by ensuring that all food pans and feeding stations are situated above ground and guaranteeing that this part of the enclosure is out of reach to rodents. Maintaining a clean workplace by removing faecal matter daily will also ensure rats and mice are not attracted into the exhibit in the first place. Methods of control should include rat and traps laid around the exterior of enclosure so that rodents are caught before entering exhibit, laying poisons and baits and euthanasing trapped rats and mice and finally but most important make sure that all food is stored securely in metal drums so that rodents are not able to gain access into food where they are able to spread disease and parasitic infections.

Ectoparasites, endoparasites, extensive stress caused to *Wallabia bicolor* as well as death by predation are key factors that contribute to the decline of health in this species if foxes are a pest problem in the exhibit. Foxes are able to be detected through smell, discovery of faeces, diggings, mutilated or slaughtered animals and daylight sightings. Approaches taken towards the prevention and control of foxes in and around enclosure will include various techniques with the main method being electric/fox proof fencing (Minimum 2m high, 0.5m beneath ground and 0.5m overhang at 45° outward and constructed of smooth, unclimbable panel). Control of foxes can be dealt with by using either mechanical traps or by laying poisons such as 1080. Shooting foxes when sighted as well as euthanasing trapped foxes are further techniques that are able to be carried out.

Finally preventative procedures for control of native birds such as the Ibis, as they are airborne vectors of disease and parasites that are able to be contracted by *Wallabia bicolor*, will include practices such as laying nesting spikes in probable nesting areas in enclosure and around wildlife park or zoo. Feeding animals early before the daily arrival of birds from outside areas to avoid birds consuming wallaby food and landing in food pans to gain better access to feed as well as advising public visitors to NOT feed the birds by use of signage to explain the consequences of such actions and the effect it will have on the animals residing in the park or zoo are additional preventative measures able to be taken.

5.2 Record keeping

Maintenance of good records is an important aspect of management and can be used to determine the probability of genetic variation and to plan breeding programs which maximize retention of genetic variability within a captive colony (Dixon, 1997).

Records for Swamp Wallabies shall be kept on an individual basis in a form which can be quickly and easily examined, analyzed and compared with those kept by other establishments.

The records shall provide at least the following information for each individual:

- The common name and correct scientific name.
- The current total number of animals held, the number of males, number of females and the number of unsexed animals.
- The dates of acquisition and disposal, with details of circumstances and addresses.
- The date or estimated date of each birth, stipulating the basis on which the date is estimated.
- The date of each death and the results of the post mortem examination (Jarman, 1990).

Animals moving to new locations must be accompanied by copies of all records relevant to those animals.

All documents and other information pertaining to each animal from previous locations must be kept safely (EAPA, 1995).

Species identification shall be made by a suitably qualified person and the records shall state who was responsible for species identification for the purposes of the Exhibited Animal Protection Act. The Director-General may direct an establishment to utilize the services of a suitably qualified person to make species identification if there is some doubt as to species identification (EAPA, 1995).

Observation records of the housed species must also be documented. Remarks and notable information must be written on an animal observation sheet to allow daily comparisons to be made. General behaviour, disposition, mobility, defects, animal's demeanour, appetite, urination/defecation patterns, water consumed, appearance, clinical signs and environmental conditions must also be recorded.

5.3 Methods of Identification

It shall be the aim of the exhibitor to individually identify all *Wallabia bicolor* using approved methods of ID including ear tags, earmarks, collars, tattoos, (only where ventral surface of ear or inside of hind leg is relatively hairless) and through the use of PIT tagging.

Establishments exhibiting any Swamp Wallaby shall ensure each new individual of this species acquired is individually identified. Existing individuals shall be identified as the opportunity arises (Tamworth TAFE Animal Care Teachers, 2005).

- Passive Integrated Transponder (PIT) tags: These devices are implanted between the scapulae of individual Swamp Wallabies. Although expensive, PIT tags are a permanent method of identification. Care must be taken when implanted as they may track out along the injection site. This may be avoided by sealing the entry wound with tissue glue (Vetbond) or similar fast setting adhesive.
- Ear tags: These have the advantage that they can be read from a distance, however can be torn out and lost. This is the chief ID method used on Swamp Wallabies.
- Tattoos: Tattoos can be made on the inner ear or inside of the hind leg. This again requires moderately close contact to read but provides a permanent form of ID; however they may fade over time when exposed to natural elements. Waterproof ink markings can also be used but only as a temporary technique used for identification purposes.
- Collars: With assorted colours and patterns, reflective collars can be seen at a distance; however they detract greatly from the natural appearance of wild individuals when on display.
- Ear notching: Avoiding blood vessels in the ear, ear holes can be made using a leather punch. Although ear notching does not inconvenience the Swamp Wallaby it can be viewed as mutilation from the general public. The numbering method for this system works as shown in the illustration on page 82, Appendix F.

5.4 Routine Data Collection

Codes for the use with Daily Report Sheets:

AQU= ACQUISITION: any importation from outside the collection, public donation or capture from grounds or from the wild.

B/H= BIRTH/HATCHING: the date on which the animal is 'permanently out of the pouch', or the day a juvenile is thrown from the pouch.

D/30= DEATH WITHIN 30 DAYS: death/euthanasia within 30 days of birth or acquisition.

D/E= DEATH ESTABLISHED: death/euthanasia of any animal which has been resident in the collection for longer than 30 days.

DIS= DISPOSITION: includes exports from the collection, releases, sales, escapes.

BRD= BREEDING: reproductive details/observations. Any nesting, oestrous, menstruations, matings, courtship, pouch checks, sexing of previously unsexed individuals or any other reproductive matter.

INT= INTERNAL MOVEMENT/TRANSFER: any movement of an animal from its residing enclosure, be it within a section or to a different section. Transfers/exports out of the collection NOT included.

TAG= TAGGING: animal identification by tagging, notching, tattooing, naming or any other method of identification.

W/L= WEIGHT/ LENGTH: weight or length measurements.

Rx/Tx= TREATMENT: any medical treatment administered to animals, either by vets, or continuing treatments administered by animal care staff. Include observations of anything related to treatment. Flag if veterinary examination is required.

VET= VET EXAMINATION REQUIRED: note if veterinary treatment/examination is required.

OTH= OTHER: any notable observation made in reference to daily routine on animals, e.g. behaviour, change to routine, etc. Also include anything else of interest, e.g. animal management procedures, diet change, maintenance, etc. (Phipps obtained through Taronga Zoo records, 2005).

6 Feeding Requirements

6.1 Captive Diet

A Swamp Wallaby should be provided with food and water for a balanced macropodid diet to sustain health and vitality. The quality and quantity of the diet should be adequate to maintain well-being and meet the requirements of growth, pregnancy, lactation and cold/heat stress (Ellis, 2000).

The animal should be offered quality food or an allowance equivalent to 15% of its body weight each day. The food should be provided ad-lib due to their high nutritional requirements and low incidence of obesity.

It is recommended not to feed *Wallabia bicolor* whole grain crops as some seeds have sharp husks which can cause abrasions to the animal's gums providing possible sites for necrobacillosis infections-Lumpy Jaw (Dixon, 1997).

Supplementary feeding of Lucerne hay or commercially available macropod pellets during winter or in drought conditions should be offered at least every third day otherwise there is no need for the species' diet to change throughout the year (unless enrichment feeding is trialed) (Jackson, 2004).

The Swamp Wallaby must be provided with substantial amounts of browse at least weekly to supplement their captive diet. However a minimal quantity daily is usually the most effective way to recreate the species' natural behaviours and surroundings.

In captivity, a green vegetarian diet of similar foods as fed to other wallaby and kangaroo species will sustain their nutritional requirements. Food items will therefore include:

- Kangaroo cubes
- Lucerne hay or Lucerne chaff
- Browse-eucalypt, elm, ash, acacia, melaleuca, bracken fern
- Sweet potato
- Dried corn
- Carrot
- Spinach
- Oat grass/pasture
- Apple
- Stale bread (fed 2-3 times per week) (Jackson, 2004).

Uncontaminated drinking water should be available to *Wallabia bicolor* at all times. A water trough must be provided which is sufficiently large enough to allow each Swamp Wallaby to immerse its forelegs for cooling purposes. Water troughs shall be in a shaded area away from fence lines. Food shall be placed above the substrate in suitable food containers. The enclosure shall have facilities for placing the food containers under shelter to ensure the provision of unspoiled food. The number of feeders and waterers and the available space for feeders and waterers shall be sufficient to ensure easy access to food and water by each individual wallaby (EAPA, 1995).

The following are assorted diets fed to *Wallabia bicolor* at different captive animal institutions in New South Wales and Victoria:

Featherdale Wildlife Park Swamp Wallaby Diet

Ad-lib

Water
Lucerne hay
Fresh pasture/oat grass
Browse- eucalypt/ acacia/ bracken fern/ elm

Daily diet

Kangaroo pellets (fed every second day)-approximated by food dish size
Lucerne chaff
1 carrot (halved)
1 large sweet potato (chopped into quarters)
30g dried corn
30g apple (chopped coarsely)
1 slice of white bread (sliced in half)

Healesville Sanctuary Swamp Wallaby Diet

Ad-lib

Water
Lucerne/grass hay
Pasture/green grass

Daily Diet

350g macropod pellets
100g kangaroo cubes
60g maize
1 carrot piece
1 browse selection: eucalypt/ acacia/ native mint bush branches (fed every 2 days)
80g apple (coarsely chopped)
1 leaf spinach

Hunter Valley Zoo Swamp Wallaby Diet

Ad-lib

Water
Lucerne hay
Pasture

Daily diet

1 cup macropod pellets
1 cup kangaroo cubes
50g dried corn
2 medium carrots (coarsely chopped)
Browse selection: eucalypt/ acacia/ bracken fern (fed every 3 days)
1 small apple (halved)
2 medium sweet potatoes (coarsely chopped)

The diets presented are all very similar in quantity and food choice which therefore signifies the success and suitability of each diet in captivity. Each method does not require any complicated or hard labour and is so straightforward that it does not alter in each circumstance.

All diets aim to replicate a Swamp Wallaby's nutritive requirements in the wild as close as humanly possible. Vegetable and fruit substitutes are provided to supply the species with all the energy, vitamin, mineral, fibre and carbohydrate requirements that are usually gained from the assorted shrubbery and plant life foraged for in the Swamp Wallaby's natural environment.

Browse is a substantial part of *Wallabia bicolor's* captive diet. Due to the wallaby's natural browsing behaviour all park diets explored deem this form of dietary intake essentially necessary to maintain the Swamp Wallaby's need for roughage. Exact natural sources of browse in *Wallabia bicolor's* wild consumption is provided at each park or zoo listed, however, different forms of browse are supplied at the assorted locations. This is due to the availability of each vegetation resource at the various locations each wildlife sanctuary is sited. For example, Bracken fern is obviously far more abundant and accessible in Hunter Valley Zoo's surrounding regions than at Healseville Sanctuary. Native mint bush branches, on the other hand, may be the most common browse item available at this locality and therefore easier to provide at their wildlife park than Bracken fern would be.

Without supplying exceedingly large amounts of food daily each diet displayed previously vary slightly in the quantities provided to the animals (e.g. Featherdale: 1 carrot, Hunter Valley Zoo: 2 carrots). This may be the result of trialed amounts given out daily and therefore the outcome of individual Swamp Wallaby preferences for larger measures of a certain food item than others at native wildlife institutions.

Featherdale Wildlife Park's provided Vitamin E supplement may also be the result of trials on the park's Swamp Wallabies overall appearance and health. Featherdale personnel may find the supplement of great benefit to the *Wallabia bicolor* displayed and discover that increased health benefits are the positive consequence of the supplementation. Other captive facilities may find no need for extra supplements which are otherwise gained from their diet and therefore consider it unnecessary to make available such enhancements (if not medically essential).

As all variables and alterations in food are very slight throughout the listed diets it is therefore a testament to the aptness of the diets in all three institutions. All Swamp Wallabies, though basic the food items are, obviously thrive off such rations and as a result assorted parks and zoos find no need to change the diets to suit their individual needs.

6.2 Supplements

No supplements are essentially required; however salt blocks are also occasionally provided as a source of minerals (Jackson, 2004).

6.3 Presentation of food

Developing food related enrichment strategies helps to provide a stimulating and challenging environment for the Swamp Wallabies to participate in. Enrichment feeding is carried out to alleviate stereotypic behaviour and provide the species with obvious benefits such as relieving boredom, producing mental stimulation, reducing the incidence of obesity and adding variety to the diet.

As captive Swamp Wallabies do not have the activity associated with finding their daily nutritional needs, it is important to provide them with activity feeds. Various forms of food related enrichment and presentation include:

- Activity feeds: food items that the animal will have to work to obtain or search to find. Small amounts often are the best regime, as it stimulates natural foraging. If possible it should be an item in the animal's natural diet.
- Assorted dimensions of food: vegetable and fruit materials such as sweet potato, carrot and apple should be large enough to allow the individual to manipulate the particle and should also vary enough in size to provide occupation for the animal whilst eating.
- Scattered food: scattering food around the enclosure, under leaf litter and through small, visible plant life will again enhance the Swamp Wallaby's innate foraging behaviour. However care is needed to monitor food and unclaimed fruit and vegetable items as when left undiscovered may lead to disease exposure, fly attraction and rotting food matter. Always remove these items after wallabies have completed feeding.
- Browse: browse supplies should be presented in an upright fashion and made easily accessible to animals. Browse may be placed in erect canisters, such as PVC piping fitted with a cap on one end and filled with water to prolong the freshness of the foliage

Food should always be fed off ground wherever possible. This will assist in reducing the incidence of diseases such as Lumpy Jaw and potentially Toxoplasmosis. Lucerne chaff and carrots should be provided in troughs so that they are off the substrate. Alternatively, pellet hoppers and bins can be used. These have the added advantage of reducing the amount eaten by birds and prevent birds defecating over feed. Pellet bins 1m long x 20cm high x 30cm deep with a top that slopes to the back of the bin, leaving an opening of approximately 25cm discourages young macropods from getting in the containers and also defecating and urinating on the food supplied (Williams, 1999).

Feed should be either spread out throughout the enclosure or placed in food pans positioned 4-5 feet off the ground and placed in various vicinities in the exhibit. Hay racks, which can be wall mounted or double sided and free standing, are used for holding bails of Lucerne (Dixon, 1997).

Water can be provided in numerous ways, including flow through or static ponds, troughs or self-filling watering points.

7 Handling and Transport

7.1 Timing of Capture and Handling

All Swamp Wallaby captures should be organized well in advance and generally undertaken in the coolest periods of the day-early morning or throughout late evening. This will reduce heat stress of the animal, especially during summer months (Jackson, 2004).

7.2 Catching Bags

Catching bags should be constructed of a thick cloth such as Hessian, as this helps to keep the eyes in darkness so the wallaby is able to settle down sooner. It is important that the bags have a wide mouth so that *Wallabia bicolor* can be easily swung into the device (70-80cm opening, 80-90cm deep). After restraint has occurred adult Swamp Wallabies are then to be placed in a canvas bag or alternatively into an Australian Post bag and hung off the ground (Jackson, 2004).

Juvenile *Wallabia bicolor* may be captured with the use of a bag net made from a Hessian sack sewn to a padded metal hoop, attached to a long wooden handle which is able to be hung off the ground (Dixon, 1997).

7.3 Capture and Restraint Techniques

The routine methods for catching macropods are with nets, blankets or by hand (manual restraint).

