

Ring-Tailed Lemur Husbandry Manual



Ring-tailed Lemur *Lemur Catta*

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HM Statement

These husbandry guidelines were produced by the compiler/author while studying at TAFE NSW – Western Sydney Institute, Richmond College, N.S.W. Australia as part assessment for completion of Certificate III in Captive Animals, Course number 1068, RUV30204. Since the husbandry guidelines are the result of student project work, care should be taken in the interpretation of information therein, - in effect, all care taken but no responsibility is assumed for any loss or damage that may result from the use of these guidelines. It is offered to the ASZK Husbandry Manuals Register for the benefit of animal welfare and care. Husbandry guidelines are utility documents and are ‘works in progress’, so enhancements to these guidelines are invited.

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1.0 TAXONOMY

1.1 Nomenclature

- KINGDOM: Animalia
- PHYLUM: Chordata
- CLASS: Mammalia
- ORDER: Primates
- SUBORDER: Prosimii
- INFRAORDER: Lemniformes
- SUPERFAMILY: Lemuroidea
- FAMILY: Lemuridae
- GENUS: *Lemur*
- SPECIES: *catta*

Lemur catta Linnaeus, 1758

1.2 Subspecies

Species (*Lemur catta* is a monotypic genus).

Groves (2001) acknowledges the potential existence of two subspecies of Ring-tailed Lemurs as indicated by an article by Goodman *et al* (1996). The Andringitra high-mountain population is darker with a rufous brown back, darkish brown rump and dark grey-brown on limbs. It also has a thicker pelage and fewer tail rings in comparison to normal *Lemur catta* which has approximately fourteen rings of white and black, with a lightish red grey and light greyish rump and limbs (Jolly 1996 & Goodman *et al* 1996). Correspondence with the AZA & EAZA regions indicates as with the ARAZPA region *Lemur catta* are managed at the species level.

1.3 Other Common Names

- Ring-tailed Lemur (English)
- l mur catta (French)
- maki (Malagasy)
- lemur colianillado (Spanish)
- ringsvanslemur (Swedish)

2.0 NATURAL HISTORY

Ancestral Lemurs were isolated at least 50million years ago and have gradually diversified in to the modern array of over 40 species (including several extinct large bodied species). As such, Lemurs have retained numerous primitive characteristics while at the same time developing may features in parallel to the monkeys and apes of the major southern land masses, in particular increased diurnal activity. (Bateman 1984)

This is the only surviving semi-terrestrial diurnal lemur in Madagascar.

The ring-tailed lemur is the most intensively studied of all lemur taxa.

Lemurs are a good environmental health indicator of the area in which they live and contribute a great deal to the longevity of the forest area through seed germination and dispersal.

Though the more serious threat to ring-tailed lemurs is human-induced habitat loss, the success of captive breeding programs could be important to restocking forested areas if hunting pressure becomes too great and ring-tailed lemur populations drop significantly. Easily bred and raised in captivity, there are about 2000 ring-tailed lemurs in zoos around the world (<http://www.isis.org>). This large population can serve as source lemurs to be reintroduced if necessary. Experimental release programs on St.

Catherine's Island, Georgia reveal that captive ring-tailed lemurs released into a natural environment readily adapt to their new environment and begin to exhibit the broad repertoire of behaviors seen in

wild ring-tailed lemurs (Keith-Lucas et al. 1999). At this time, release programs are not part of the conservation plan for ring-tailed lemurs in Madagascar, but knowing how captive animals will adapt to natural conditions maintains release as a future option, if necessary.

Most field studies of ring-tailed lemurs have been conducted at Beza Mahafaly Special Reserve and Berenty Private Reserve, a family-owned forest set aside in the 1940s (Sauther et al. 1999). They have also been studied at Andringitra National Park, Isalo National Park, and Andohahela Nature Reserve (Mittermeier et al. 1994). One particularly notable field researcher, Alison Jolly, has been conducting long-term ecological and behavioral research on ring-tailed lemurs at Berenty since the early 1960s and has contributed greatly to the knowledge of wild ring-tailed lemurs. Long-term studies have also been ongoing at Beza Mahafaly most notably conducted by Robert Sussman, Lisa Gould, and Michelle Sauther. Captive research has been conducted at the Duke University Primate Center in North Carolina since the mid-1980s and also has provided invaluable information about the species (Sauther et al. 1999).

2.1 History in Captivity

ISIS (2007) indicates a captive population as of 26 November 2007 to be 2130 individuals:

AZA studbook records indicate that Ring-tailed Lemurs first came into captivity around 1900. The EAZA studbook traces the species entering that region between 1950 and 1960. In Australasia, Ring-tailed Lemurs arrived in zoos in the early 1970s; these individuals were recorded as originating from various European populations. The first breeding in the Australasian studbook occurred in 1976.

Due to the Ring-tailed Lemurs long history in captivity, lack of complete historical records in zoos and multiple cases of uncertain parentage, not all founders have been traced back to the wild. In general, founding lineages at the majority of Australian zoos have been traced back to the wild. (Tyler, 2007)

The five male Ring-tailed Lemurs housed at TWPZ originated from

3.0 MORPHOMETRICS

3.1 Mass & Basic Body Measurements

Ring-tailed Lemurs in the wild measure about 42.5 cm from head to rump and weigh between 2207 and 2213 g, on average. In captivity, ring-tailed lemurs weigh slightly more than their wild counterparts with males weighing, on average, 2705 g and females average 2678 g. Males and females are about the same size.

3.2 Sexual Dimorphism

There is no pelage difference with males and Females. The males have heavier heads and shoulders in comparison to the females. Both sexes possess small dark antebrachial glands on either wrist, with the females half the size of the males. The male's antebrachial glands are overlain with horny epidermal spine. The males also have brachial cutaneous glands on the axillary surface of the shoulder region (Wikipedia 2007, Mittermeier et al 2006, Jolly 1966).



Fig 1: Male antebrachial glands with horny spur



Fig 2: Male scent glands (on shoulders)

Both male and female ring-tailed lemurs have anogenital scent glands (Mittermeier et al. 1994; Rowe 1996; Groves 2001; Palagi et al.)

3.3 Distinguishing Features

The conspicuous characteristic for which ring-tailed lemurs are known is their long tail, measuring about 60 cm (23.6 in), that has alternating bands of black and white rings (Mittermeier et al. 1994). The rest of their bodies are light reddish gray to dark red-brown with light gray to dark brown rumps and light gray to gray-brown limbs. They have white undersides, hands, and feet. They have white faces with dark brown or black triangular eye patches that look like a mask around their light brown eyes and they have black muzzles. Their ears are white and angular, similar to a cat's.