Swamp Wallabies are best captured by having one or two personnel slowly herding the animal along the fence line with another one or two people waiting with a hand-held hoop-net or ready to catch the tail. *Wallabia bicolor* will often make use of narrow pathways, such as behind feed sheds, so these make appropriate points to herd the animal towards, with someone waiting at the other end.

Once the macropod has been caught the opening of the net should be quickly lifted up in the air and twisted if possible to prevent escape.

As an alternative to hand catching, Swamp Wallabies can be darted with an immobilization drug such as tiletamine/zolazepam (chemical restraint) using a blowpipe or compressed CO² or explosive power charge (gun license required).

A routine manual capture and restraint technique is carried out as follows:

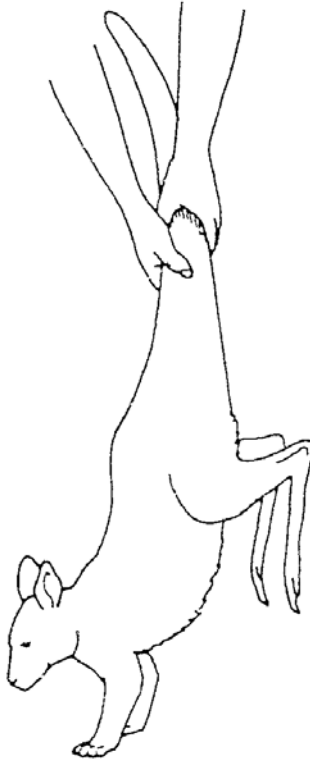
- Once the animal is captured, grasp the base of the tail and lift the hind legs off the ground-keep the animals legs pointed away from you.
- Place your other hand under the animal's ribs and lift the whole body off the ground (for small to medium-sized macropods such as the Swamp Wallaby only).
- Transfer the animal to a catching bag (adults-into a canvas bag, orphans- into a cotton bag wrapped in a blanket) as soon as possible and hang it off the ground. Be careful when placing the animal in the bag as they can break their necks if in contact with the ground.

The major consideration in capturing *Wallabia bicolor* is the reduction of stress. This requires that capture time be kept to a minimum and the actual capture and handling be carried out quickly and effectively. Even with efficient procedures it is advisable to administer diazepam (Valium) (0.5-1.0mg/kg IM) to sedate individuals that become highly stressed during and after capture (Jarman, 1990).

If a macropod licks its forearms after being chased, the person overseeing its capture shall immediately attempt to minimize further disturbance until the following day. No more than four attempts should be made to capture the animal.

CAUTION: Claws, teeth and hind legs. Although larger macropods are far more dangerous to handle, special consideration is still needed to capture and restrain *Wallabia bicolor* to avoid injury (Dixon, 2004).

AT ALL TIMES THE SAFETY OF THE ANIMAL AND THE HANDLER MUST BE OF PRIME IMPORTANCE.



Picture: Macropod handling technique (Dixon, 1997).

7.4 Weighing and Examination

Once the capture of *Wallabia bicolor* is successful you are then able to weigh the macropod relatively easily by placing the bag containing the wallaby on a large walk-on-scale. During the examination it is important that the eyes are covered at all times inside the catching bag, as this will reduce the stress level (Jackson, 2004).

The pouch can be examined by two people where one person will hold the chest and the legs and the second can thoroughly examine the pouch. The condition of the pouch can appear and be recorded as follows:

- Dirty, indicating a non pregnant animal with no young.
- Clean, indicating oestrous.
- Glandular, indicating pregnancy.
- Pouch young present.
- An elongated lactating teat for a young at foot; or
- Regressing and producing only a clear fluid when squeezed (Dixon, 1997).

A general examination should include inspecting the teeth and gums for disease such as Lumpy jaw, the eyes, ears and general body condition. The Swamp Wallaby can be examined in or out of a bag by placing the animal on the ground on their side, kneeling behind them with one knee at the shoulder and the other around the hip region. One hand puts pressure on the shoulder and the other holds the tail. A second person can then hold its legs above the hocks, to prevent it from kicking itself or the examiner and then is able to examine the pouch or any other part of the animal's body.

Wallabia bicolor can also be pouch checked by one person by lying the animal on its back between your legs whilst sitting on the ground (refer to image below). It is important to hold the animal so that it is wrapped firmly in the sack and cannot kick out (Jarman, 1990).

7.5 Release

Many Swamp Wallabies have a tendency, when they are released, to immediately hop off quickly and erratically. It is therefore extremely important that as few people as possible are used to carry the bag into the enclosure, to minimize noise and visual stress. The release area should be in as open an area as possible and away from potential sources of collision such as large logs, fences, sheds or trees. This is often a very delicate time as very flighty macropods can break their necks from a collision. Once the animal is released, keep low, slowly retreat toward a fence line and head toward the exit of the enclosure.

Some *Wallabia bicolor* have a tendency to drop their pouch young (that are able to be released from the teat) shortly after being released. It is therefore vital that females have their pouches taped closed (for example with Elastoplast) to reduce the chances of the young being dropped on the ground. Once the female is released and settles down, she will remove the tape and the young should be allowed to remain in the pouch (Jackson, 2004).

7.6 TRANSPORT REQUIREMENTS

7.6.1 Box Design and Transportation Requirements

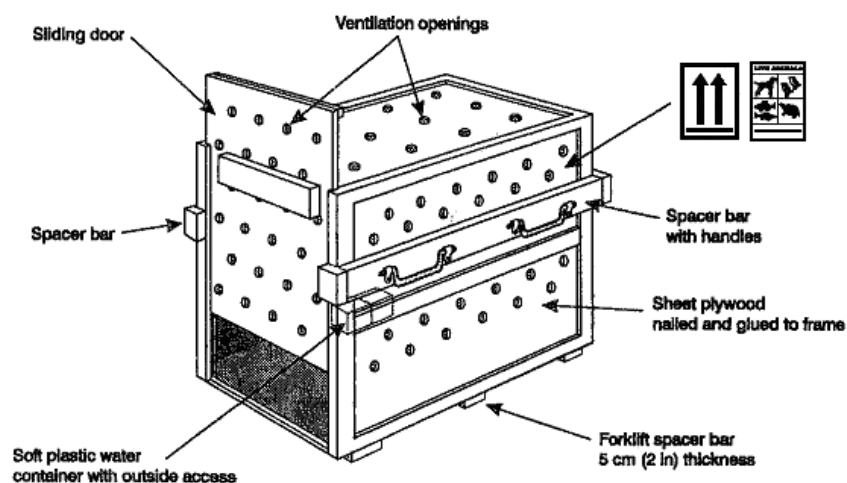
Box design must incorporate the following features when transporting *Wallabia bicolor*:

- For transport expeditions of less than 24 hours duration, *Wallabia bicolor* should, wherever possible, be transported in suspended bags made of Hessian or similar open-weave material.
- For transport trips greater than 24 hours duration, the macropods shall be transported in a container constructed from fibreboard, hardboard, wood/ plywood, or other appropriate material adhering to the correct design requirements.
- Framework shall be 20mm x 20mm light timber for Swamp Wallabies weighing less than 20kg.
- Bottom and fixed sides shall be constructed of 6mm plywood, glued using a non-toxic adhesive and further screwed or nailed. Macropod transport containers shall not have slatted floors.
- The ceiling shall not be solid. It shall consist of flexible chicken wire mesh or a soft, non-destructible material, padded on the underside with Hessian to protect the animal's head should the animal become agitated and jump. The roof must have ventilation openings made over its entire surface.
- The end is to be closed by a sliding door of 6mm plywood which, once in place, shall be secured by screws at each end so that it cannot be opened unintentionally. Alternatively

the top of the container can be used as the access in which case it must be screwed to the frame and not nailed and glued.

- *Wallabia bicolor* transport containers shall not have internal framing.
- The transport container must allow the animal to stand fully erect, to turn around and lie down comfortably however not to exceed spatial requirements so as the area is deemed too spacious to cause the animal to potentially injure themselves.
- Dimensions shall not exceed these criteria as no room for exercise is needed
- A transport container for *Wallabia bicolor* shall not allow the entry of light, with the exception of through ventilation holes. The ventilation holes shall be 5cm below the internal roof height and 5cm above absorbent material used on the floor of the container to prevent spillage. The ventilation holes of 15mm diameter shall be pierced at no greater than 10cm centres at the top and bottom of each side.
- Ventilation holes must be covered with screening on the inside. Any sharp edges of the mesh screening must be protected by smooth material.
- Spacing blocks or bars of 2.5cm shall be fixed to the outside of the box on all four sides.
- The container must be correctly labeled. Labels are to be affixed to the container of not less than 20cm in length and 14cm in width on which is clearly, legibly and indelibly printed in capital letters the words: "WALLABY", "LIVE ANIMAL", "HANDLE WITH CARE", "THIS WAY UP", and "KEEP COOL"
- Attach to the outside of the container an envelope in which is contained a consignment note showing the consignor's name, address and telephone number; the consignee's name, address and telephone number; the date of dispatch; the number of Swamp Wallabies dispatched and the common name, scientific name of the species enclosed.
- The Swamp Wallaby must be sedated with diazepam (Valium) administered under the supervision of a registered veterinarian before being enclosed in the transport container.
- During transfer to or from an airport or another institution, a keeper or veterinary surgeon experienced in the care and treatment of macropods should accompany animals when transferred by vehicle.
- *Wallabia bicolor* must not be subjected temperatures greater than 30°C or less than 10°C during transfer.
- Noise and time from crating to destination must be kept to an absolute minimum.
- Macropods must not be removed from their cages or handled in transit unless it is considered essential by the keeper or veterinary surgeon (IATA, 2000).

Picture: Illustration of macropod box design (IATA, 2000).



7.6.2 Furnishings

Swamp Wallabies require additional curtaining over the door and ventilation openings to offer reduced lighting inside the container. This will provide to the animal a calmer atmosphere which, as a result will reduce the stress of transportation and make the animal less agitated.

The floor of the container must be covered with a minimum of 2.5cm layer of soft bedding material, such as wood shavings or wood wool packing, placed over a layer of newspaper.

Feed and water bowls are also essential furnishings considered necessary to be placed inside the container during the journey (see below) (IATA, 2000).

7.6.3 Water and Food

A soft plastic water container must be provided, raised off the floor and with outside access. Swamp Wallabies, however, do not generally require additional feeding or watering during a 24 hour transportation period following the time of dispatch. If feeding is necessary due to an unexpected postponement a small quantity of carrot, fruit and water must be provided. Care must be taken not to overfeed (IATA, 2000).

7.6.4 Animals per box

Under no circumstances may more than one Swamp Wallaby be contained in one compartment of the container. However compartmentalized containers are available to transport wallabies which are divided into two separate partitions.

Females with pouch young should not be transferred unless only recently born and still attached to the teat (IATA, 2000).

7.6.5 Timing of Transportation

Due to the potential for overheating, Swamp Wallabies should be transported overnight if on a long journey or in the early morning or evening for shorter expeditions (IATA, 2000).

7.6.6 Release from box

An enclosure in which *Wallabia bicolor* is to be released should have its wire fences made more visible by hanging Hessian or similar material.

The same precautions should be used in this situation as when releasing an animal from a bag. It is often best to open the box, fully remove the door very slowly and exit the enclosure from behind the box immediately. Macropods shall then not be disturbed for at least three hours after release into their new enclosure to allow familiarization with their surroundings and to leave box when the individual feels ready. The box can then be removed in the next one or two days once the animal(s) have had the chance to adjust and calm down (Jackson, 2004).

8 Health Requirements

8.1 Daily Health Checks

While cleaning housing or feeding and watering *Wallabia bicolor*, it is important to be observant and survey all animals for any signs that may indicate problems associated with ill health. Information to be observed and recorded should include the following:

- The animal's demeanour (is it bright, alert, active, dull, lethargic, etc).
- The animal's appetite, food consumption and description of food type eaten.
- The amount of water consumed and the receptacle used to hold water.
- The animal's bowel and bladder movements-normal or abnormal (what colour and consistency).
- Any deviation from normal in the animal's appearance (e.g. coat condition, body condition, etc).
- Behaviour and disposition-include interaction with people or other animals as well as temperament.
- Does the animal's behaviour appear normal for that species?
- Is its behaviour normal for the individual?
- Fur on the enclosure floor suggesting fighting or mating.
- Cloaca and rump-wetness.
- Discharges-from the eyes, ears, nose, mouth or cloaca.
- Nose-wrinkles may suggest dehydration.
- Injuries.
- Presence and development of pouch young by observation of the bulge in the pouch.
- Movement and mobility-include consistency of paces, freedom from impairment and activity level.
- Environmental conditions (Jackson, 2004).

8.2 DETAILED PHYSICAL EXAMINATION

8.2.1 Chemical Restraint

Adult Swamp Wallabies do not require pre-anesthetic fasting; however hand-reared animals should be fasted for at least one hour. Sedation is usually undertaken with Valium (diazepam) at a dose rate of 0.5-2.0mg/kg intramuscularly in the thigh muscle (dose rate will also depend on animal's temperament). A more rapid effect can be achieved with an intravenous injection of Valium at 0.1-1.0mg/kg in the coccygeal vein near the base of the tail. The use of Valium is particularly important as a muscle relaxant in highly volatile animals that have been hand-captured to prevent myopathy (Jarman, 1990).

Tiletamine (Zoletil) at a rate of 5-15mg/kg intramuscularly, is the injectable drug of choice for anesthesia and is given either by hand or by dart. Although this provides good induction, recovery may be slow and violent, ranging from one to five hours. Inhalation anesthesia using halothane in oxygen either for induction and/or maintenance is commonly used in Swamp Wallabies, with premedication with Valium often being necessary to stress. Induction using a face mask while the animal is physically restrained is useful.

Although intubation is possible, it is often not necessary unless performing prolonged procedures or examination of the face or mouth (Jackson, 2004).

During recovery from the anesthesia, the animal should ideally be placed by itself in a small dark enclosure (or the head covered with a towel) that is free of obstacles, otherwise it can potentially bound into buildings, trees, rocks, fences and other obstacles that can cause fatal injuries (Jarman, 1990).

8.2.2 Physical Examination

The physical examination of *Wallabia bicolor* when inspected should include the following procedures (Jackson, 2004):

- Body condition: Assessed by muscle palpation in the area over the scapula, (part of shoulder blade, situated on either side of spine) temporal fossa (the base of cranium) and spine or by feeling the base of the tail.
- Temperature: Normally 35-36.5°C, can be taken through rectum via the cloaca.
- Weight: Record and compare to previous weights. Trends in body weight of *Wallabia bicolor* give a good indication of the animal's state of health, provided age; sex and geographical location are taken into account. Swamp Wallabies should be weighed monthly if possible to gain an indication of trends (Jarman, 1990).
- Pulse rate: Normally 60-150 beats per minute. Should be taken under anaesthesia as it will increase after capture.
- Respiratory rate: Normally 10-30 breaths per minute. Should also be taken under anaesthesia as it will increase after capture.
- Fur: Check for alopecia, ectoparasites, fungal infections or trauma.
- Observe for the presence of lumps over body and auscultation of lungs (Clear sounds should be heard during inhalation and expiration).
- Eyes: Should be clear, bright and alert.
 - Normal bilateral papillary light response.
 - Normal corneal reflex (dilation of the pupil).
 - Should be free of discharge.
- Cloaca: Should be clean.
 - Check for faeces around cloaca region.
- Pouch: Condition of the pouch.
 - Check the length of the teat, as long teats usually indicate young at foot, especially if milk can be expressed from teat.
 - If pouch young are present, record sex, stage of development, weight if detached from teat and measure to determine age from growth curves if available.
- Males: Check testes-size (length, width, depth) and consistency (firm not spongy). Extrude penis and assess.