Ring-tailed lemurs share unique dental characteristics with other members of the Superfamily Lemuroidea. They have the dentition formula: $2/2, 1/1, 3/3, 3/3$. They have specialized teeth in their lower jaw where the lower incisors and canines protrude forward and form a dental comb. These long, narrow teeth project nearly straight forward from the jaw and this specialized dentition is thought to aid in grooming and cleaning the hair coat. (Swindler 2002).



Fig 3: Lower jaw dentition (dental comb)

Ring-tailed lemurs are the most terrestrial of all lemurs, but they spend time in all layers of the forest. They move by walking or running quadrupedally, holding their tails almost completely vertically as they move, with the tip of the long tail curving away from the body forming the shape of a question mark (Mittermeier et al. 1994; Jolly 2003).

Lemurs have a low basal metabolic rate compared with other primates. Several behaviours exhibited by Lemurs (Basking and huddling) are related to energy conservation. They also possess dense coats compared with other tropical primates.

3.2 Distribution



Fig 4: Location of Madagascar in relation to Africa



Fig 5: *Lemur catta* range (in red) within Madagascar

Ring-tailed lemurs, can only be found in the wild on the island of Madagascar. They are restricted to the south and south-western portion of the island, reaching a northern limit near the town of Morondava on the west coast and the town of Ambalavao in the east. The southeastern limit is the town of Tolagnaro on the southern coast (Mittermeier et al. 1994; Jolly 2003). Ring-tailed lemurs are found in the vicinity of nine forests: Andohahela, Andringitra, Ankilitelo, Berenty, Beza Mahafaly, Isalo, Tsimanampetsotsa, Tsirave, and Zombitse (Godfrey et al. 1998).

3.3 Habitat/Range

Ring-tailed Lemurs live in a variety of habitat types including rainforests, subalpine, deciduous, gallery, and spiny bush forests.

The average day range of ring-tailed lemurs in the wild is about 1000 m and one group will use the same part of its home range for three or four days before moving to another part. The home range size varies, depending on habitat, and average size ranges from 1 to 35 km² (Sussman 2000). In drier or more disturbed habitats, home range sizes are larger, averaging 32 km² compared to wetter habitats where ring-tailed lemurs have home ranges averaging 17 km². Ring-tailed lemurs seasonally expand their home ranges; during the dry season they utilize larger areas because of the resource scarcity (Sussman 1991). The home ranges of multiple groups of ring-tailed lemurs overlap, and there are few areas that are exclusively used by only one group. Population density is also linked to habitat quality. In wetter, lush areas, there are more ring-tailed lemurs per square kilometer, up to 350 per km², compared to dry or disturbed areas that can have densities as low as 17 per km².

3.4 Conservation status

In addition to being listed as *Near Threatened* in 2008 by the IUCN (IUCN 2008), the Ring-tailed Lemur has been listed since 1977 by CITES under Appendix I (CITES 2008), which makes trade of wild-caught specimens illegal. Although there are more endangered species of lemur, the Ring-tailed Lemur is considered a flagship species due to its recognizability (Cawthorn 05).

The wild population has been indicated in decline due to habitat loss / degradation with agriculture (livestock presence), extraction (collection of wood), fires (natural and man made), harvesting (hunting/gathering), cultural / scientific / leisure activities, persecution and human encroachment which are ongoing. The result has been a decline in area of occupancy, extent of occurrence and/or quality of habitat. The wild estimated population is between 10,000 – 100,000 individuals (Ganzhorn *et al* 2000).

The Ring-tailed Lemur resides in several protected areas within its range, each offering varying levels of protection (Cawthorn 05). At the Beza Mahafaly Special Reserve, a holistic approach to in situ conservation has been taken. Not only does field research and resource management involve international students and local people (including school children), livestock management is used at the peripheral zones of the reserve and ecotourism benefits the local people (Cawthorn 05).

Outside of its diminishing habitat and other threats, the Ring-tailed Lemur reproduces readily and has fared well in captivity. For this reason, along with its popularity, it has become the most populous lemur in zoos worldwide, with more than 2000 in captivity (ISIS 09). Ex situ facilities actively involved in the conservation of the Ring-tailed Lemur include the Duke Lemur Center in Durham, NC, the Lemur Conservation Foundation in Myakka City, FL and the Madagascar Fauna Group headquartered at the Saint Louis Zoo. Due to the high success of captive breeding, reintroduction is a possibility if wild populations were to crash. Although experimental releases have met success on St. Catherines Island in Georgia, demonstrating that captive lemurs can readily adapt to their environment and exhibit a full range of natural behaviors, captive release is not currently being considered (Cawthorn 05).

Ring-tailed Lemur populations can also benefit from drought intervention, due to the availability of watering troughs and introduced fruit trees, as seen at the Berenty Private Reserve in southern Madagascar. However, these interventions are not always seen favorably, since natural population fluctuations are not permitted. The species is thought to have evolved its high fecundity due to its harsh environment; (Cawthorn 05) therefore, interfering with this natural cycle could significantly impact the gene pool.

3.4.1 Conservation Measures

Ring-tailed Lemurs are considered vulnerable and are listed on CITES 1 appendix.

The ASMP Primate TAG has identified the Ring-tailed Lemur as a priority lemur species for the region due to its good founder base and the potential to source new founders from the American and European populations, as well as the large number of spaces being dedicated to the species by member institutions (Tyler, 2007).

3.4 Wild Diet and Feeding Behaviour in the Wild.

The Ring-tailed Lemur is an opportunistic omnivore primarily eating fruits and leaves. It is known to eat from as many as three dozen different plant species, and its diet includes flowers, herbs, bark and sap. It has been observed eating decayed wood, earth, spider webs, insect cocoons, arthropods (spiders, caterpillars, cicadas and grasshoppers) and small vertebrates (birds and chameleons). During the dry season it becomes increasingly opportunistic.

The diet regimen of *L. catta* contains a wide variety of plants, but the majority of the diet comes from a relatively few species. Sussman (1977) found that eight species made up over 70% of the diet at Antserananomby, while the same number made up over 80% of the diet at Berenty. Important species included the fruits of *Rinorea greveana* and *Pithecelobium dulce* and the mature leaves and fruits of the tamarind or kily tree, *Tamarindus indica* (Sussman, 1977). Ring-tailed lemurs at Berenty consume

bananas from tourists, as well as plant parts from introduced species such as *Eucalyptus* flowers, melons, sweet potato leaves and other raided crops have also been reported in the diet (IUCN, 1990). Most water needs are thought to be met through the diet, but drinking from tree hollows, puddles and rivers has been observed (Sussman, 1977).