8.3 Routine Treatments

Topical treatments are to be given for diseases such as Ectoparasites, where an insecticidal rinse would be used, or for open wounds, where an antibiotic cream or spray would be used. Topical treatments need to be in direct contact with the causative agent outside the body in order to be effective (Dixon, 1997). Topical treatments include creams, lotions, baths, rinses, sprays and powders.

Oral treatments are used for diseases such as Endoparasite infection, Candidiasis and worming by using Ivomec Pour-On. Oral treatments are used when the remedy can only be in direct contact with the causative agent within the body's digestive tract in order to be effective. Oral treatments include powders, pastes, liquids and tablets.

Inoculation treatments would be given for diseases such as Necrobacillosis and Post-Capture Myopathy (Dixon, 1997). Vaccinations against macropod diseases and their prevention also require administration via injectable means. This form of treatment is used when the medication must be absorbed by the body tissues in order to have a valuable effect. Inoculation treatments include liquids, water or oil based injections.

8.4 Known Health Problems

ECTOPARASITES:

Cause: The Swamp Wallaby can be host to various ectoparasites. This group consists of external parasites such as chigger mites and sarcoptic mites, fleas, lice, flies and ticks. Healthy Swamp Wallabies may carry heavy burdens of ectoparasites in the wild but in captivity they are more seriously affected (Christian, 1988).

Signs: Signs may include dermatitis, anaemia, (in cases of blood loss due to the contraction of ticks) alopecia, crusting, erythema and pruritus. Visible clusters of mites may also be found around the pinnae with extensive dermatitis affecting the inguinal, abdominal and axillary regions. Sand flies can also cause irritation particularly around the eye area of *Wallabia bicolor*. Cysts of variable size associated with internal organs (e.g. liver, stomach, lungs, brain) will occur in the case of Tapeworm infestation.

Diagnosis: Skin scrapings or skin biopsies and microscopic examination showing the presence of ectoparasites as well as visual detection.

Treatment: Ectoparasites can be actively treated with ivermectin (Ivomec) by pouring on 200ug/kg repeated weekly for four to six treatments; however the lesions are known to have healed themselves after 10 weeks (O'Callaghan, 1994). Pyrethrin baths is a further treatment option. Ticks may also be removed manually. In the instance of blowfly infection, wash off and manually extract the maggots. Treat the raw lesions and remember to check inside the pouch for additional maggot numbers.

Prevention: As mites are usually the result of overcrowding, appropriate numbers in enclosures along with good husbandry standards is the best form of prevention. Swamp Wallabies can harbour the intermediate (cystic) stage of Tapeworm. The cycle involves dingoes and feral dogs. It is a possible source for spread to domestic animals and humans. Do not allow macropodid carcasses (especially viscera) that have not undergone a professional meat inspection to be eaten by dogs.

ENDOPARASITES:

Cause: This group contains a wide range of intestinal worms (including round worm, hookworm, tapeworm, whipworm, pinworm and other nematodes), parasites and liver flukes. Again healthy, wild Swamp Wallabies may carry quite a substantial amount with no ill effects, but the conditions become exacerbated by the stress of capture, high stocking rates and increased obesity caused by residing in a captive enclosure.

Signs: Signs and symptoms vary with the degree of infestation but may include weight loss, progressive anorexia and even death (Blyde, 1999). These signs will mainly be caused by strongyloides (Speare, 1982). Pneumonia and dyspnoea (difficulty breathing) may also occur and can further include anaemia, hepatitis and neoplasia (tumours or cancers).

Diagnosis: They can usually be detected in faecal analysis or faecal flotation.

Treatment: Mebendazole at the dose rate of 25mg/kg can be used and is especially effective on eliminating tapeworms. However care should be taken using Mebendazole as there have been documented reports of toxicity. Worming is required using treatments such as Panacur (15-50mg/kg depending on severity of infestation) as well as a regular worming program instigated.

Prevention: Prevention is available through parasite drenching given in the form of Ivomec Pour-On or ivermectin (Blyde, 1999). It is also important to maintain good hygiene by limiting access to faecal matter and removing faeces daily from enclosure. Off ground feed stations with anti-spill food hoppers should also be provided. The parasite load of Swamp Wallaby groups should be checked regularly by faecal examinations to monitor the degree of influx so as treatment options and further preventative procedures can be carried out. As a cause of endoparasite infestation includes overcrowding, low stocking rates within the enclosure should be maintained with excess *Wallabia bicolor* culled if no additional stock is required. However culling may be prevented by instigating contraception among captive Swamp Wallaby mobs. Contraception methods are outlined in Section 10.4.

BACTERIA

NECROBACILLOSIS or "LUMPY JAW":

Cause: Caused by a bacterial infection of a wound (*Fusobacterium necrophorum*), usually in the mouth, creating lesions that are necrotic, eroding and give off a characteristic odour. Lumpy Jaw is the single most important health problem for macropods held on exhibit, which has been recorded in all species in captivity (Munday, 1988). Once the bacteria have spread into the gum line they attack the jaw bones, resulting in the decay of bone and loss of teeth. Lumpy Jaw is generally associated with poor hygiene, overcrowding and a poor diet that contains soft foods such as fresh bread, pears and apples and inadequate roughage. These soft foods allow the gums to become soft, which then allows the bacteria to enter around the gum line, causing tooth root abscesses and swelling of the mouth (Jackson, 2004). Abrasions are commonly caused by coarse sharp feeds such as oat hawns.

Signs: Signs of Lumpy Jaw include facial swelling-usually apparent around the jaw and lip, tongue or neck, weight loss, excessive salivation, nasal discharge and flicking of the tongue. Other signs may also include difficulty in swallowing, laboured breathing, inflammation of the mucous membranes of the nose, dull or weeping eyes, poor coat condition and progressive weakness (Blyde, 1999; Booth, 1999).

Diagnosis: Diagnosis can be made by clinical signs and the use of an anaerobic culture. Lumpy Jaw should also be considered in differential diagnosis of facial abscesses in Swamp Wallabies.

Treatment: Treatment is possible but not very successful. Radial surgical treatment and antibiotic therapy may be effective in early cases where only the incisors are affected. Teeth extraction and drainage of soft tissues along with antibiotics-Clindamycin at a dose rate of 11mg/kg bodyweight or a large dose of penicillin (150mg/kg) every second day for approximately two weeks are the main treatment options in combating this disease. Euthanasia is commonly resorted to especially when the disease is at an advanced stage and there is little that can be done (Blyde, 1999).

Prevention: As predisposing conditions include overcrowding, trauma, unhygienic conditions and poor nutrition, prevention can be seen through the daily removal of faeces from exhibit yards as bacteria are found over the entire ground, particularly around feed areas, low stocking rates as this potentially increases the faecal contamination of enclosures and the removal of all affected wallabies into quarantine immediately after the disease is detected. When possible, contaminated enclosures that have had the disease spread throughout the exhibit should be rested for three to four weeks with disinfection of all the utensils that may have been contaminated (Jackson, 2004). It is also very important to provide all wallabies with food that is relatively hard, as this helps strengthen the teeth and gums. Recommended food items include long, dry grass, fibrous bark and pelleted food, as this will help reduce the incidence of Lumpy Jaw. Providing mature eucalypt branches with bark aids for a clean eruption of molar teeth as they progress in the jaw. It is also vital to avoid coarse, sharp feeds (such as oaten and Lucerne hay with a high proportion of stems) as they can cause injury to the mouth, allowing bacteria access (Jackson, 2004). Food should also be provided off ground to reduce the chance of ingesting bacteria.

Footvax vaccination has been suggested to prevent Lumpy Jaw; however its success is debatable (Blyde, 1994).

PNEUMONIA:

Cause: Common in hand-reared Swamp Wallabies if constant exposure to the cold occurs or through the inhaling of provided milk formula. Often associated with bacteria including *Pseudomonas* sp., *Klebsiella* sp., or *Escherichia coli* (Blyde, 1999).

Signs: General signs associated with pneumonia include dyspnoea (laboured breathing), anorexia, coughing after bottle feeding, difficulty in drinking and wheezing (Blyde, 1999).

Diagnosis: Clinical signs and auscultation of the chest.

Treatment: Initial treatment should include Dexadreson (1mg/kg intra venous) or through the use of antibiotics including Baytril (enrofloxacin) at 5mg/kg bodyweight subcutaneous or gentamycin 2.3-3mg/kg intramuscularly three times a day (Blyde, 1999).

Prevention: Preventing feeding milk formulas too quickly (otherwise it may be coughed up through the nose and enter the lungs) can aid in avoiding this disease from occurring (Blyde, 1999). Good hygiene standards of both Swamp Wallabies kept in captivity as well as those hand-reared indoors by changing artificial pouch lining daily, removing pouch faeces as soon as possible and keeping the joey at an ideal, constant warm temperature will also prevent the onset of pneumonia.

SALMONELLOSIS:

NOTE: CARE SHOULD BE TAKEN AS THIS IS A POSSIBLE ZONOSIS

Cause: Caused by the bacterium *Salmonella* sp. and may be carried by individuals with no clinical signs (Blyde, 1999). Poor hygiene and husbandry standards along with overcrowding are primary causes of this disease. There is often a high carrier rate amongst young wallabies and orphaned joeys and is frequently fatal.

Signs: The main visible sign is diarrhoea (black, tarry or unformed faeces) which can be detected by faecal analysis. Inappetence, depression, weakness, lethargy and pneumonia are further signs indicating a wallaby may be infected. Sudden death may also occur.

Diagnosis: Diagnosis may be confirmed via faecal culture.

Treatment: Treatment involving the use of antibiotics such as Excenel at a dose rate of 2mg/kg intramuscularly for 7-10 days or Baytril (5mg/kg) for duration of 7-10 days intramuscularly may also be used.

Prevention: Maintenance of high hygiene standards is the greatest form of prevention (e.g. low stocking rates, adequate number of off ground feeding stations, daily removal of faeces, good hygiene practices whilst preparing animal feed, storage of feed should prevent rodent/pest access, enclosure disinfection, etc.)

TETANUS:

NOTE: CARE SHOULD BE TAKEN AS THIS IS A POSSIBLE ZONOSIS

Cause: Caused by the bacterium *Clostridium tetani* entering an anaerobic wound from the soil (Jackson, 2004).

Signs: Prolonged contraction of the muscles and often sudden death. Convulsions with muscle stiffness and unsteady gait, often unable to eat due to stiffness in the jaws resulting in excess saliva production (drooling). Other signs include nostril dilation, laboured breathing and death as a result of convulsions and respiratory failure (Blyde 1994, 1999).

Diagnosis: Clinical signs (Blyde, 1999).

Treatment: Intravenous fluids, muscle relaxants such as diazepam (Valium) (2mg/kg intramuscularly), procaine penicillin at 30mg/kg intramuscularly and tetanus antitoxin and toxoid are suggested treatment options (Blyde, 1994).

Prevention: Begin vaccination when hand-reared animals start grazing or the injection of tetanus toxoid (1mL) intramuscularly (Blyde, 1994) will prevent the contraction of tetanus. This should be given two doses four weeks apart, then annually or opportunistically.

FUNGI AND YEASTS

CANDIDIASIS:

Cause: Caused by budding of yeast, *Candida albicans* which occurs frequently in joeys being hand-raised where hygiene is less than adequate, but can also appear in adult *Wallabia bicolor* under stress (Woods, 1999). A compromised immune system along with improper antibiotic use are further causes of Candidiasis.

Signs: The main signs are a reluctance to eat caused by difficulty in eating and swallowing accompanied by a distinguishing "yeasty" smell around the mouth or cloaca (Blyde, 1999, 1994). Diarrhoea with a yellowish-green and sometimes frothy or curdled appearance along with oral thrush resulting in the mouth becoming sore, appearance of ulcers and crusting around the mouth are also signs of Candidiasis. Severe cases may include oesophageal and gastric lesions.

Diagnosis: Diagnosis is made through Gram-positive stains of the faeces or oral cavity with high numbers of budding yeasts being used to confirm the diagnosis of *Candida*. The organisms are about half the size of a red blood cell and stain blue-purple.

Treatment: Treatment using an antifungal such as Nystatin up to 50 000 IU/kg three times daily over three to five days is usually successful in treating this disease.

Prevention: Prevention is obtained by maintaining high hygiene standards by frequently cleaning the macropod so that excess milk formula or urine does not build up. It is also important to minimize stress as it decreases an animal's ability to fight off infection (Woods, 1999). Proper antibiotic use will also aid in preventing this disease from occurring.

TRYCOPHYTON DERMATOMYCOSIS (Ringworm):

NOTE: CARE SHOULD BE TAKEN AS THIS IS A POSSIBLE ZONOSIS

Cause: Caused by an outbreak of fungus, *Trichophyton* spp. or possibly *Microsporum* spp. (Blyde, 1999)

Signs: Usually occurring in orphaned, hand-reared joeys Ringworm is identified by alopecia-small circular patches of hair loss that progressively increase in size and erythema with or without pruritis (Blyde, 1999).

Diagnosis: Can be detected from skin scrapings or under a Woods lamp. Culture and skin biopsies can also be used.

Treatment: Topical antifungal agents such as Conofite cream, Iovone washes or Halamid washes can be used in general treatment of ringworm (Jackson, 2004).

Prevention: Again high hygiene standards and upkeep is the major form of prevention when avoiding ringworm in Swamp Wallaby exhibits. Isolate affected animals from other juveniles (rarely affects adults) until the condition has resolved. Wear protective clothing when handling affected animals; and avoid handling as much as possible.

PROTOZOANS

COCCIDIOSIS or "BLACK SCOURS":

Cause: Caused by an intestinal parasite of the genus *Eimeria*. This disease occurs by transmission via direct faecal contamination of moist grazing areas used to exhibit wallabies and kangaroos over a long period of time.

Signs: Characterized by profuse black diarrhoea containing varying amounts of blood, it usually only affects younger macropods. Sudden death can occur within two or three days with no prior symptoms (Blyde, 1994, Woods, 1999). Most affected *Wallabia bicolor* will die. Coccidiosis may also be identified by depression, lethargy, anorexia, dehydration and severe weight loss.

Diagnosis: Clinical signs of Coccidiosis include the presence of oocysts in the faeces observed through faecal flotation, although the absence of oocysts in the faeces does not preclude diagnosis (Jackson, 2004).

Treatment: Medication with an anti-protozoal drug such as Amprolium and Toltrazuril can be used to treat Coccidiosis (Booth, 1999). Alternative treatment is through the use of Baycox at 25mg/kg bodyweight orally for three days using a syringe. The treatment should be given in combination with fluid replacement and treatment for diarrhoea (Blyde, 1999). If signs are severe, euthanasia should be considered (Booth, 1999).

Prevention: Coccidiosis is prevented by maintaining clean, dry yards, especially around drinking troughs, providing all food off the ground and not overcrowding exhibits so that stress is minimized. Employing good husbandry may also ensure the prevention of this highly pathogenic disease. Amprolium at 125 ppm in a pelleted diet has been suggested as being effective in preventing this disease (Finnie, 1974).

TOXOPLASMOSIS:

NOTE: CARE SHOULD BE TAKEN AS THIS IS A POSSIBLE ZONOSIS

Cause: *Toxoplasma gondii* is a small intracellular protozoan parasite that can affect any warm-blooded animal; however macropods, including *Wallabia bicolor*, seem to be extraordinarily sensitive to toxoplasmosis. Toxoplasmosis is transferred from cats, by macropods consuming food contaminated with oocysts shed in infected faeces. This is often the result of cats defecating on feed, such as Lucerne, while in storage, or on grass within the enclosure (Blandon, 1897). Infection with the protozoan is not always accompanied by disease as it often lies dormant in tissues awaiting a period of immunosuppression due to stress (e.g. illness, aggression from fellow macropods, etc) to produce clinical disease (Booth, 1999).

Wallabies evolved in the absence of cats and therefore have never developed an immune reaction to this particular disease.

Signs: Affected animals show various signs, including sudden death, neurological signs, respiratory distress and depression (Blyde, 1999). Once the disease begins, it often results in sudden death without any signs appearing. If early signs do occur they will include lethargy, inappetence, convulsions, diarrhoea, staggering, incoordination, circling and apparent blindness as a result of encephalitis and paralysis (Blyde, 1999). It is often associated with pneumonia.

Diagnosis: Diagnosis is usually based on clinical signs but this disease is inevitably fatal and most animals die before an accurate disease identification can be made.

Treatment: Treatment is usually unrewarding, but can be attempted using clindamycin (11 mg/kg body weight twice daily orally or intramuscularly for at least 30 days). Wellvone has also been attempted at a dose of 50-100mg/kg/day for at least 30 days, but results are again poor (Blyde,

1999). Those that are still alive are generally euthanased due to pain resulting from encephalitis associated with the disease (George, 1990).

Prevention: It is essential to restrict cat access to enclosures and food to prevent *Wallabia bicolor* from contracting this disease (Blyde, 1994, 1997). This can be achieved by sealing and storing all animal feed in air-tight metal containers in sectioned off storerooms. Also ensuring that the Swamp Wallaby's enclosure is free from any access areas/holes in fenceline due to lack of maintenance upkeep will also prevent feline entry into enclosures. Maintaining husbandry protocols such as removing faeces daily from exhibit, especially around feeding areas and changing substrate on a regular basis are further methods of prevention. Attempts have been made to develop a vaccine for the prevention of toxoplasmosis in macropods; however these have been unsuccessful to date (Lynch, 1993).

ENVIRONMENTAL DISEASES

HYPERTHERMIA:

Cause: Hyperthermia is distress due to an excessive rise in body temperature (above 38°C) and can occur from capture undertaken in high ambient temperatures or humidity; excessive chasing, leaving the animal in direct sunlight, overexertion in hot weather and from extensive water loss in poorly ventilated vehicles, crates or bags (Hume, 1989). Inadequate shelter provided within the exhibit will also lead to onset of Hyperthermia as well as poorly controlled artificial heating in juvenile Swamp Wallabies.

Signs: Signs of hyperthermia include panting, excessive licking of the forearms, sweating, rapid pulse rate and heart rate, elevated rectal temperature, general stress and agitation and eventual collapse, coma/unconsciousness or convulsions (Hume, 1989).

Diagnosis: Elevated rectal temperature (D. Blyde, pers. comm.).

Treatment: Immediately removing the animal from the heat source (e.g. exposure to direct sunlight) must be done first to prevent further heat exhaustion. Common treatment options include the use of steroids and cooling by hosing the animal down or covering with wet towels (care should be taken not to unintentionally induce Hypothermia).

Prevention: Avoid capture and restraint and transporting animals during the warmest part of the day (D. Blyde, pers. comm.).

HYPOTHERMIA:

Cause: Hypothermia is brought on by subnormal body temperature lower than 35°C. Commonly occurring in hand-raised joeys due to inadequate heating/insulation, prolonged exposure to low environmental temperatures for recently orphaned joeys left in a dead mother's pouch, inadequate facilities, advanced disease states and an overall lack of carer knowledge associated with species temperature requirements when hand-rearing marsupials. Low body temperature causes all metabolic processes to slow down so that tissue activity is reduced. Eventually, cell and tissue damage may result from a lack of blood, oxygen and nutrients. This may consequently lead to the death of the animal.

Signs: Signs include decreased heart rate, pulse rate and breathing, lethargy, inactivity, weakness, slow movement or appearing deceased, unresponsive and the fact that the joey is cold to touch. The Swamp Wallaby may not be able to suckle or feed.

Diagnosis: Diagnosis is able to be confirmed by the presence of decreased heart rate and through body temperature examination resulting in a temperature below 35°C.

Treatment: Slowly warming the Swamp Wallaby in a 37°C environment by use of heat pads, electric blankets, radiators and insulated warm water bottles with care as the joey is not to be warmed too quickly. Do not apply an exceedingly hot temperature directly to skin as burns may result. Wrap and hold the joey near to your body if no other alternative is available. Minimising heat loss through constant monitoring of both body and room temperature and treating underlying diseases causing Hypothermia are also appropriate treatment options. Warmed fluids such as paediatric physiological saline with glucose and lactated ringers (Hartmann's) administered by injection (parenterally) help to raise the core temperature and provides glucose to elevate the low blood sugar.

Prevention: Consistent observation of temperature of Swamp Wallaby joeys, monitoring heat source functions and obtaining vital information relating to temperature needs of *Wallabia bicolor* if considering caring for injured wildlife will see to the prevention of Hypothermia.

POST CAPTURE MYOPATHY (White Muscle Disease):

Cause: Degeneration of skeletal and cardiac muscle brought on by unusual exertion or anxiety. This occurs when an animal experiences the stress of capture, from excessive chasing of animals prior to capture and/or their struggle to escape from nets and catching bags at its maximum speed (Cole, 1994). Lactic acid builds up more rapidly than it can be metabolized, producing necrosis of muscle cells.

Signs: Affected animals show stiffness or even paralysis of one or more limbs, spasms of muscle groups (particularly the neck region), twisting of the neck, laboured breathing, tremors, tachycardia (rapid heart beat) or twitching of the limb muscles and a reluctance to move and even sudden death if the heart is affected. Signs can appear within twelve hours or may take weeks or months to affect an animal (Booth, 1999). However signs are usually observed between one and two days post capture. The degenerating muscle may also cause renal failure and the myoglobin released from the degenerating muscle results in myoglobinuria (the presence of myoglobin in the urine that makes it turn a dark shade of red) and may result in kidney failure. In some cases the Swamp Wallaby may die from acute heart failure without showing any of the above signs (Booth, 1999).

Diagnosis: A diagnosis can be made using clinical signs associated with muscle damage and the appearance of dark urine. Myoglobinuria may be present (Blyde, 1999).

Treatment: Treatment is only supportive and rarely successful however IV fluids, corticosteroids, Vitamin E, Valium, selenium and B vitamins can be administered to offer calming effects on the animal and prevent renal damage. Care needs to be taken when administering selenium as selenium toxicity can occur if overdosed. Wrapping towels soaked in iced water around the forearms, inner thighs, thorax and forehead may also be useful (Kakulas, 1963a) however once necrosis of muscle has occurred euthanasia is commonly resorted to (Booth, 1999).

Prevention: Swift and efficient capture and handling techniques are effective in preventing this disease. Undertaking quick captures during the coolest part of the day (when the temperature is less than approximately 20°C) is critical if hand-catching *Wallabia bicolor*. These temperatures are usually encountered during early morning or late dusk.

A very important prevention of Capture Myopathy is the use of Valium intra-muscularly at 0.5-2mg/kg immediately after capture. Vitamin E and selenium have also been used to prevent this disease occurring (Blyde, 1992). This may not be necessary for wallabies that are conditioned to handling or for very short procedures such as pouch checks, particularly if they are carried out in a fast and skilful manner (Vogelnest, 1999).

Myopathy may also be influenced by the size of the enclosure. Inadequate space for the Swamp Wallaby to exhibit natural behaviours must be avoided by complying with the set standards described by the EAPA-Minimum floor area of Swamp Wallaby enclosure: =60m² (EAPA, 1995).

SHOCK:

Cause: Shock can result from fear, trauma, injury and from immobilization drugs that depress respiration and induce severe hypotension (abnormally low blood pressure) (Hume, 1989). Shock is usually caused by a fall in either total blood volume (haemorrhage) or effective circulating volume due to vasodilation (an increase in diameter of the blood vessels which results in decreased blood pressure).

Signs: It is characterized by apathy, exhaustion (Hume, 1989), rapid pulse, pale or purple mucous membranes and cold extremities and will occur soon after suboptimal capture.

Diagnosis: Diagnosis can be confirmed by increased capillary refill times (greater than two seconds), weak pulse and decreased blood pressure (Blyde, 1999).

Treatment: Treatment involves the use of administered fluids and steroids yet can be easily prevented by avoiding stressful situations.

Prevention: Prevention can also be carried out through employing proper antibiotic use as well as minimizing unnecessary stress on the animal.

TRAUMA:

Cause: Significant trauma can occur to bones and soft tissue from collisions into fences and other obstacles, falls, impact damage from excessive speed in tranquilizer darts, entanglement in capture netting and hopping into fences at speed (Hume, 1989). Abnormal hernias can also result from males fighting.

Signs: Swelling around the face, lacerations, broken bones, unnatural or awkward hopping and bleeding (Jackson, 2004).

Diagnosis: Diagnosis can be made by radiography and palpation under anaesthesia or heavy sedation (Blyde, 1999).

Treatment: Depending on the diagnosis treatment can vary from further sedation, isolation from aggressive wallabies or euthanasia if severe case of trauma injury is presented.

Prevention: Maintain mobs of less agitated individuals which are easily stressed and flighty. Hand-rearing helps greatly as does providing adequately large enclosures so that if they become frightened from outside disturbances they are less inclined to injure themselves when colliding into fences or other obstacles.

NUTRITIONAL DISEASES

MALNUTRITION:

Cause: Malnutrition is one of the major problems seen in macropods in private ownership, and is usually the result of ignorance or an inability to obtain suitable food sources instead investing in feed containing insufficient or inappropriate total nutrients.

Signs: Weight loss, poor to emaciated condition, weakness, lethargy, failure to grow, stunted growth.

Diagnosis: Clinical signs.

Treatment: Increase total food intake of a balanced diet.

Prevention: The feed should provide all the nutrients available in the natural environment. For the larger macropodids this will be provided by adequate supplies of concentrates (kangaroo pellets or cubes), Lucerne, grass, vegetables and fruit. Care should be taken when observing the quality of some foods as many manufacturers have no quality control. Eucalypt branches with mature bark should be provided to maintain healthy gums and to reduce attacks on enclosure trees.

VITAMIN DEFICIENCIES:

Cause: The most significant vitamin deficiency to occur in *Wallabia bicolor* is vitamin E, which results in an increased rate of myopathy (Speare, 1982). Lack of exercise due to small enclosures.

Signs: Many and varied depending on the deficiency (Jackson, 2004) however paralysis and atrophy (wasting) of hind limb muscles may occur.

Diagnosis: Clinical signs and assorted vitamin levels tested and examined.

Treatment: Vitamin E supplementation in addition to implementation of an appropriate exercise regime. A correct diet and husbandry program is also vital

Prevention: Vitamin E supplementation as well as the introduction of selenium into the diet as it has been thought to increase the absorption of vitamin E. Exercise and the addition of artificial supplements to the diet will prevent Vitamin deficiencies occurring.

VIRUSES

HERPES VIRUS

Cause: Caused by one or more types of virus and there is a high mortality rate once infected (Speare, 1988).

Signs: General signs include conjunctivitis with pyrexia (fever) and often respiratory distress, uncoordination and death. It has also been found to result in ulceration of the genital tract (Munday, 1988). The clinical lesions to observe are blisters and ulcers in the mouth, cloaca and on the penis (Speare, 1988).

Diagnosis: Difficult to diagnose in live animals.

Treatment: All treatment options have proved ineffective to date and are only supportive, offering no cure.

Prevention: Difficult as the virus appears to be widespread in all macropods, not only *Wallabia bicolor*. Minimizing the amount of stress inflicted on the animal will aid in the prevention of this disease as well as practicing good husbandry. This can be seen through limiting the amount of times capture and restraint needs to be conducted by carrying out all procedures (e.g. weighing, treating a disease, transporting animal, etc.) in one capture under anaesthetic. Furthermore employing high hygiene standards will ensure that all *Wallabia bicolor* exhibited are healthy with no suppressed immune-system allowing them to be more susceptible to disease.

<p>NOTE: All medical or drug related treatments must be administered through qualified veterinary staff ONLY. Once animals show signs of any disease stated, seek veterinary advice immediately.</p>
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8.5 Quarantine Requirements

Quarantine and isolation are critical practices to prevent disease and illness from spreading within a facility.

All new arrivals need to be quarantined for a period of a minimum of three weeks to ensure that they are healthy and have no infectious diseases that could affect the other animals held in captivity. This also allows the spread of any possible viruses that are being incubated within the animal (Dixon, 1997). During this time, the animal can be treated for internal and external parasites, and diagnostic tests are to be performed if disease is suspected (Dixon, 1997). Three consecutive negative or acceptable faecal tests a week apart should be obtained before the animals are introduced to the collection. This period is also necessary to acclimatise the newly arrived animals to new diets, procedures and environments.

Once the animal has been cleared, it can then be introduced to other animals and be openly placed on exhibit, or into a breeding program. Constant monitoring for a prolonged period is also needed to observe the animal's behaviour and ability to adapt to its new found surroundings.

Animals that are showing signs of illness should be isolated to a quarantined area that is well away from the rest of the facility. Again this will help to prevent the potential outbreak of disease throughout the rest of the stock and help to monitor the individual progress of each patient. Care must be taken not to contract a zoonotic disease from handling sick animals (Armbrust, 1998).

Rehabilitated animals ready for release along with those prepared for pre-shipment are also to be placed in a quarantined environment. The same principles apply here as with other Swamp Wallabies requiring isolation.

Hygiene is of utmost importance and extensive precautions need to be taken when working in a quarantined/isolated vicinity. Requirements when entering quarantine facilities include (Tamworth TAFE Animal Care Teachers, 2004):

- Always disinfect your hands before entering isolation areas.
- Wear overalls, overshoes, gloves and masks when working in this area.
- Wash and disinfect overalls separately and dispose of gloves and masks into a separate garbage system.
- Have separate feeding, watering, cleaning equipment, stethoscopes and thermometers specifically for the isolation area.
- Before leaving place gloves, overshoes and masks in garbage, place overalls in laundry hamper for washing.
- Wash hands thoroughly with disinfectant wash prior to leaving the area.
- Contagious diseases may require all animals within a cage to be treated even if not showing symptoms.
- If it is at all possible one person should be in charge of quarantined animals to further reduce any risks of contamination.
- Very close observation and constant monitoring needs to be carried out during an animal's quarantined period.

9 Behaviour

9.1 *Activity*

Swamp Wallabies are predominantly nocturnal animals, resting in thick undergrowth, remaining in dense cover during the day and moving out to more open grassy areas to feed at night. Bimodal peaks of activity occur in the first three hours after sunrise and sunset (Coulson, 1978). Generally solitary, they have home ranges of up to six hectares or more and sometimes feed with two or more others.

Moving slowly they often seem relatively uncoordinated with the tail held high, often making high leaps into long grass. Moving fast they hold the head low and the tail horizontal.

9.2 *Social Behaviour*

They have been found to gather at common food sources with other unrelated animals without showing signs of territorial defence (Ellis, 2000). *Wallabia bicolor* have no known natural enemies, although feral dog and fox attacks have been recorded occasionally. When feeding time has completed *Wallabia bicolor* will disperse as individuals. The only predominant social behaviour evident in this wallaby species is during reproduction where a male and female will come together to mate.