Sussman (1977c) as cited in Harcourt *et al* (1990) indicated two main periods of feeding during the course of the day, with at midday a rest period of several hours.

Budnitz (1978), Sussman (1974 & 1977b) as cited in Harcourt *et al* (1990) wrote the species being active and foraging in all part of the forest and the species spends a good considerable periods of time on the ground.

Fruit (Frugivory)	54%	(34-70%)
Leaves (Folivory)	33%	(24-50%)
Flowers	3%	(0-8%)
Herbs	8%	(6-15%)
Bark, sap, cactus, misc	2%	(0-7%)
<i>Tamarindus indicus</i>	25% of diet:	12% leaf, 12% pod
(Nutrient Requirement of Nonhuman Primates <i>et al</i> , 2003)		

The % indicates the average amount of the food type consumed in wild studies. The brackets indicate the mean range from the different field studies.

Soil has been indicated as being consumed (Sussman 1977; Rasamimanana *et al* 1993 as cited in Mowry *et al* 2001).

3.5 Longevity

3.5.1 Wild

In the wild, it is rare for female ring-tailed lemurs to live past 16 years of age and the oldest known wild female was between 18 and 20 years old. Male life span is even less well-known, because of the social system, but have been recorded living to at least 15 years of age (Gould *et al*. 2003; Sauthers pers. comm).

3.5.2 Captivity

Studbook average life expectancy of females – ASMP 14 years & AZA 18 years
 Studbook maximum longevity of females – ASMP approx 26 years & AZA 34 years.
 Studbook average life expectancy of males – ASMP 17 years & AZA 20 years
 Studbook maximum longevity of females – ASMP approx 30 years & AZA 35 years.

4.0 HOUSING REQUIREMENTS

The NSW Agriculture Departments: Policy on Exhibiting Primates in New South Wales, Exhibited Animals Protection Act (2000) is utilised to provide a summary of requirements for housing Ring-tailed Lemurs. For further details please refer to the complete document.

Ring-tailed Lemurs are found in the following group types in captivity and the wild:
Adult male groups, adult female groups and breeding groups of females with one male and their dependent offspring.

Tyler (2007) current regional management & husbandry practices for Ring-tailed Lemurs suggest that a three enclosure management system may provide for optimal, best practice management within this region. It should be noted however, that other regions, supporting a different management approach may prefer to use a complimentary enclosure management system somewhat different to that applied in Australasia. Single sexed groups of *Lemur catta* have proven viable in many zoos, and the management problems outlined above have been resolved in a number of institutions by maintaining breeding groups with only a single resident male; all remaining males forming a separate 'bachelor group', similar to those observed in the wild. To control aggression within groups of Ring-tailed Lemurs, it is recommended that captive groups be managed to more closely approximate the recruitment and social structure of wild populations.

4.1 Exhibit Design.

TWPZ currently exhibits its 5 male Ring tailed Lemurs on an island in a lake containing other species of Lemur (Black and White Ruffed Lemurs and White Fronted Lemurs) as well as Black Handed Spider Monkeys.

The Rig-tailed Lemur Island is approx 48m circumference with 15m north to south and 14 metres east to west. There are several large trees for aboreal climbing with several large lateral poles between them. They are provided with 4 bird proof feeders that can be hung from the trees and one elevated shelter 50 width, 70 depth and 40 height.

The night house is 230 in height with 2 compartments that can be separated with a slide operated off the island. It is not used frequently by the animals possibly due to its size and elevation of the shelves inside the house (only approx 50 cm above floor level).

Ring tailed Lemurs are not natural swimmers and exposure to large bodies of water such as in a moat may be dangerous. Therefore unstable groups may not be suitable for housing in a moated exhibit (Embury Etal. 09).

4.2 Holding Area Design.

TWPZ does not currently have a designated Ring tailed Lemur Holding area, however the quarantine facilities have been used in the past to assist with introductions and controlling aggression.
See Appendix 1

4.3 Position of Enclosures.

Multiple holding of the species requires that the majority of the enclosure must be out of visual range of any neighbouring enclosures housing other groups of Ring-tailed Lemurs or other predatory or territorial primate species. To minimise visual, olfactory, auditory and antagonistic behaviour developing between groups. Where visual contact is available, the group should be monitored for signs of stress and actions taken to alleviate this distress. (NSW Agriculture 2000)

Primate enclosures must be constructed so that the exhibited animals can rest at least 2 body lengths above the eye level of any member of the viewing public (NSW Agriculture 2000).

4.4 Weather Protection.

NSW Agriculture Department (2000) indicates the exhibits are required to provide the primates with access to shelter from climatic extremes over the course of the given year. A sheltered area is required to provide an environment with air temperature ranging between 18 to 30 degree Celsius. It should be noted heated concrete shelving can be utilized within these areas to provide the required heating during the winter months. The shelters need to be of sufficient size and number to the group needs to prevent dominant animals denying access to subordinate animals. Cocks (2000) as cited in Tyler (2009b) indicated when possible during summer three quarters of the exhibit should in shade and during the winter months one quarter in shade.

4.5 Substrate.

Natural ground cover is ideal for Ring tailed Lemurs as it allows them to eat the grass that is growing and dig for soil and insects. Sand is also appropriate for an easily cleaned substrate – ideal for under high traffic areas. Bark chip and/or mulch is ideal as long as it is untreated wood free from pesticides/insecticides and other toxins as Lemurs will forage through the mulch. Natural Substrates must be effectively managed to avoid disease such as harbouring parasites and must be well drained. (NSW Agriculture 2000)

4.6 Nestboxes and/or Bedding Material

NSW Agriculture Department (2000) indicates one nesting box per adult is required, 0.5m cubed and heated in cold weather.

Ring-tailed Lemurs most often sleep in the trees, however nestboxes should be provided for weather protection. Most of the time straw is appropriate as a bedding material however due to the risk of Toxoplasmosis transfer to infants, straw should not be used for birthing bedding.

4.7 Enclosure Furnishings.

NSW Agriculture Department (2000) indicates the following minimum exhibit furniture for three adult lemurs or a pair including dependent offspring being:

Sufficient perches for sitting or sleeping of a minimum height of one metre above the ground. Therefore allowing each adult lemurs to position it selves by itself or to allow for more than one lemur to sit allowing for mutual grooming to occur. The lemurs prefer broad horizontal limbs to allow traversing over.

A minimum of four horizontal pathways of rigid or semi rigid materials are required allowing the lemurs to move throughout the exhibit promoting exercise and well being. Also allowing any group members to move away from any undue dominance, or conflict occurring. Areas are also required to allow for sitting at or near ground level for the lemurs to sun bath themselves. Solid resting and traversing surfaces need to be of a rough texture to ensure they are not slippery when wet. Should ropes be utilized within the exhibit, they need to be of a weight were they remain taut when the lemur(s) traverse over them. The rope ends must be protected against fraying, which has the potential to result in entanglement and possible death (Tyler 2009)

4.8 Spatial Requirements.

NSW Agriculture Department (2000) indicates the following minimum exhibit dimensions for three adult lemurs or a pair including dependent offspring being:

- Minimum length of 6.5 metres
- Minimum width of 4.5 metres
- Minimum height of roof / climbing structures of 3.5 metres
- For each additional Ring-tailed Lemurs add a minimum of 50 x (43)² to the floor area.
- Minimum height of roofed enclosures is dependent of the number of animals.

The species is classified as “arboreal quadruped” and requires solid horizontal surfaces to travel. The exhibit requires the minimum of two climbing structures, within the minimum height indicated at 6.5 metres. Sufficient climbing structures are to be provided in the exhibit to allow all of the lemurs to simultaneously climb to the height of the exhibit, in particular when staff enters the exhibit for routine duties. The exhibit should be planted allowing for visual barriers for group members to move out of visual view of one another and in particular out of view of the public. Exhibits are required to allow the lemurs to rest at least two body lengths above the eye level of the viewing public.

Sufficient watering points within the exhibit to provide fresh, clean water at all times. It should be noted all animals to have access to water though not necessarily at the same time. All doors should open into the exhibit; though allowing for staff safety with the door to returning to a closed position should a lemur jump onto the door.

Tyler (2007) current regional management & husbandry practices for Ring-tailed Lemurs suggest that a three enclosure management system may provide for optimal, best practice management within this region. It should be noted however, that other regions, supporting a different management approach may prefer to use a complimentary enclosure management system somewhat different to that applied in Australasia. Single sexed groups of *Lemur catta* have proven viable in many zoos, and the management problems outlined above have been resolved in a number of institutions by maintaining breeding groups with only a single resident male; all remaining males forming a separate ‘bachelor group’, similar to those observed in the wild. To control aggression within groups of Ring-tailed Lemurs, it is recommended that captive groups be managed to more closely approximate the recruitment and social structure of wild populations.

4.9 Night Quarters

NSW Agriculture Department (2000) indicates lighting to be of a level to mimic natural lighting of the wild. The lighting is to be adequate to allow routine health checks and to allow scheduled cleaning to occur. Sufficient air flow to prevent the build up of noxious gases and to allow ample fresh air to circulate. Humidity to be maintained at appropriate levels for the species needs see 4.5 Winter Enclosures for details. The night quarters should be used for the shortest possible time, as a holding facility. Or with the exception of when the night quarters meet the requirements of an off exhibit facility. The minimum night quarter requirements are dependent on the number of lemurs held and should be incorporated into the exhibit design brief for the total number of lemurs to be held. The species is arboreal quadruped and requires solid horizontal surfaces to traverse. The exhibit and the night quarters require a mechanism to allow ease of separation between the two areas. With the internal design of the night quarters preventing the cornering of a lesser ranked individual by a higher ranked individual during conflict. Floors require a slope to the drainage area situated on the outside of the night quarters to prevent the pooling of water. The walls and floors should be coated with an epoxy based paint for ease of cleaning. Rodent proofing is required. Outside noise entering the night quarters should be reduced to a minimum. The maximum gap between the door to the floor should be 2 cms.

4.10 Breeding Enclosure

According to the Annual Report and Recommendations for the Ring-tailed Lemur (Tyler 08): Institutions that are holding and/or seeking to maintain breeding groups must have potential to manage at least two groups of Ring-tailed Lemurs. Breeding institutions that hold females with a high mean kinship (family group) in their breeding group may be asked to transfer the female component of their breeding group to another institution wishing to hold a single sexed group as new females cannot be integrated into an established female group.

Separate breeding exhibits from the main display exhibit are generally only utilized when particular individuals need to be separated from the main group for specific breeding recommendations as indicated by the ARAZPA Annual Report and Recommendations for the species 2008. NSW Agriculture Department (2000) indicates one nesting box per adult is required, 0.5 m cubed and heated in cold weather.

4.11 Cage Enclosure

NSW Agriculture Department (2000) indicates the species requiring a minimum wire diameter of 2.5mm and a maximum mesh dimension of 25mm x 25mm. Personal observation, though the species has not been indicated in literature as digging, the mesh should be partially dug into the ground to compensate for soil erosion around the perimeter of the exhibit etc.

4.12 Open Enclosures & Island Enclosures

NSW Agriculture Department (2000) indicates island enclosures have a minimum moat width of 3.0 metres, with the minimum height of the perimeter moat wall above the maximum water level being 0.50 metres and including the minimum depth of water at the perimeter moat wall being 0.90 metres. With the moat sloping upwards towards the land assisting any individual this has fallen into the water to reach land easily.

4.13 Interspecific Compatibility.

Ring-tailed Lemurs have been housed with other Lemur species with some manageable aggression and territoriality issues.

Historical Incidences:

- Brown Lemurs (*Eulemur fulvus*),
- Black and White Ruffed Lemurs (*Varecia variegata variegata*)
- Red Ruffed Lemurs
- Other unspecified lemurs species.
- Tamarin Spp

Single sex mixed exhibits appears generally more viable with less potential for territorial and resource deutes occurring.

An example is Jersey Zoo in the Channel Islands (late 1980s) which held Red Ruffed Lemurs, Ring-tailed Lemurs and Mayotte Brown Lemurs in a non breeding situation in a large outdoor wooded area–with some limited aggression/dominance noted from the Red ruffs, and with separate feeding hut facilities utilized.

Examples of non-primates housed with RTLs are South American parrot species.

At TWPZ we have housed a group of male Ring-tailed Lemurs (3.0.0 and 5.0.0) with a mixed group of White Fronted Brown Lemurs (1.2.0 and 1.3.0). Over the course of the 3 or so years they they were housed together there were no reports of any major aggression between the species other than the odd stink fight between the two species. There was some competition over food which was alleviated by different feeding locations, heights, times and multiple feeding stations. Aggression was however substantial between the White Fronted Brown Lemur group, however they were undergoing introductions at the time.

5.0 GENERAL HUSBANDRY

5.1 Hygiene and Cleaning

The EAPA (amended, 2004) lists specific hygiene and cleaning requirements that need to be met in order to provide adequate housing for Ring-tailed Lemurs.

The EAPA states that watering points must have regular water changes, and that faecal deposits and uneaten food must be removed daily. The Act however does not go into detail.