9.3 *Reproductive Behaviour*

Males and females of the Swamp Wallaby species will associate without conflict; however the presence of an oestrous female often induces aggression between males. Medium sized macropods such as *Wallabia bicolor* will sometimes jump over each other, striking their opponent with their hind feet. Such display of hostile interactions can lead to severe injuries and in major conflict, even death. As a result of these spiteful contacts, a dominance hierarchy is established where the Alpha male has access to all close-ranged females when they are in oestrous (Jackson, 2004).

The copulatory behaviour is fairly uniform amongst all macropods, with the male following the female and investigating her cloaca. These behaviours are often associated with the male attempting to grip the female's tail as he emits a clicking sound; however Swamp Wallabies will generally remain silent. If the female is in oestrous the male continues to clutch the tail of the female and to follow her. Mating takes place when the female remains stationary and crouches with the male approaching from behind. Mating is detectable by examining the female's cloaca as it will contain a semen plug shortly after the mating, which is then expelled onto the ground (Triggs, 1990).

9.4 *Bathing*

As outlined in Section 4.6 the Swamp Wallaby is an exception to most macropod species as generally most macropodids do not bathe. *Wallabia bicolor*, however, are not repelled by water and will walk through and rest in wet areas to bathe and more commonly to alleviate heat exhaustion (Williams, 1999). Therefore it is necessary to provide suitable enclosure furnishings such as a stream or pond to allow exhibited Swamp Wallabies to explore these natural behaviours.

9.5 Behavioural problems

Some individual males, particularly males that have been hand-raised, can become aggressive and attempt to grab and kick anyone within their enclosure, especially when there is a female in oestrous. If an animal is showing aggressive behaviours, these can quite often be addressed by crouching down, as the animal will then think that the individual no longer poses a threat to its dominant position. Alternatively the head of a rake or shovel can be lifted over the head of the wallaby so that the macropod knows you are much larger than it and therefore more superior (Williams, 1999). It is also highly important one does not allow themselves to be cornered by the animal as this can allow the wallaby to grab and kick you more easily. If a wallaby does show consistent aggressive behaviour it is advisable to leave the enclosure and return later in the day.

Occasionally males will also behave aggressively toward each other if a female of a different species is in oestrous (Jackson, 2004).

9.6 Signs of Stress

Behavioural stressors include unfamiliar surroundings, unfamiliar animals, overcrowding, territorial or hierarchical upsets, changes in biological rhythms, courtship, lack of social contact or lack of isolation, and lack of habitual or imprinted foods. Miscellaneous stressors include malnutrition, toxins, parasites, infectious agents, trauma (including burns and surgery), drugs, chemical or physical immobilisation, transport, confinement, poor housing (suboptimal microclimate: temperature, humidity, air quality) and general boredom.

Major signs of stress exhibited in the Swamp Wallaby species will commonly include (Spielman, 1994):

- Licking of the forearms, paws, shoulders and flanks depending on the degree of stress (resulting in increased thirst)
- Vocalization (major indicator that stress levels are high as *Wallabia bicolor* species are generally silent)
- Flinching
- Escape attempts
- Avoidance/hiding
- Thumping the ground with the hind feet
- When Swamp Wallabies sense danger approaching they swish their tails about on the ground. However some male *Wallabia bicolor* also demonstrate tail swishing when sniffing a female to see if she is ready for mating.
- Body trembling
- Head shaking
- Ear flicking
- Teeth grinding
- Reduced food intake (associated with chronic stress)
- Diarrhoea
- Chronically stressed animals may refuse to eat or drink or some may enorge themselves.

9.7 Behavioural Enrichment

Although not requiring as much active enrichment as other animal groups, there are several activities and procedures that are able to be carried out to provide behavioural enrichment for the Swamp Wallaby. These may include:

- Providing substantial quantities of browse throughout enclosure using assorted species of foliage (refer to Section 6 for suitable types) and placing them at different heights and locations in PVC piping.
- Hiding or scattering food throughout the enclosure to stimulate foraging behaviours.
- Providing tussocks and other nesting material to encourage *Wallabia bicolor* to create individual hip-holes for comfort whilst promoting natural nesting behaviours.
- Installing a water-based structure such as a stream or pond to encourage Swamp Wallabies to explore their natural bathing behaviours and activities. Ground sprinklers may also be used to promote these behaviours, especially during dry summer months.
- Social scent markings (faecal matter), from neighbouring Swamp Wallabies, may be placed inside enclosure to encourage *Wallabia bicolor*'s olfactory senses.

9.8 Introductions and Removals

When animals are introduced for the first time, particularly males, they may show some aggression towards each other until a hierarchy is determined within the group (Jackson, 2004) as wild Swamp Wallabies will generally avoid each other in their natural habitats so as no competition of territory is encountered. This is obviously unavoidable in captivity but will suppress in time (Jackson, 2004).

When introducing a new animal into a yard, Hessian or shade cloth should be hung on all fences to prevent them colliding with the wire netting, which they can find difficult to see if they are running wildly. Sometimes the most minimal noise will trigger panic in newly introduced Swamp Wallabies.

Releasing a hand-raised joey into a captive group will be a fairly slow-paced process. Initially, when the time comes to get the animal used to the captive surroundings it is recommended for the first weeks it should spend a few hours each day, with the carer primarily, in the exhibit it is to be placed in (if possible with a fellow quiet hand-raised joey or with the group that it originated from). When the Swamp Wallaby appears quite calm and sedated and moves about comfortably in its new area, it should be taken there (Williams, 1999). This process is repeated daily for the next few weeks. Eventually the joey is then able to be left overnight once it appears settled. Ultimately, when the wallaby is totally established it is then able to be assimilated into the already established wallaby mob residing within the enclosure.

9.9 Intraspecific Compatibility

The type of social organisation designated for *Wallabia bicolor* species is considerably solitary except during reproduction. Therefore the suggested sex ratio of this macropod species is 1:2-3. It is very important not to overstock enclosures as this can lead to greater competition for food and resting sites, resulting in higher levels of aggression, stress and disease of, particularly subordinate, animals. The total number of Swamp Wallabies held and the sex ratio also depends on the total area available and number of shelters accessible.

9.10 Interspecific Compatibility

Swamp Wallabies have successfully been held with Agile Wallabies, Parma Wallabies, Red-necked Wallabies and Tamar Wallabies with no instances of aggression. However hand-reared Tamar Wallaby and Swamp Wallaby joeys have been observed interacting in “playful wrestling” whilst young with no ongoing aggression resulting between the species as they develop into adults (Williams, 1999). Although there have been no reported attacks on Swamp Wallabies by Matschie’s Tree Kangaroos it is not advised to house these two species together as the Matschie’s Tree Kangaroo has had numerous aggressive behaviours reported towards other wallabies such as Dorcopsis Wallabies and Grey Dorcopsis Wallabies whilst held together in captivity (Steenburg, 1984). Medium-sized macropods, such as the Swamp Wallaby have been held with many species of birds including Cape Barren Geese *Cereopsis novaehollandiae*, Black Swans *Cygnus atratus*, Jabirus *Xenorhynchus asiaticus*, Magpie Geese *Anseras semipalmata*, Emus *Dromaeius novaehollandiae*, Brolga *Grus rubicunda* and numerous species of ducks (Anatidae) as well as with Fallow Deer *Dama dama*.

9.11 Suitability to captivity

One could argue, due to the species’ solitary temperament, that holding wild *Wallabia bicolor* in captivity will be viewed as unnecessary stress infliction on the species. As individual Swamp Wallabies are flighty by nature it is discouraged to house the animals in walk-through enclosures where the public have close contact to the wallaby, potentially causing agitation for those exhibited.

Many wild-caught animals fail to adapt to the captive environment. Hand-rearing Swamp Wallaby joeys will increase the macropod’s suitability for captive life as human interaction will subdue the species innate, erratic behaviours which will result in the species performing better as a displayed animal.

10 Breeding

10.1 *Mating System*

The Swamp Wallaby is a polygynous macropod (the condition or habit of mating with one or more females). Within the *Wallabia bicolor* species a single male is generally placed with up to five or six females (Jackson, 2004). Subadult males are usually permitted within the recommended sex ratios (1:2-3), however they should be removed before sexual maturity (occurring at the age of 15 months).

The mating procedure of the Swamp Wallaby will last for approximately 10-20 minutes in length. A male will usually approach a female from the rear, sniffing her urogenital opening and her urine to analyze if she is coming into oestrous. He will then grab at her tail and back with his forepaws and may nip the female's rump. Males will usually mark the fur on the females back with their sternal (chest) scent gland by grabbing her around the waist from behind and rubbing against her. The female will not allow a male to mount her unless she is totally in oestrous.

Wallabies are known for their impatience during the mating procedure. Often more than one male will be seen relentlessly following the female, sometimes causing her to become quite distressed, especially in warm weather (Williams, 1999).

When copulation does take place the male stands behind the female, grasping her around the waist with his forearms. The mating stance of the female may vary. On occasion the female will stand otherwise she will crouch on all fours with their hindquarters raised (Williams, 1999).

10.2 *Ease of Breeding*

Generally the Swamp Wallaby breeds extremely well in captivity due to the species ability to exhibit embryonic diapause and the fact that there is no defined breeding season as it is a continuously reproducing macropod. Vast populations reported of *Wallabia bicolor* in assorted captive environments reflect the fertile nature of this wallaby.

10.3 **REPRODUCTIVE CONDITION**

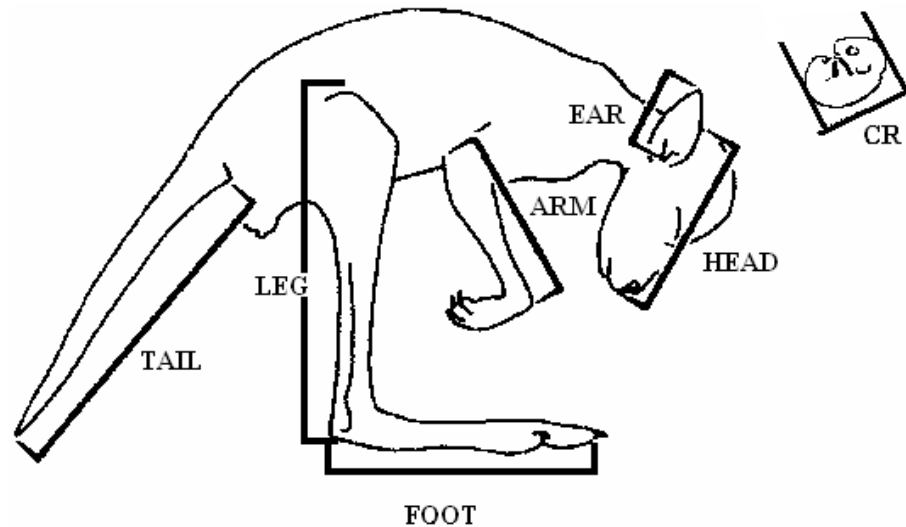
10.3.1 *Females*

- Non-parous (females that have never bred)-Pouch small with no skin folds, clean and dry teats, teats very small.
- Parous (females that have bred previously but not presently)-Pouch is small but distinct, dry and dirty, the teats are slightly elongated.
- Pregnant-Pouch pink in colour and glandular in appearance, skin folds may be observed on the lateral margins of the pouch.
- Pregnant: Pouch young present-attached to teat.
- Lactating (young absent from the pouch but continuing to suckle): Pouch area large, skin folds flaccid (limp not firm), hair sparse and stained, skin smooth and dark shade of pink, teats elongated.
- Post lactation with teats expressing only clear liquid and/or regressing.

If pouch young are present, a number of measurements can be recorded and compared to existing known growth progress. These will include:

Measurements

- Weight (grams)-if not on teat.
- Head length (mm)-from the occiput to snout tip.
- Head width (mm)-maximum width across the zygomatic arches.
- Crown rump length (mm)-primarily for very small neonates.
- Body length (mm)-from snout tip to cloaca.
- Tail length (mm)-from cloaca to the end of the last vertebra of the tail tip.
- Tibia tip (mm)-from the hip to the bottom of the pes.
- Pes length (mm)-from the heel to the base of the longest toe, not including the claw.



Picture: Calculating juvenile measurements. Obtained through (Jackson, 2004)

10.3.2 Males

Sexual maturity will occur at 15 months of age in male *Wallabia bicolor* as sperm will appear in the reproductive tract. Other than this, the reproductive condition of Swamp Wallaby males is not easily defined.

10.4 Techniques Used to Control Breeding

As the Swamp Wallaby is a continuous breeder and able to reproduce very frequently a number of techniques have been devised to use in situations where many *Wallabia bicolor* are held together. These include:

- Separation of the sexes
- Vasectomy of the dominant male (can also include all independent males)
- Castration of all breeding age males
- Removal of pouch young
- Contraception (still in developmental stages in which *Wallabia bicolor* is involved-refer to Introduction)
- Tubal ligation in females
- Culling

Combination of techniques may be used to ensure that maximum control of breeding is reached- e.g. vasectomy of dominant male as well as pulling any young, or non-preferred sex that may be produced from subordinate males.

10.5 Occurrence of Hybrids

Care needs to be taken that hybridization does not occur between different species of macropods. Those recorded to hybridize with *Wallabia bicolor* and therefore should be avoided being housed together include the Common Wallaroo *Macropus robustus robustus*, Red-Necked Wallaby *Macropus rufogriseus*, Agile Wallaby *Macropus agilis* (Close and Lowry, 1990) and the Red Kangaroo *Macropus rufus* (J. Thomas, pers. comm.).

Numerous hybrids have been produced to date, however they generally are not fully fertile as they usually have deformed reproductive organs, including empty scrota, small testes, no spermatogonia and small non everted teats (Lowry, 1990).

10.6 Timing of Breeding

Births in captivity have been recorded from January-May and October-December (Salisbury, 2002) however in the wild there appears to be no sharply distinguished breeding season as Swamp Wallabies are continuous breeders and will breed persistently throughout the year. The Swamp Wallaby is also the only macropod with a post partum oestrous.

10.7 Age at First Breeding and Last Breeding

Wallabia bicolor are sexually mature at 15 months (Strahan, 1995) and will generally reproduce until death-15 years on average (Jackson, 2004).

10.8 Ability to Breed Every Year

All macropods have the ability to breed every year with *Wallabia bicolor* being no exception.

10.9 Ability to Breed More than Once Per Year

Females are polyoestrous, able to breed all year long and exhibit embryonic diapause. As a result of the species exclusive oestrous cycle and gestation period (refer to 10.12) the Swamp Wallaby is able to breed every 8 months on average, however *Wallabia bicolor* are not able to fully raise more than one young in a year. After post partum oestrous occurs it will result in an embryo in the state of diapause in which a blastocyst is formed. The neonate is then born shortly after the joey in the pouch vacates the pouch permanently. The wallaby is then able to have three young at different stages of development: 1) one in a state of embryonic diapause, 2) one in the pouch attached to the teat, and 3) one which has vacated the pouch permanently and which will put its head into the pouch to feed (Jackson, 2004).

10.10 Nesting, Hollow or Other Requirements

No nesting or hollow requirements are necessary in order for Swamp Wallabies to breed however providing grass tussocks will allow the Swamp Wallaby to create a hip-hole for comfort during mating and pregnancy.

10.11 Breeding Diet

There is no specific breeding diet that is required prior to or during the Swamp Wallabies breeding season however additional browse may be supplied for further nutritional intake.