At TWPZ the minimum standards state that faecal deposits should be removed daily with the sandy areas being raked daily and mulched areas spot cleaned. The hanging feeder trays should be cleaned daily with wonderclean disinfectant and rinsed thoroughly with clean water. The outside of the hanging feeders should be cleaned weekly with wonderclean disinfectant. There are 2 scrubbing brushes, one rectangular brush for scrubbing faecal deposits and a long-handled brush for scrubbing water dishes.

For keeper hygiene, gloves and boots must be provided as Lemurs can carry bacteria and other pathogens that may be ingested by any person who touches faecal deposits and these pathogens may be harmful to humans (EAPA, amended, 2004).

Please see the husbandry maintenance schedule detailed in the appendix.

5.2 Record Keeping

Keeping accurate records for all animals is of great importance, for many reasons. Records are an excellent database for health problems, veterinary procedures, treatments administered, growth and development, feeding patterns among many more aspects of animal husbandry.

5.3 Methods of Identification

The NSW Agriculture Department (2000) states that each primate should be individually and permanently identified by an appropriate method of identification.

Microchipping is a frequently used identification method which is a valuable and permanent form of identification and widely used at TWPZ.

One further identification technique may be as simple as using photographs of distinguishing features on each of the individuals and writing descriptions on care cards for all staff and keepers. This is an easy method which can be applied to most animals, however it must be ensured that as growth and development continues the photographs are updated with new ones and the old one stored in a file. This will help with record keeping also.

Numbered ear tags have also been used in the past, however due to the high incidence of them falling out and fading, microchipping and photographed distinguishing features are more widely used among primate species.

5.4 Routine Data Collection

The collection of data should be a routine in the workplace. Any data collected provides a written record of any notable events or other comments about each animal. Records are an excellent database for health problems, veterinary procedures, treatments administered, growth and development, breeding, feeding patterns among many more aspects of animal husbandry.

A routine should be established of when observations are taken or data collected. For example, it is recommended that each animal should be checked for any changes or problems daily, and if any notable events have been observed these should then be recorded. It is of great value if the type and amount of food offered to and taken by the individual is always recorded so that if any illnesses or problems occur keepers and veterinarians are able to use the feeding records to help determine the cause of the problem.

6.0 HANDLING AND TRANSPORT

As some species of primate can inflict serious injuries, all primate handling must be done by experienced trained personnel. Animal care staff must be aware of the potential for injuries and ways to prevent them. (NSW Agriculture 2000)

At TWPZ Ring-tailed Lemurs are classified as Hazardous and appropriate care is taken to minimize risks to keepers and animals.

6.1 Timing of Capture and Handling.

Animals should be caught away from the heat of the day and very cold conditions as they can overheat and chill very easily.

6.2 Catching Box.

Pet packs are ideal to catch Lemurs in as they are sturdy, easily cleaned and moved, and cannot be shredded by the Lemurs' sharp teeth. Lemurs are easily desensitized to enter pet packs and are conditioned to enter these as part of the daily routine.

6.3 Capture and Restraint Techniques.

The Ring-tailed Lemurs at TWPZ are conditioned to enter a pet pack to lock away for transport to the veterinary centre. Once locked into the transport crate, it must be secured with cable ties or a padlock. Once at the veterinary centre, the lid of the pet pack is unscrewed and lifted slowly by one keeper, while another restrains the Lemur using protective gear such as a thick towel and gloves. The Lemur is held in the Type-A hold while a member of the veterinary team delivers the sedation.

Lemurs can also be netted by experienced keepers. Using a fine mesh net (2 cm or less) is recommended to prevent the Lemur's paws from becoming entangled in the net. Once the Lemur has been netted and the net tied off, the individual can wither be transferred to the vet department within the net and be sedated by hand injection by the veterinary staff. Prior to transfer the net should be placed into a hessian sack to provide a dark environment and a second safety cover.

Other restraint techniques: (as explained by Tyler 07)

Type a) half nelson primate hold. The staff member hands hold the upper arms just below the shoulders and bring the lemurs arms back, therefore keeping the head / jaw area away from the staff member's hands. This technique should only be used on an anaesthetised animal for example taking it out of the capture net at the veterinary department when the individual may not be fully under. Lemurs are particularly known to play possum (remaining perfectly still, until the restraint hold has been relaxed or removed and then attempting to flee).

Type b) should a restraint on a partially anaesthetised or non anaesthetised lemur be required, restraint by grasping the individual behind its head and above the tail. This is particularly the case when the lemur has been taken to the vet department for a general anaesthetic for a procedure and the lemur is in the net and requires the induction mask to be placed over the nose mouth area.

If individuals need to be caught by hand it is best to firmly grasp the base of the tail and the scruff of the neck for a short time before putting into a net or petpack. Extreme care must be taken as these Lemurs have soft skin that is easily torn.

Handling should only occur by trained / experienced staff and as a last resort for capture.

6.4 Weighing and Examination

Individuals can be conditioned to stand on scales, or to stand on a platform for a hanging weight. Alternately animals that are conditioned to enter a petpack can be weighed in the pet pack. Alternately, Lemurs can be conditioned into a pet pack and weighed, subtracting the weight of the pack to gain the correct animal weight.

Lemurs at TWPZ have also been conditioned to stand up and undergo a physical ventral examination.

6.5 Release.

Animals should be released into a smaller secure area initially so that keepers are able to gauge their physical health and alertness before releasing them into the main enclosure. It is best to place the pet pack on the ground with the door opening away from the keeper opening it to reduce the risk of an attack. Also if the animal is still slightly under sedation it is safer on the ground. If animals require introductions, there can be many complications and must be undertaken with caution. Introductions must occur in several steps, gradually increasing contact from sound and smell to sight and finally to physical contact. This process may take several months. Often the use of a different, neutral cage facilitates introductions or re-introductions. This area must allow for quick separation of individuals and close monitoring. Once physical introductions are made, the group must be carefully monitored for at least 48 hours and daily monitoring for at least 2 months (NSW Agriculture 2000).

7.0 TRANSPORT REQUIREMENTS

The International Air Transport Association (IATA) is the governing body that dictates the standards required involving the transport of any animal using member airline services. The standards and regulations cover all container requirements necessary for the transport of all animals as well as the accompanying permits and documentation that apply.

General requirements state that the box must prevent the animal from escaping and prevent the handlers from being bitten (IATA, 2006). The transport container must be adequately ventilated, and the size of ventilation holes depends on the ambient temperature. However, the ventilation holes must be small enough to prevent escape (IATA, 2006). Accompanying the transport box and animal must be the appropriate labelling and marking, and documentation – names, addresses, and phone numbers of the person shipping the crocodile/s and the person receiving them. All boxes must have labels stating “THIS WAY UP” and “LIVE ANIMAL” affixed to all four sides, and reptiles/amphibians must be indicated on the live animal label (IATA, 2006). Further information on the general container requirements can be found in the appendix.

7.1 Box Design.

See Appendix 3

All shipping containers need good ventilation. Make several 3cm diameter holes on both sides and top of box and cover with fine strong metal mesh. The front side of the transport crate should also be 2/3 strong wire mesh approx 1cm. This will allow for good ventilation and prevent the Lemurs from probing their hands through the holes of the mesh, yet big enough for keepers to provide with more water or food while waiting for transport. The wire mesh should be covered with burlap to give the animals' privacy.

If Pet-packs are used, ventilation is rarely a problem, however, it is often difficult to keep the animals warm. Wooden crates are ideal as they will help to muffle sounds as well as insulate the animal being transported.

Attach handles on the side to carry the crate. The advantage to having the handles on the side is it provides extra space for ventilation in case two crates are placed close to one another. A device to create space for ventilation is mandatory when shipping animals. In the past wooden bars approx 2cm wide have been affixed to the sides of the transport crate to ensure adequate ventilation.

It is best to use a sliding door for the transport crate. This can be secured with a bolt and padlock. Quarantine tags will be placed through this to ensure the box has not been tampered with during transport.

A second wooden floor should be fastened to the original floor to allow for urine to be drained away. IATA regulations specifically require a removable dropping tray.

7.2 Furnishings

The bottom of the box should be filled with absorbent substrate such as wood shavings or shredded paper. These substrates will absorb any excretions and must be disposed of as per quarantine guidelines.

7.3 Water and Food

Most Ring-tailed Lemur transfers occur regionally, therefore transport times are usually less than 24 hours. In this time-frame, Ring-tailed Lemurs can usually go without food. However in the case where food is necessary to include within the transport crate, care must be taken with AQIS guidelines of food transport. In most cases food travelling with an animal can be quarantined and disposed of properly when it arrives at its destination.

Water must be provided during transport. In the past hook on water dishes have been affixed to the window mesh with a plastic tube running into it so that keepers can add water as required. Lemurs have also been known to accept water from pet water dropper dispensers.

7.4 Animals Per Box

Animals should travel singly to avoid aggression, unless it is a female with infant.

7.5 Timing of Transportation

When possible, schedule departure and arrival for Tuesday through Thursday (to avoid weekends) and during normal business hours to ensure that the cargo office is open for pickup.

It is best to ship animals during the milder weather to avoid extreme temperatures. Ring-tailed Lemurs are easily chilled or overheated.

7.6 Release from Box

Upon arrival, animals should be released from the shipping crate and reunited with family members if appropriate. Animals should be given a nest box, food and water immediately upon release from the crate.

Ring-tailed Lemurs are quite placid animals and if given regular access to transport boxes, travel is less of a stressful time.

If any sedation is required, I would only suggest something very mild such as Clomicalm, Bach's remedy or something natural. Essential oils and antistress aromatherapy pet combinations have been used with success.

The shipping container must be labelled on the sides and top as to which side is up (use arrows to indicate direction), note the content of the crate (i.e., number of animals, species), and consignor and consignee addresses and phone numbers.

A representative from the zoo should stay with the Lemurs until they are loaded to be sure they are kept in as quiet an area as possible, are not disturbed by curious airport personnel, are not left in drafts or

direct sun, are not placed under or between other freight, and are actually loaded on the correct flight. The animals do not need to be fed for a short flight, if they were fed prior to being crated. If the trip exceeds five hours, some food should be provided (fresh fruit, browse). Specimen reports, medical records, and health certificates for each individual should accompany every shipment, in addition to necessary permits.

8.0 HEALTH REQUIREMENTS

8.1 Daily Health Checks

When servicing Ring-tailed Lemur enclosures on a daily basis, the general physical condition of each individual should be checked to ensure each Lemur has no signs of stress, physical injury, or ill health. General observation of behaviour checking for abnormalities or changes can be done from a non-invasive distance, and can be done continually throughout the day.

It may even be possible on some occasions to perform a general physical examination quickly whilst the Lemur is being conditioned to perform tasks such as walking on ropes, standing up tall, jumping on the platform and entering the pet pack.

8.2 Detailed Physical Examination

The Ring-tailed Lemurs housed at TWPZ (5.0.0) do not currently allow keepers to touch them for a detailed physical examinations. However with regular conditioning they may allow tactile interactions in the future. For thorough physical examinations, individuals will have to be sedated.

8.2.1 Chemical Restraint

There are several methods in which chemical restraint can be achieved. As all chemical sedatives are potentially dangerous, the chemical used in restraint should be used in moderation. Lemurs being sedated will have to be separated from their social groups and the quicker they are alert enough to return to this group, the smoother the re-introduction will go. Chemical restraint drugs should only be administered by qualified veterinarians.

8.3 Routine Treatments.

Annual Health checks at TWPZ include:

- regular TB testing (yearly),
- blood iron levels tested for haemochromatosis,
- blood sugar levels for obesity
- regular faecal floats for worm egg floats
- regular worming treatment for a variety of worms
- Checking microchips and locations (as they can move over time)

8.4 Heating Requirements.

An environment with air temperature ranging between 18 to 30 degree Celsius is ideal for Ring-tailed Lemurs.

8.5 Cleaning Requirements.

Ring-tailed Lemur enclosures should be checked for slugs and/or snails and these should be removed due to Rat Lung Worm risk. Water bowls should be scrubbed and refilled daily and faecal deposits should be disposed of. If feeding containers are used they should be scrubbed free of old food, faeces and any urine deposits and sanitized and rinsed before refilling with fresh food.

Enclosure furniture should be sanitized minimally as stripping the furniture entirely of the Lemurs scent can be quite stressful to the group. Wooden furniture requires less sanitization as it contains natural antibacterial properties.

8.6 Known Health Problems

Two health issues have been historically noted with Ring-tailed Lemurs held in captivity:

1.) Hemochromatosis (hepatic iron storage disease)

Hemochromatosis (hepatic iron storage disease) historically has been considered a common problem in lemurs in captivity, although usually in *Elemur* and *Varecia* species. It is suspected from excess iron storage resulting in pathologic changes in the liver. Literature indicates its likely occurrence from the excess intake of dietary iron, ascorbic acid (citrus fruits) which promotes the conversion of Fe³⁺ to Fe²⁺ and due to insufficient tannins (which assist in binding the iron) which are generally not provided in captive diets. The Fe²⁺ is a form which is more absorbable to the body. In recent years the reduction of high iron foods and citrus fruits from the diet has reduced the occurrence of Hemochromatosis in captive populations (Fowler *et al* 1999 and AZA Prosimian Taxon Advisory Group 2003 as cited in Tyler 2008).