10.12 Oestrous Cycle and Gestation Period

The gestation period of the Swamp Wallaby is 33-38 days long while the oestrous cycle is on average 34 days in length. This species is therefore unique in that it is the only marsupial whose gestation period is longer than their oestrous cycle (Ellis, 2000). This means that females are able to mate during the last few days of their pregnancy allowing them continuous breeding and birthing every 8 months. After this mating occurs, a near term foetus will be growing in one uterus while the new embryo is developing in a second. The suckling of the newborn temporarily halts the development of the second embryo which remains dormant until the first young is ready to leave the pouch. At this the time, the second embryo resumes development and is born 33-38 days, the length of one gestation period, later.

10.13 Litter Size

Females will usually give birth to one young per cycle although twins have been reported. Twins are known to occur about once in every 500 hundred births, but usually only one will survive to the young-at-foot stage of development. When twins occur in captivity it is more likely that both will survive as the female has guaranteed ample food supply and no predators to contend with.

10.14 Age at Weaning

The average age of a Swamp Wallaby joey when weaned is 64 weeks of age.

10.15 Age of Removal from Parents

The pouch life of the young is complete by 8-9 months (34 weeks) but will continue to suckle as a young-at-foot until approximately 15 months. After this time period has ended young are then to be removed from their parents as the parents also may become intolerant of them.

10.16 Growth and Development

Following the joey's birth, the young, normally weighing less than 1g and will spend the next 8-9 months in the mother's pouch developing. The young can usually be sexed within a few days to three weeks after birth.

There are no visible external ears or eyes at birth. The foetus is very red in colour at this stage and climbs instinctively and unaided through the fur, using its forearms alternatively, for a distance of 15 to 20cm up the mother's stomach to the pouch entrance. The claws that the foetus uses to climb to the pouch are shed soon afterwards and new permanent ones grow (Williams, 1999).

The joey's life until it reaches independence can be divided into three stages. The first stage, while it is permanently attached to the teat, is total dependence on the pouch for milk and warmth. In the second stage, when it is in and out of the pouch, the joey is not as dependant on the pouch for warmth as it has started thermoregulating itself, but it is still quite dependant on the now stronger milk. The major growth stage is preparation for the permanently out of the pouch third stage, when the joey is eating a great deal of solid food and does not rely as much on milk.

Certain physical changes occur during the pouch life of a Swamp Wallaby joey. The following measurements illustrate various growth features during pouch life.

Permanently attached to teat: 95 days

Ears free: 100-120 days

Eyes open: 120-135 days

Soft fur on head: 150 days

Fully furred: 230 days

In and out of pouch: 160-260 days

Note: The last number in the 'In and out' column represents the length of pouch life.



Picture: Three Swamp Wallabies approximately five, six and seven months old (Williams, 1999)

The next table demonstrates growth measurements of the Swamp Wallaby segmented into assorted body measurements.

Age in days	140	160	180	200	220	240	260	280	300
Head (mm)	64	72	80	84	87	91	96	99	103
Leg (mm)	90	113	136	149	164	175	185	195	204
Foot (mm)	75	90	115	126	135	142	148	153	157
Weight (grams)	300	450	650	960	1350	1825	2400	3250	3750

11 Artificial Rearing of Mammals

11.1 Housing

Minimizing stress when a Swamp Wallaby joey is first taken into care is a major consideration. Choosing suitable housing can aid in creating a stress-free environment. Therefore it is vital that the following factors are taken into account when preparing a home for a joey:

- Ensure the area is secure from children and other animals, especially domesticated cats and dogs.
- Maintaining the area in a hygienic manner with all disease agents eliminated.
- Escape-proof fencing is installed.
- Clearing the area of obstacles and hazards
- Ensuring the area offers shelter from the weather and noise and disturbances (Jackson, 2004).

When first presented, joeys are usually hypothermic and will need to be warmed in a pouch with a heating unit (e.g. heat pad) set at 32-34°C (Booth, 2002). Furless and furred joeys are best kept in an artificial pouch made of non-synthetic fibres such as cotton flannelette that is placed in a woolen pouch, including woolen jumpers or windcheaters and kept in a consistent warm environment. Pouches must be washed and disinfected every day as bacteria and yeasts thrive in unsanitary and warm conditions (Bellamy, 1992). Another technique that has proved successful for unfurred joeys is to place the joey and its pouch inside an esky. A hot water bottle at a temperature of approximately 40°C is placed on the bottom of the esky, which is covered in a sheepskin rug. At each feed, remove one cup of water and replace it with a cup of boiled water. The temperature is monitored using a thermometer and adjusted as required (J. Cowey, pers. comm.).

Once the joeys become fully furred and ready to start exploring outside the pouch, they can be placed in hanging pouches that allow them to go in and out at their own free will. There should also be a towel folded up underneath them (Austin, 1997).



Picture (left of photo): Example of joey artificial pouch housing (Williams, 1999).

11.2 Temperature Requirements

In regards to thermoregulation (temperature control), for the first half of its pouch life the pouch young has no control over its temperature. During the second half it gradually develops the capacity, being able to shiver first, then is able to control temperature fairly well when the fur develops at about 2/3 through pouch life. Complete ability to control temperature does not develop until permanent evacuation therefore artificial heat sources must be made available. Heating methods include (human) body warmth, sheepskins, heat pads, hot water bottles, electric blankets, heating rooms and pouch bags. The temperature of the bag should be 32-36°C if the joey is furless. As the joey grows fur the temperature can be reduced to 28-30°C when fully furred (Bellamy, 1992; Austin, 1997). The correct temperature can be maintained with the use of hot water bottles (that are well wrapped in towels, as they have the potential to burn a joey's skin) or heat pads. Care should be taken not to overheat Swamp Wallaby joeys. A minimum/maximum temperature gauge with a plastic-coated probe that can be placed next to the joey should be used, as this will ensure that the temperature is constantly monitored (J. Cowey, pers. comm.). When using heat pad devices joeys should be insulated from the pad surface by inserting layers of woolen fabric between them and the pad. The thickness of insulation required will depend on the room temperature and should be adjusted so that the young wallaby appears comfortable. This method is to be carried out when the room temperature exceeds 10°C. As the room temperature drops below 10°C animals should be as close as practicable to the pad surface. The heat pad usually produces a temperature on the pad surface of about 20°C above room temperature. Therefore measure the temperature where the animal rests with a thermometer. It should be between 27°C and 35°C. Note that young animals can rapidly suffer heat stress if the temperature of the pad is too high.

11.3 Diet and Feeding Routine

Natural milk: The concentrations of assorted milk components generally change throughout lactation in *Wallabia bicolor* with the carbohydrate content decreasing towards late lactation and protein remaining relatively steady, but with a small peak in mid lactation. Lipids, however, show a marked increase in concentration towards late lactation.

Milk Formulas: The three low lactose formulas mainly used for hand-rearing Swamp Wallabies include:

- **Biolac:** The first formulation to be used is **M-100** on all furless macropods. When dense fur has developed, progress to **M-150**, which is a transition milk. Then, when the animal produces solid, dark pellet droppings, change to **M-200**, which contains elevated lipid in the form of canola oil. To change between formulas use a ration of 3:1 for the first week, then 2:2 for the second week and finally 1:3 for the third week and fully onto the next formula the following week. As the joey progresses to weaning, the level of lipid in the mother's milk continues to increase, this lipid is a major source of energy for the young. When the joey is nearing weaning, add 2-5ml of canola oil per 100ml of formula. Joeys should be fed 10-15% of their body weight per day. (Refer to page 76, Appendix B for dietary analysis of Biolac milk formulas).
- **Wombaroo Swamp Wallaby Formula:** Use Wombaroo as a complete food for rearing orphaned joeys. Maternal milk supplies immunoglobulins throughout much of lactation, providing immunity to diseases and intestinal protection due to its many antimicrobial

properties. Success in hand-rearing joeys will be improved if **Impact Colostrum Supplement** is added to the Wombaroo milk for up to five days when first coming into care and repeated later if necessary. Milk should be warmed to approximately 30°C and fed using a bottle and teat. The following points should be constantly referred to when feeding Wombaroo mixtures:

- Milk energy and daily energy requirement determine milk feed volume.
- Increasing body weight ten times only increases milk volume seven times.
- Increasing body weight decreases milk volume as percent body weight.
- Increasing milk energy decreases milk volume as percent body weight.

The following table displays specific measurements used to feed Wombaroo Milk Formula to *Wallabia bicolor* (Wombaroo website and booklet, www.wombaroo.com):

MILK	AGE (days)	LEG (mm)	FOOT (mm)	WEIGHT (grams)	FEED (ml/day)
<0.4	Up to 110	65	47	160	As per label
Transition from <0.4 to 0.4	111 to 113		30ml <0.4 + 10ml 0.4		40
	114 to 116		20ml <0.4 + 20ml 0.4		40
	117 to 119		30ml <0.4 + 30ml 0.4		40
0.4	Up to 160	115	86	550	As per label
Transition from 0.4 to 0.6	161 to 163		40ml 0.4 + 20ml 0.6		60
	164 to 166		30ml 0.4 + 30ml 0.6		60
	167 to 169		20ml 0.4 + 40ml 0.6		60
0.6	Up to 200	152	119	1110	As per label
Transition from 0.6 to 0.7	201 to 205		70ml 0.6 + 10ml >0.7		80
	206 to 210		50ml 0.6 + 30ml >0.7		80
	211 to 215		30ml 0.6 + 50ml >0.7		80
	216 to 219		10ml 0.6 + 70ml >0.7		80
>0.7					
Emerging from pouch	220			1470	As per label
Fully out of pouch	260			2310	◆◆

◆◆Feed volume now depends on other food eaten. Growth rate is now approximately 25g per day.





- **Di-Vetelact (Digestlact):** A widely used low lactose milk formula. Swamp Wallabies, be they pink (no fur) or furred begin with their milk strength 100/1. 100/1—consequently translates as 100ml of cooled to warm temperature boiled water to 1 scoop of Di-Vetelact or Digestlact. Over the rearing time, the formulas will reduce to 50/1 with 2 teaspoons of Farex in 200mls of milk—which will exist as the joey's milk total for the day. The joey is fed a minimum of 10% of body weight per day however the majority of joeys are contented with 15%. Due to its low energy concentration when prepared as directed, some experts advise the addition of mono and polyunsaturated fats such as canola oil as with Wombaroo diets. There has been some suggestion that saturated fats in the form of cream are too highly saturated and can lead to malabsorption of calcium. Some 2-5ml canola oil can be added per 100ml milk during the last phase of milk feeding (Messer and Walker, 1992). Various institutions also add a tablespoon of High Protein Baby Cereal per litre for unfurred joeys (G. Males, pers. comm.). Joeys require 5 feeds per day at 4 hourly intervals and will take between 10mls to 20mls per feed—15mls being ideal. The following points should be constantly referred to when feeding Di-Vetelact mixtures:
 - Always test the milk temperature on your wrist before feeding the joey.
 - Make up a fresh mix of milk every 24 hours and store in the refrigerator.
 - Do not reheat left-over milk. Use fresh milk in every bottle.
 - Always use boiled water to make up milk.

Cow's milk is not recommended for feeding to marsupials as it contains vast quantities of fat and lactose, which are poorly digested and result in dehydration, diarrhoea and in some rare instances, cataracts due to nutritional deficiencies (Stephens, 1975; Messer pers. comm.). As joeys are lactose intolerant many will also die. Furthermore, only small weight gains can be expected if cow's milk is used, with the energy intake being well below the amount required to satisfy the normal diet.

Gut flora are established by offering dry dirt and fresh grass (species only known to be consumed by wild *Wallabia bicolor*—refer to Section 3.4) as macropods (including adults) are known to eat soil, a habit known as pica. The development of gut flora can also be encouraged by including half a teaspoon of natural yoghurt or a pinch of acidophilus powder, that is not pasteurized, in the chosen formula daily until the faecal consistency appears normal (Austin, 1997; J. Cowey, pers. comm.).

Feeding Apparatus: Very small joeys are able to be fed using a syringe fitted with a plastic intravenous catheter or one-inch length of infant gastric feeding tube. As the Swamp Wallaby grows it will be able to be fed with a plastic bottle feeder (50ml or 100ml) attached with specially designed wallaby teats. Teats should resemble mother's shape and length for mouth comfort, fit and correct tooth eruption. Wallaby teats get longer as the joey grows, so progression to longer teats is essential. Most joeys will refuse the teat the first few times the apparatus is offered. Introduce it into the side of its mouth and squeeze no more than a drop or two of milk into its opening. The joey will soon recognize the use of the bottle's teat. However careful consideration must be carried out when performing this as fluid can enter the lungs and cause pneumonia. Cover joey's eyes with your hand for extra security. If milk bubbles from the nasal passages occur, the joey is being feed incorrect. This may be due to the hole in the teat being too large and the joey being held in the wrong position whilst feeding takes place. The tip of the teat should be pierced with a hot needle to create a hole about 1mm in diameter, or for a larger joey, a hole may be cut using scissors. The hole should be large enough for milk to drip out slowly, when the bottle is inverted.

Feeding teats and bottles have been designed to specific strengths and texture for a large range of young animals by both Biolac and Wombaroo companies. The following pictures are examples of such teats available:

 <p>STM</p>	<p>STM-Small in-pouch kangaroos, wallabies, possums. Available through Wombaroo stockists.</p>	 <p>MTM</p>	<p>MTM-In-pouch kangaroos, wallabies, koalas. Available through Wombaroo stockists.</p>
 <p>TM</p>	<p>TM - Out of pouch kangaroos and wallabies. Available through Wombaroo stockists.</p>	 <p>T1</p>	<p>Long Joey teat. Hard or soft. Available through Biolac stockists.</p>

Picture: Assorted teat graphics obtained through Biolac and Wombaroo websites: (www.biolac.com, www.wombaroo.com).

Feeding Routine: It is important not to feed the milk formula too quickly; the rate at which the milk is squeezed into the mouth should not be faster than the rate at which it is swallowed.

Too much milk results in an accumulation in the pharynx/throat, which is suddenly sneezed or coughed out the nostrils. To avoid this, extreme care should be taken of the rate at which milk is released to the Swamp Wallaby joey with use of a smaller hole on teat surface if required.

Milk should be fed at approximately 36°C or otherwise directed on label.

The number of feeds changes as the joey develops (Bellamy, 1992). Very young, unfurred joeys should be fed every two to three hours around the clock. Once the joey is taking the required volume needed over a 24 hour period the night feeds are then able to be reduced. For furred joeys, the number of feeds is decreased to five and the volume increased per feed. At full emergence, when it is fully furred, the number of feeds is reduced to two or three per day (night feeds are not required) and the joey is given access to grass and finely chopped carrots, sweet potatoes, kangaroo cubes and apples. Due to the Swamp Wallaby's browsing nature the joey should also be given access to leaves, native shrubs such as wattle, eucalypt branches and tree Lucerne.



Picture: Swamp Wallaby joey (Image by Sue Ulyatt, 2004-2006)

11.4 Specific Requirements

Weigh the joey regularly. Consistency in growth rate is a good measure of correct nutrition. Animals have an optimum, or ideal, growth rate that allows development to occur in a controlled manner. A growth rate in excess of this optimum may lead to obesity and possible skeletal

deformities. A sub-optimal growth rate may lead to poor development and a more disease prone animal. A continuing decline in growth rate could herald the onset of disease or indicate dehydration in the Swamp Wallaby.