2.) Weight Gain

Weight gain (obesity) in the species, in particular at the TWPZ, has been of concern. Particular individuals have exceeded the captive weight ranges of 1.96 – 2.705kg as indicated in the (Nutrient Requirement on Nonhuman Primates). This generally occurs due to the selective consumption of preferred food items by alpha individuals in the group (Tyler 2008).

Other possible health issues:

Tuberculosis

Susceptible to human and avian tuberculosis. Incidence of disease is low in lemurs. Can be tested routinely. Risk significantly reduced with limited human contact.

Herpes Virus infection (herpes simplex, cold sores)

Susceptible to human cold sores but unaware of previously reported cases in lemurs. Can cause serious disease and can be fatal. Risk is increased if contact occurs with a person actively shedding virus (cold sore present). Risk will be significantly minimized if contact with people is limited.

Dermatophytosis (ringworm)

Susceptible to human ringworm infection. Skin mycosis cases are rare however. Risk is very minimal.

Toxoplasmosis

Lemurs are considered quite sensitive to Toxoplasmosis infection. Transmission possible from cat faeces if contamination of exhibit occurs. Can cause peracute death therefore diagnosis is usually on post mortem. Risk is minimal as contamination from public is unlikely.

Foreign body ingestion and toxins

Reported to be moderately discretionary in foraging habits. Risk of foreign body ingestion is minimal.

Rat Lung Worm *Angiostrongylus cantonensis*

Lemurs are also susceptible to this disease contracted by eating slugs and/or snails infected with contaminated Rat/Mouse faeces.

8.7 Routine Vaccinations

No routine vaccinations are recommended for Lemurs, however some institutions vaccinate against rabies virus infection and with tetanus toxoid without complication (Fowler, Miller 2003). Both should be effective. Regular fecal examinations for parasites should be performed.

8.8 Routine Quarantine treatments

When in Quarantine, animals should receive intradermal tuberculin testing or opportunistically during regular vet checks is also recommended.

8.9 Vet Procedures

No information available at this time.

9.0 BEHAVIOUR

Literature indicated two peaks during the day with feeding and around midday an approximate two hour rest period (Sussman 1977c as cited in Harcourt *et al* 1990).

Jolly (1966) indicated wild lemurs awaken an hour to half an hour prior to dawn and may quieten as the first light of the morning appears. The lemurs may become active, moving, sunning and feeding between 5.30 am to 8.30 pm or becoming active around 8.30am to 9am depending on the weather and the seasons. There may be a second period of activity between 8am to 10am with movement between the different tree type levels which may include the ground for feeding,

At approximately noon the lemurs may move to an area for a midday siesta. This siesta period during the hot season may occur from noon to approximately 4pm and during the cold season is generally shorter. During this period the lemur group may move. During the siesta the preference is for a sleeping branch of a large tree and the lemurs may sleep in contact with another lemur, social grooming or self grooming may occur, in general few spats between individuals observed.

The lemurs may become active in the early afternoon and may settle or may remain in the same location until the feeding period in the afternoon. Approximately around 3 pm to 5pm the lemurs awaken and move to the afternoon feeding site, this period involves social interactions between group members. A period following sunset finds them reaching the sleeping trees for the night ½ to 1 hour after sunset at approximately 6.30pm to 7.30pm. The lemurs as a group tend not to change trees during the night; individuals have been observed leaping, feeding, grooming and spats between individuals occurring during the night.

This may occur in a similar pattern over a given area for approximately three to four days, there after the lemurs may shift to another part of the lemurs range.

Budnitz (1978), Sussman (1974 & 1977b) as cited in Harcourt *et al* (1990) wrote the species being active and foraging in all part of the forest and the species spends a good considerable periods of time on the ground.

9.1 Habits

In the mornings the Ring-tailed Lemur sunbathes to warm itself. It faces the sun sitting in what is frequently described as a "sun-worshipping" posture or Lotus position. However, it sits with its legs extended outward, not cross-legged, and will often support itself on nearby branches. Sunning is often a group activity, particularly during the cold mornings. At night, troops will split into sleeping parties huddling closely together to keep warm (Cawthon 05). A group of huddled Ring-tailed Lemurs is referred to as a lemur ball.



Fig 5. Ring-tailed Lemur sunning

Despite being quadrupedal the Ring-tailed Lemur can rear up and balance on its hind legs, usually for aggressive displays. When threatened the Ring-tailed Lemur may jump in the air and strike out with its short nails and sharp upper canine teeth in a behaviour termed jump fighting (Cawthon 05). This is extremely rare outside of the breeding season when tensions are high and competition for mates is intense. Other aggressive behaviours include a threat-stare, used to intimidate or start a fight, and a submissive gesture known as pulled-back lips (Cawthon 05).

Border disputes with rival troops occur occasionally and it is the dominant female's responsibility to defend the troop's home range. Agonistic encounters include staring, lunging approaches and occasional physical aggression, and conclude with troop members retreating toward the center of the home range (Cawthon 05).

9.2 Social systems

Troops are classified as multi-male/multi-female, with a matriline as the core group (Cawthon 05). As with most lemurs, females socially dominate males in all circumstances, including feeding priority. Dominance is enforced by lunging, chasing, cuffing, grabbing and biting. Young females do not inherit their mother's rank and young males leave the troop between three and five years of age (Sussman 99, Cawthon 05). Both sexes have separate dominance hierarchies; females have a distinct hierarchy while male rank is correlated with age. Each troop has one to three central, high-ranking adult males who interact with females more than other group males and lead the troop procession with high-ranking females (Cawthon 05). Recently transferred males, old males or young adult males that have not yet left their natal group are often lower ranking. Staying at the periphery of the group they tend to be marginalized from group activity (Cawthon 05).

For males, social structure changes can be seasonal. During the six month period between December and May a few males immigrate between groups. Established males transfer every 3.5 years (Sussman 99), although young males may transfer every 1.4 years. Group fission occurs when groups get too large and resources become scarce (Cawthon 05).