When first brought in for hand-rearing, the joey may be dehydrated, so it may be necessary to supply plain boiled water with 5g (one teaspoon) of glucose to 100ml of water or 1g of electrolyte replacer if available (Austin, 1997). Young wallabies drink water when thirsty. It is therefore important to provide drinks of water during periods of hot weather. Supply joeys with small drinks of water between feeds once they begin to emerge from the pouch. Ensure drinking water is available when joey is fully out of pouch.

Young joeys suckle small volumes of milk frequently and can only cope with large, infrequent feeds as they become older. As a rule, it is preferable to feed a little often rather than a lot infrequently. It is important to warm the joey prior to feeding to avoid the risk of inhalation pneumonia. If this takes too long, administer fluids subcutaneously and bottle-feed later. If the joey is extremely cold, place it in a warm water bath and dry it off rather than put it in a hot box (J. Cowey, pers. comm.).

Wild Swamp Wallabies satisfy their nutritional needs by foraging for a variety of assorted food and browse. It is difficult to regularly supply a captive animal the diversity of vegetation found in its natural diet. Therefore it is inevitable that hand-reared wallabies are usually fed diets composed of foods that are easily accessible. It is hence vital that care be taken when selecting food types to avoid dietary deficiencies or imbalances due to a lack of variety in the diet. The level of nutrition should also be cycled throughout the year. Increasing the nutritional value of the food above maintenance level as the breeding season approaches is to be carried out. Continue offering food of high nutritional value during the breeding season then reduce it back to maintenance level once the young have achieved independence (Rich, 1992).

The well-being of captive, hand-reared *Wallabia bicolor* is influenced by the quality of their environment as well as their diet. The captive environment should represent, as close as humanly possible, that found in the wild. The enclosed area used for rearing the wallaby should mimic the environmental conditions and natural regions of the Swamp Wallaby by ensuring the vicinity is as large as possible and contain the necessary features such as leaf litter, branches and secure, sheltered hiding places that the animal would normally encounter.

The skin of unfurred joeys and slightly furred young should be kept moist with the use of Sorbelene cream (with no added glycerine) so that the wallaby does not become dry and cracked (George, 1995). Alpha keri oil applied three times per day and unscented vitamin E cream may also be used to lubricate the joey's skin. Baby oil does not appear to be properly absorbed and tends to stay on the skin surface where it rubs off and is soaked up by the liner bag fabric (George, 1995).

Stress is a major problem in the successful rearing of native mammals and can often be fatal. Therefore it is important to keep noise to a minimum, not to overhandle the Swamp Wallaby and to constantly maintain high standards of hygiene (A.Gifford, pers. comm.).

It is also important to teach your joey to flip into its pouch. If the female does not know how to flip, she will never be able to teach her young. The joey should proceed head first, and then roll the rest of its body into the pouch in one single action. From here the joey is then able to put its head out and look around at its surroundings.

In regards to holding a joey very small pouch young should be cradled in your hands. They should not be picked up around the ribs without being supported under the tail and back legs as this will make them feel very insecure and may result in spinal injuries.

Unfurred joeys should be massaged or gently moved about in their pouches after each feed to exercise their muscles. This mimics conditions in the mother's pouch, where a joey is subject to constant movement as the mother moves about. Short-furred joeys can be put out for a few minutes in a warm environment to exercise their muscles and lungs, important for their well-being. Older joeys should be allowed to get in and out of their pouches when they wish.

11.5 Data Recording

When an animal is first brought in for hand-rearing, its sex and approximate age, using growth charts, should be recorded. During the hand-rearing process a number of important pieces of information should be recorded. This information serves several purposes including providing important background information such as food consumption which will assist a veterinarian reach a diagnosis if the animal falls ill or fails to grow or gain weight. The following information should be recorded on a daily basis (Jackson, 2004):

- Date
- Time when the information is recorded
- Body weight to the nearest 1g if possible
- General activity and demeanour
- Characteristics and frequency of defecation and urination
- Amount (grams) of assorted food types offered
- Food consumption at each feed
- Veterinary examinations and results
- The developmental stages and measurements should also be recorded on a weekly basis

11.6 Identification Methods

Visual identification or implant chips (once the individual is fully furred) are very useful methods of identification. Once the animal is weaned, other techniques are able to be used (Jackson, 2004).

11.7 Hygiene

Maintaining a high standard of hygiene is critical to the survival of the Swamp Wallaby joey. Emphasis must be placed on the following key protocols (Jackson, 2004):

- Maintain a clean pouch lining at all times. Older joeys are able to be trained to urinate on newspaper by keeping a piece of newspaper with the smell of urine implanted 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 of separate joeys if more than one is in your care.
- Use boiled water when making up formulas for very young joeys to prevent disease and bacteria spreading.
- Clean spilt milk formula, faeces and urine from the joey's skin and fur instantly, and then proceed to dry the animal.
- Wash all feeding equipment in warm, soapy water and sterilize it in a suitable antibacterial solution such as Milton, or boil utensils for 10 minutes. After each instrument is sterilized, rinse the equipment in cold water.

- As many teats are made of a natural product, Latex, deterioration can be slowed by storing teats in an opaque, airtight container. Alternatively many carers store the teats and bottles in the fridge after they have been disinfected (J.Cowey, pers. comm.).
- Only heat up milk once and discard leftovers.
- Avoid contact with other animals unless you are sure they pose no health risk.
- Stimulate to toilet before or after feeding. As with other macropods and marsupials, toileting can be achieved by the application of warm water to the cloaca using cotton wool to stimulate urination and defecation, which allows the animal to keep drier and warmer in its pouch. If joey is soiled use Vitamin B Cream on cotton wipe to clean. Do not use "Wet Ones" or other perfumed wipes.
- If furless, cover the joey's body with Sorbelene cream after each feed until fur appears.
- Use a new pouch liner after each feed.

Toileting between meals may also be required until good habits are established (George, 1995). Careful consideration is necessary with this stimulation process as if done excessively it can lead to cloacal prolapse and possibly urethral swelling (Bellamy, 1992). If this occurs it can be treated with the use of creams such as Panalog (Squibb), Proctoseyl (Roussel) and Topigol (Squibb) (George, 1990). Once the joey is ready to vacate the pouch, it should be stimulated in a standing position so that it will eventually learn to defecate when standing (Bellamy, 1992). Joeys that are wet with urine and faeces should be cleaned with a mild soap solution and dried thoroughly. If the fur becomes soiled, wash it under warm tap water and dry thoroughly (George, 1990).

Several diseases and parasites can occur during hand-rearing, particularly if hygiene is poor, including:

- Aspiration pneumonia- Is an infection of the lung which results from impatient feeding and teats with holes that are too large and allow milk to get into the lungs with force-feeding. It is often seen when joeys discharge milk through the nostrils during and after feeding, even when they are fed slowly (Booth, 2002). Signs include rattly chest, high temperature (fever), laboured breathing and lethargy. It can be treated with Ampoxil PP, Nyastin for thrush and gentle exercise such as physiotherapy or hopping practice, if they are old enough.
- Bacterial infections- Results in a change in faecal colour, acute smelly scouring and lethargy. Bacteria can include: 1)haemolytic *E. coli* that is strongly associated with acute liquid diarrhoea in newly captured joeys; 2)*Salmonella* spp. is associated with chronic pasty diarrhoea and long-term captivity; and 3)*Klebsiella* spp. associated with long-term captivity and acute chronic liquid diarrhoea (Cargill and Frith, 1991 in Booth, 2002). Treated by culturing to identify bacteria and providing appropriate antibiotics.
- Coccidia- A protozoan in which there is no satisfactory treatment. Once the disease is recognized the damage to the intestine is often so severe that nothing can be done. Joeys can be treated with Baycox liquid 25mg/kg, 10ml/kg orally in a single dose; check the faeces in one week (J. Cowey, pers. comm.).
- Hypervitaminosis D-Caused by excess of Vitamin D, usually in the form of vitamin supplements. It is most common in hand-raised wallabies. Signs include loss of appetite and general depression. It can lead to hardening of the arteries and severe kidney damage. Appropriate diet and husbandry is needed to prevent this disease from occurring (Dixon, 1997).

- Osteoporosis- A lack of absorption of calcium resulting in brittle bones that break easily (Jackson, 2004). Can occur due to lack of absorption due to scouring, overheating in pouch, lack of sunlight (Vitamin D), lack of protein in the diet and lack of exercise. Therefore, access to sunlight and exercise are required once the young are well furred and ready to leave the pouch. Diagnosis requires an X-ray analysis (Jackson, 2004).
- Worms- An overburden of worms can result in scouring, failure to thrive and dull coat condition. Worming is required using treatments such as Panacur (15-50mg/kg depending on severity) (Jackson, 2004).
- Yeast Infection- *Candida* and *Torulopsis* can build up and become serious pathogens, particularly when numbers of bacteria in the gut have been reduced by antibiotics (Booth, 2002). As a result, the animal is reluctant to suck, its faeces will turn a shade of green, saliva may appear rusty when the mouth is wiped after feeding and lesions occur in the mouth. This can be treated with Nystatin oral drops (1/2 ml three times per day) per 1.5kg for the first two days and then ½ ml twice a day for eight to eleven days.

11.8 Behavioural Considerations

Care must be taken that the Swamp Wallaby joey being hand-raised does not become too attached to the raiser, as this will make the weaning process much more difficult. Minimizing stress is also vital as shock can result from shock from the initial loss of the mother, inappropriate temperature, constant handling (George, 1990), different people feeding and unusual (especially sharp) sounds such as traffic, dogs, construction work and loud, piercing music.

Smells of predators such as cats and dogs should be avoided as joeys should not associate with these species while being hand-reared as they will not develop a fear of them and therefore increase the risk of attack from feral cats, foxes and dogs once they have been released (J. Cowey, pers. comm.). Reintroduced *Wallabia bicolor* have been known to often fall prey to predators they have not learnt an appropriate recognition and flight response from potential predators previously stated (Blumstein, 2002).

11.9 Use of Foster Species

Cross fostering involves the transfer of pouch young from a target species into the pouch of a recipient with a pouch young of similar size. The recipient then raises the young as its own and its young is removed from hand-rearing or it euthanased (Taggart, 1997). This technique relies on the two species being roughly the same size and the pouch young being approximately the same age.

To date, use of foster species have been trialed to primarily increase the reproductive output of target species as this allows them to breed again while the other joey is being raised by the foster parent. This reason, however should not relate to the Swamp Wallaby due to the abundance in both captive and wild populations and their ease of breeding. Nonetheless a foster species that coincides with all requirements stated above is the Red-Necked Wallaby. The surrogate female must have a pouch young of its own that is between 10% lighter and 25% heavier in size than the pouch young of the target species, *Wallabia bicolor*. Under no circumstances is a female to be used as a foster female if her natural pouch young is more than 10% lighter than the target animal.

11.10 Weaning

Once the Swamp Wallaby leaves the pouch it will eat more solid foods and less milk. The amount of milk to feed till fully weaned will depend on the amount and nutritional value of other foods consumed. The length of time taken to wean a macropod joey depends on the species. As a

guide the joey should be weaned at about 1.3 times the joey's pouch life. Therefore in the case of the Swamp Wallaby the pouch life is 238 days (34 weeks) hence the joey should be weaned at approximately 309 days i.e. 238×1.3 . Nonetheless some cases report weaning at 450 days for a Swamp Wallaby joey (Jackson, 2004).

The eruption of teeth is also a good indicator of when to begin weaning and offering solid food (Bellamy, 1992). This often coincides with the first emergence from the pouch. Initially the food is only mouthed but eventually the joey will start eating it as well. Gradual reduction in the amount of milk provided will increase the amount of solid food eaten. A general rule is to decrease the formula by 5% per week as long as the joey continues to gain weight at a minimum of 5-10% of body weight per day (J. Cowey, pers. comm.). The Swamp Wallaby should be given access to fresh grass with new shoots initially, and then hard fruits and vegetables such as apples, carrots and sweet potato are introduced with Lucerne, kangaroo cubes and a vast array of browse finally being added to the diet (J. Cowey, pers. comm.).

Before the amount of food is decreased, the macropod should be drinking water from a bowl and consistently eating solid foods. Initially, start decreasing the number of feeds per day to three and then two and then decrease the volume, without watering down the mixture (Austin, 1997).

11.11 Rehabilitation and Release Procedures

Prior to releasing the Swamp Wallaby raised, it is important to assess their fitness to return to their natural habitat. Prior to release any animal must be:

- Eating the diet that will be widely available after release, including recognizing it and able to access the vegetation.
- In a physically and mentally capable condition to withstand the setback that release will cause.
- Able to recognize its own species.
- Be familiar with the social behaviour of its species.
- Aware of and wary of any dangers, including natural predation by dogs, cats, foxes, etc. that it will face in its new environment as well as appropriate levels of fear of humans.
- Show no evidence of being imprinted on humans.
- Be able to seek shelter.

An enormous deal of care should be given to selecting a release site. National Parks place clear restrictions on release areas, as they must be in close proximity to where the animal was discovered. Within these restrictions, the carer should aim for a designated area that is:

- Away from roads and domesticity (dogs, cats, humans).
- Provides an abundance of the Swamp Wallaby's food requirements (Sclerophyll forests, dense bushland, etc.).
- Is not already overpopulated or another animal's territory.

A soft release is the preferred method-whereby the wallaby is able to be released from its place of pre-release care and is able to leave and return if it so desires, and can receive supplementary feeding for a time. However this is not always possible (Tamworth TAFE Animal Care Teachers, 2004).

Release should always occur in good weather conditions and in the morning (after a feed) for a nocturnal species such as *Wallabia bicolor*, so that they have an adequate time period to adjust to its new surroundings and find somewhere to rest/sleep.

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15 Glossary

Abscess: A localized collection of pus in a cavity, caused by disintegration of body tissue.

Alopecia: Loss of hair; baldness.

Alpha: Dominant or top ranking animal.

Anaesthesia: Loss of feeling or sensation. Usually the result of artificial means.

Anorexia: Complete loss of appetite.

Anteriorly: Situated to the front opposed to posterior.

Antibody: A protein produced in the body of a vertebrate in response to the presence of a foreign substance, which neutralizes that substance.

Apathy: Lack of feeling or absence of emotion, excitement, etc.

Axillary: Located near the armpit.

Bipedal: Movement on two legs.

Blastocyst: Hollow ball of foetal cells with no differentiation of organs.

Browser: To feed on leaves and twigs of shrubs (i.e. not grasses).

Cloaca: A single opening containing the termination of the digestive tract, urinary tract and reproductive tract.

Coccygeal: Tail bone.

Conjunctivitis: Inflammation of the conjunctiva-the mucous membrane which lines the inner surface of the eyelids and is reflected over the forepart of the sclera (dense, white fibrous membrane) and the cornea.

Copulatory: To engage in coitus or sexual intercourse.

Dehydration: An excessive loss of water from the body. It can be confirmed by pinching the skin and letting it go. If it does not fall back in a few seconds the animal may be severely dehydrated.

Dermatitis: Inflammation of the skin.

Diarrhoea: An intestinal disorder characterized by morbid frequency and fluidity of faecal evacuations.

Dicotyledons: A plant characterized by producing seeds with two cotyledons or seed leaves.

Diprotodont: An herbivorous marsupial having only one functional pair of lower incisors.

Distribution: The known boundaries of an area which a species is known to inhabit.

Dyspnoea: Difficult or laboured respiration.

Embryo: Living animal in early stage of development before emergence from an egg.

Embryonic Diapause: During diapause a viable embryo is carried in the uterus for long periods (many months) with its development arrested at the stage of a blastocyst. This is lactational anoestrous where the suckling stimuli stop the development of the blastocyst.

Encephalitis: Inflammation of the substance of the brain.

Erythema: Redness of the skin caused by dilatation and congestion of the capillaries, often a sign of inflammation or infection.

Foetus: The young of an animal still in the womb or at the latest stage in an egg.

Forb: Small herb-like plant, not a grass.

Gait: A particular manner of posture and movement.

Gestation Period: The duration of pregnancy.

Glandular: Consisting of, containing, or bearing glands.

Habitat: An area providing the physical and biological needs of a species.

Hallux: The innermost of the five digits normally present in the hind foot of vertebrates.

Herbivorous: To feed on vegetation (i.e. not meat).

Hock: Ankle

Home range: An area frequented by an individual animal.

Hybrid: An offspring of parents of different strains, variations, species or subspecies.

Inguinal: Of, pertaining to, or situated in the groin.

Insemination: The process of introducing semen into a female species to cause fertilization; impregnate.

Interspecific: Between species.

Intraspecific: Within species.

Intramuscularly: Administered into the muscle.

Intravenous: Administered into the vein.

Lactation: The process of producing milk.

Lethargy: A condition of drowsiness or indifference.

Macropodid/Macropod: (Big Hind Foot) An individual of **Macropodidae**, a family of herbivorous marsupials comprising of kangaroos, wallabies, rat kangaroos and tree kangaroos, having short forelimbs, long hind limbs, long muscular tails and adapted for hopping.

Mammae: The organ, characteristic of mammals, which in the female secretes milk; a breast or udder.

Marsupial: Pouched mammal; a species that has a marsupium, found chiefly in Australian regions.

Myoglobin: The oxygen-transporting pigment of muscle.

Necrosis: Death of a circumscribed piece of tissue or of an organ.

Nematodes: Any of several worms of the phylum Nematoda, having unsegmented, cylindrical bodies, often narrowing at each end, and including parasitic forms such as the hookworm and pinworm. Also called roundworm.

Neonate: Newborn.

Nocturnal: Active during the night.

Oocysts: Female germ cells in the mature stage (of internal parasites).

Oestrous: State of sexual receptivity in a female.

Oestrous Cycle: Cycle of regularity with which non-pregnant females come into oestrous.

Permeability: The property or state of being permeable (to penetrate through substances' pores).

Pinnae: A feather, wing, fin, or similar appendage.

Polygynous: The condition or habit of mating with one or more females.

Pruritis: Severe itching, often of undamaged skin.

Pyrexia: Fever.

Quarantine: Restrictions placed on entering or leaving premises where a case of communicable disease exists or is suspected.

Sarcoptic: Of, relating to, caused by, or being itch mites of the family Sarcoptidae and especially the genus *Sarcoptes*.

Sclerophyll: Any of various plants, typically found in low rainfall areas, having tough leaves which help to reduce water loss. There are two forest types- wet sclerophyll and dry sclerophyll, usually having closed canopies.

Scrota: The external sac of skin enclosing the testes in most mammals.

Sexual Dimorphism: To be able to distinguish sex and subspecies from afar. Also when there is difference in body size between the two sexes.

Solitary: Individuals that avoid the company of others.

Spermatogonia: Any of the cells of the gonads in male organisms that are the progenitors of spermatocytes.

Strongyloides: A genus (the type of the family Strongyloididae) of nematode worms having both free-living males and females and parthenogenetic females parasitic in the intestine of various vertebrates.

Subadult: No longer an infant or juvenile, but not yet fully adult physically and/or socially.

Subordinate: Subject to the authority or control of another.

Subspecies: A measurably different interbreeding population within a species, usually geographically separate from other populations.

Syndactylus: Having the second and third digits on the hind foot joined together, except at the tip where there are two claws.

Tachycardia: Rapid heart beat.

Thermoregulation: Being able to regulate the body temperature.

Tibia: The inner and larger of the two bones of the lower leg, extending from the knee to the ankle, and articulating with the femur, fibula, and talus. Also called *shinbone*.

Weaning: The act of separating the young from the dam that it has been suckling, or receiving a milk diet provided by the dam or from artificial sources.

Zygomatic: Of or relating to the cheek region of the face.

16 Appendices

APPENDIX A

ANNUAL CYCLE OF MAINTENANCE CHART

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total substrate change	_____				_____				_____			
Total disinfection and spelling of enclosure	_____	_____				_____	_____	_____	_____			
Total disinfection of holding yard	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Enclosure furnishings to be discarded	_____						_____					
Minimize disturbance												
Breeding	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
Health Checks			_____	_____			_____	_____			_____	_____
Ivomec Worming							_____	_____				

APPENDIX B

FEEDING AND HAND-RAISING SUPPLIES AND ADVICE

Biolac Milk Formula: Biolac milk, feeding instructions and teats; contact:
PO Box 93, Bonnyrigg, NSW 2177
Phone: (02) 9823 9874
www.biolac.com.au

Approximate dietary analysis of available Biolac milk formulas (obtained through the above):

M100 Approximate analysis	
Protein 5%	Carbohydrates 5%
Lipid (Fat) 5%	Total Solids 16%
Energy 390kJ/100ml	

M150 Approximate analysis	
Protein 7.5%	Carbohydrates 3.5%
Lipid (Fat) 7.5%	Total Solids 19.5%
Energy 521kJ/100ml	

M200 Approximate analysis	
Protein 10%	Carbohydrates 2%
Lipid (Fat) 10%	Total Solids 23%
Energy 652kJ/100ml	

COSY Animal Heat Pads: 260mm x 360mm
Soft PC Cover
240volts-10 watts
Useful for artificial pouches or old, sick and orphaned animals. Available through Wombaroo website:
www.wombaroo.com.au/cosy_heat_pad.htm

Impact Colostrum Supplement: Colostrum contains high levels of immunoglobulins and antibacterials that provide immunity and intestinal protection to young animals. Feed to Swamp Wallaby joeys for up to five days when first coming into care and repeated later if necessary. Available through Wombaroo website:
www.wombaroo.com.au/impact_colostrum.htm

Kangaroo Cubes: Analysis: Crude protein-min 14.0%, crude fat-min 3.0%, crude fibre-max 13.0%, actual salt-0.75%, fluorine-max 0.0096%.
Available in 40kg bags from:
Young Stock Feeds Pty Ltd
133-135 Lovell Street, Young, NSW 2594
Phone: (02) 6382 1666
www.youngstockfeeds.com.au

OR

Riverina Stock Feeds
Contacted through: Rural Buying Service Pty Ltd
145 Casino Street, South Lismore, NSW, 2480
Phone: (02) 6621 2853
www.nrrbs.com.au/stockfeedsothers.htm

Low Lactose Milk Powder: Contains taurine, and more whey protein, unsaturated fat, omega-3 fatty acids than lactase modified cows milk products. Use as an emergency milk replacer for all animals until correct milk formula (e.g. Wombaroo, Biolac, Di-Vetelact) is obtained. Available through:
www.wombaroo.com.au

Wombaroo Milk Formula: Wombaroo Milk formulas, teats, bottles and all information necessary for using this formula; contact:
PO Box 151, Glen Osmond, SA 5064
Phone/Fax: (08) 8391 1713
www.wombaroo.com.au

Worming Solutions: Ivomec available through local veterinarians.
For further information on Ivomec refer to Appendix D.

APPENDIX C

NSW ZOO AND WILDLIFE ORGANIZATION CONTACT DETAILS

AWARE: (Australian Wildlife Ambulance Rescue Emergencies Inc.)
PO Box 592, Caringbah, NSW
Phone: (02) 9525 0010
www.aware.com.au

FAWNA: (For Australian Wildlife Needing Aid)
PO Box 41, Beechworth, NSW
www.fawna.com.au

FEATHERDALE WILDLIFE PARK
217 Kildare Rd, Doonside, NSW
Phone: (02) 9622 1644
www.featherdale.com.au

HUNTER VALLEY ZOO
Lomas Lane, Nulkaba, NSW
Phone: (02) 4990 7714
www.hunternvalleyzoo.com.au

NATIONAL PARKS & WILDLIFE SERVICE
43 Bridge St, Hurstville, NSW
PO Box 1967
Phone: (02) 9585 6444
www.nationalparksandwildlife.nsw.gov.au

RSPCA NSW
201 Rookwood Rd, Yagoona, NSW
Phone: (02) 9709 5433
www.rspca.com.au

SYDNEY METROPOLITAN WILDLIFE
Lane Cove National Park, Lady Game Drive,
Lane Cove, NSW
Phone: (02) 9413 4300
www.sydneymetropolitanwildlife.com.au

TARONGA ZOO
Bradleys Head Rd, Mosman, NSW
Phone: (02) 9969 2777
www.zoo.nsw.gov.au

Wildlife Animal Rescue and Care Society Inc.
PO Box 2383, Gosford, NSW, 2250
Phone: (02)43651121
www.wildlifeanimalrescuecom.au

WIRES: (Wildlife Information & Rescue Service)
Forestville, NSW, 2087
PO Box 260
Phone: (02) 9975 1633
www.wires.com.au

APPENDIX D

DRUG DETAILS

Amprolium: A thiamine analogue used in veterinary medicine for the prevention and treatment of coccidiosis. Also known as ampisol, chloride, amprolium plus, amprosol, amprovine and anticoccid. A solid compound which is freely soluble in water.

Baycox: An anticoccidial parasiticide for veterinary use to be used in conjunction with water. Baycox's active ingredient: Toltrazuril.

Baytril: A broad-spectrum antibiotic of the quinolone/fluoroquinolone class. It is used to treat many types of bacterial infections. It is rapidly absorbed from the digestive tract, penetrating into all body fluids and tissues. Also known as Enrofloxacin it is presented as tablets, an injection and as an oral solution.

Clindamycin: Clindamycin, an antibiotic, is used to treat infections of the respiratory tract, skin, pelvis, vagina, and abdomen. Clindamycin comes as a capsule and liquid to take by mouth; topical solution, lotion, and gel for skin infections; and vaginal cream.

Corticosteroids: Corticosteroids (cortisone-like medicines) are used to provide relief for inflamed areas of the body. They lessen swelling, redness, itching, and allergic reactions. They are often used as part of the treatment for a number of different diseases. Corticosteroids are available in either oral or injectable forms.

Dexadreson: Dexadreson contains a clear aqueous solution for injection. It can be used as an anti-inflammatory and anti-allergic agent and as supportive therapy in cases of shock. Dexadreson may be administered by intravenous or intramuscular injection. When using corticosteroids to treat cases of shock the clinician should also give intravenous fluids to maintain circulating blood volume and take measures to control the acid base balance.

Gentamycin: A white solid, broad spectrum, cell culture antibiotic that is non toxic to viruses and mammalian cells at antibacterial levels. Soluble in water, it is useful for long-term virus and tissue culture studies. Gentamycin preparations' are mainly used to treat infections of the ear canal.

Halothane: A clear colourless liquid with a sweet smell which must be protected from harsh light sources. The commercial preparation contains 0.01% thymol which prevents decomposition on exposure to light. Main use includes the induction and maintenance of general anaesthesia. Although normally used to produce loss of consciousness before and during surgery an anesthetic may be given in small amounts to relieve anxiety or pain without causing unconsciousness.

Ivomec: Broad-spectrum anti-parasite medication. Effective against most common intestinal worms (except tapeworms), larval heartworms, mites, and some lice. Available in tablets/chewables for heartworm prevention, topical solution for ear mite treatment, or as oral or injectable solution for other parasite problems.

Mebendazole: Also known as Vermox, Mebendazole is a broad-spectrum anthelmintic agent (anthelmintics are medicines used in the treatment of worm infection) used to treat hookworm, pinworm, whipworm and roundworm infestations. Mebendazole is available in tablet form which may be chewed, swallowed whole, or crushed and mixed with the animal's food.

Nystatin: Nystatin is used to treat fungal infections of the skin, mouth, vagina, and intestinal tract. Nystatin comes in tablet and liquid forms to take by mouth and in powder, ointment, and cream to be applied to the skin. Nystatin liquid usually is used three to five times a day for mouth infections and three times a day for intestinal infections. Also known as Mycostatin, Nystop and Pedi-Dri.

Tiletamine: Tiletamine is a pharmaceutical related to Ketamine which is used almost exclusively by veterinarians for anaesthetizing animals. It is primarily sold compounded as a powder or tablet which is reconstituted with saline solution and then injected. It is sometimes used in combination with xylazine to tranquilize macropod species. Also known as Telazol and Zoletic.

Valium: Valium/Diazepam is an anti anxiety agent used primarily for short-term relief of mild to moderate anxiety. Diazepam tablets are available in 2mg, 5mg and 10mg tablets. An oral solution is available in 1mg/ml and 5mg/ml concentrations. There also is a 5mg/ml solution for injection.

APPENDIX E

BLEACH MSDS

[Safety \(MSDS\) data for sodium hypochlorite solution: BLEACH](#)



General

Synonyms: hypochlorous acid sodium salt, sodium hydrochlorite, clorox (also sold as a solution under a variety of trade names for use as liquid bleach)

Use: Liquid bleach

Molecular formula: ClONa

CAS No: 7681-52-9

EC No: 231-668-3

Physical Data

Appearance: colourless liquid with strong odour

Melting point:

Boiling point: typically 40°C (decomposes)

Vapour density:

Vapour pressure:

Specific gravity: ca. 1.21

Flash point: N/A

Explosion limits: N/A

Autoignition temperature: N/A

Stability

Stable. Contact with acids releases poisonous gas (chlorine). Light sensitive. Incompatible with strong acids, amines, ammonia, ammonium salts, reducing agents, metals, aziridine, methanol, formic acid and phenylacetonitrile.

Toxicology

Corrosive. Causes burns to skin and eyes. Harmful by ingestion, inhalation or through direct skin contact. Skin irritant.

Personal Protection

Use in well-ventilated areas only. Protect eyes. Do not mix with acids.

APPENDIX F

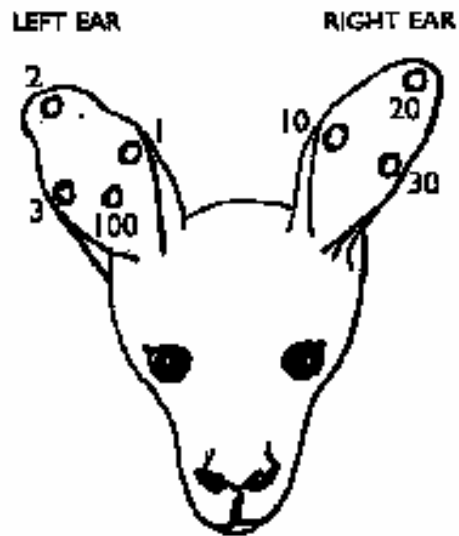
MACROPOD EAR NOTCHING NUMBERING SYSTEM

LEFT EAR

- 1-front ear, one hole
- 2-tip ear, one hole
- 3-back ear, one hole
- 4-front, two holes
- 5-tip ear, two holes
- 6-back ear, two holes
- 7-front ear, one hole + tip ear, one hole
- 8-tip ear, one hole + back ear, one hole
- 9-front ear, one hole + back ear, one hole
- 100-centre ear, one hole

RIGHT EAR

- 10-front ear, one hole
- 11-19-front ear, one hole + patterns numbers 1-9
- 20-tip ear, one hole
- 21-29-tip ear, one hole + patterns for numbers 1-9 and so on...



Picture: Obtained through (Williams, 1999).