9.3 Aggression

9.4 Olfactory communication



Fig 6. Ring-tailed Lemur scent-marking using anogenital scent glands

Olfactory communication is critically important for prosimians like the Ring-tailed Lemur. Males and females scent mark both vertical and horizontal surfaces at the overlaps in their home ranges using their anogenital scent glands. The Ring-tailed Lemur will perform a handstand to mark vertical surfaces, grasping the highest point with its feet while it applies its scent (Cawthon 05). Use of scent marking varies by age, sex and social status (Gouzoules 07). Male lemurs use their antebrachial and brachial glands to demarcate territories and maintain intragroup dominance hierarchies. The thorny spur that overlays the antebrachial gland on each wrist is scraped against tree trunks to create grooves anointed with their scent. This is known as spur-marking (Jolly 1966).

In displays of aggression, males engage in a social display behaviour called *stink fighting*, which involves impregnating their tails with secretions from the antebrachial and brachial glands and waving the scented tail at male rivals (Rowe 1996).

9.5 Auditory communication

The Ring-tailed Lemur is one of the most vocal primates and has a complex array of distinct vocalizations used to maintain group cohesion during foraging and alert group members to the presence of a predator. Calls range from simple to complex. An example of a simple call is the purr, which expresses contentment. A complex call is the sequence of clicks, close-mouth click series (CMCS), open-mouth click series (OMCS) and yaps used during predator mobbing (Macedonia 1993). Some calls have variants and undergo transitions between variants, such as an infant "whit" (distress call) transitioning from one variant to another.

The most commonly heard vocalizations are the moan (low-to-moderate arousal, group cohesion), early-high wail (moderate-to-high arousal, group cohesion), and clicks ("location marker" to draw attention) (Macedonia 1993).

9.6 Courtship.

During the mating season, males wave their scented tails at females as a form of sexual overture; this usually results in the female cuffing or biting the male and elicits subordinate vocalizations from the male.

9.6 Captive Behavioural Problems

If Ring-tail Lemurs are housed singly or in a very small group there are usually several behavioural problems and/or targeted aggression between the group. Females unrelated to the natal group will always be ostracized and targeted in aggressive displays. Obesity through lack of activity.

9.7 Behavioural Enrichment Activities.

Prosimians can be very hard to enrich as they do not have opposable fingers, this means that they find it harder than the monkeys and the apes to manipulate items. The Ring-tailed lemurs can also be very wary of new objects in their enclosure and therefore harder still to provide enrichment for. Even so there are many methods that we can utilise to keep the lemurs stimulated.

Most of the lemurs' enrichment revolves around their diet, hiding it within boxes and bags works well as does hanging whole food from the perching. Sometimes the food will be cut up extremely small and thrown amongst the grass encouraging them to forage naturally. All these methods aim to prolong their feeding times.

Sensory enrichment is another form of enrichment that we have had some success with. As they rely on scent as their main form of communication amongst each other, we can occasionally remove an item of perching from one lemur exhibit and place it in another.

Mulch is also great sensory enrichment, as they will spend hours re-scenting the individual bark chips. Small food items (ie: beans, peas, corn kernels, rasins etc.) can be sprinkled through mulch to increase foraging time. Fresh browse is not only healthy for Ring-tailed Lemurs, it is also enriching is given in larger branches that they have to climb.

10.0 FEEDING REQUIREMENTS

10.1 Captive Diet

Produce offered to *L. catta* generally falls into the following categories: fruit, starchy vegetables, leafy greens and vegetables. These are offered daily, along with a nutritionally complete biscuit, in some combination. Year-round available fruits are most often offered (e.g., oranges, bananas, grapes and apples), while a variety of other fruits are provided when in season. Starchy vegetables include sweet potatoes, turnips, potatoes and corn; greens include kale, collard greens, alfalfa, cabbage and lettuce. Other vegetables include broccoli, celery, cucumbers and green beans. Many facilities also offer leaves, fruits and flowers from local browse, although its use is governed by staff time and knowledge of safe species, availability and season. Animals are fed either once or twice daily, and produce rotation provides diet variety. Sample diets fed to ring-tailed lemurs at several institutions follow this general pattern.

Eg. Sample Diets from Hamilton Zoo and TWPZ see Appendix 5.

10.2 Supplements

Supplements are not recommended for Lemurs due to their high incidence of Haematochromatosis. If Lemurs are not given access to natural sunlight, they may require vitamin D supplementation.

10.3 Presentation of Food.

In the wild, Ring tailed Lemurs spend the majority of their time foraging on the ground, but are also known to feed in different canopies of the forest. Unlike some other species of Lemur they don't have a designated level in which they spend most of their time or select their food from.

Food should be cut into equal portions to enable each member of the group to gain access to preferred food that there may not be large quantities of. It should be of a size that they can easily hold with both hands as well as have an edge that they are able to fit their mouth around (whole apples are very difficult for this species to eat).

Give food at several times throughout the day in several different locations and levels in the trees to prevent crowding and aggression around feeding areas.

Chronic overfeeding can result in diet selectivity by the animals and obesity; therefore diets should be fed such that no more than 10-15% of the offered diet will be left uneaten. Large groups should be fed in multiple sites to prevent competition for choice items.

11.0 BREEDING

At TWPZ we have an all male group currently, with no recommendations to breed, however due to the state of the regional population, it may be necessary to upgrade our facilities and be prepared for breeding and holding multiple groups in the future.

11.1 Breeding System

In the wild, Ring-tailed Lemurs are polygamous – a pattern of mating in which both males and females have more than one sexual partner during a single breeding season.

11.2 Captive Breeding

In captivity, Ring-tailed Lemur Breeding is a more difficult scenario as there is usually a significant amount of targeted aggression during the breeding season. Males will need to be removed from the breeding group prior to breeding season starting. If recommendations have been given to breed, pairs must be separated for breeding to ensure the paternity of the offspring.

Contraceptive implants may be given to females not required for breeding as a short term contraceptive measure, to maintain the group as a cohesive unit (Tyler 07). This will not however combat the aggression issues.

11.3 Breeding Introductions

Kleiman *et al*, (1996) indicated: staff involved in the introduction should have an understanding of the species social structure, natural behaviours and history of the group in particular individual group members back grounds. Every introduction is different and therefore every introduction may have a different outcome. Where possible introductions should occur in a neutral area with circular escape routes and minimal dead ends. A minimal number of staff to be involved reducing external stress but sufficient staff to ensure good visual assessment of the introduction, and ensuring a sufficient degree of control over any situations that may arise.

Females should be considered for introduced to males at times of peak oestrous, see indicators of female's oestrus. The signs of female oestrus are often difficult to observe (pers. obser) and the females are only receptive to males for a period of 24 hours per year (Sauter *et al*, 1993; as cited in Rowe, 1996). The initial introductions should occur via a barrier to allow visual, olfactory, auditory and limited tactile contact in an adjacent enclosure. After a positive initial introduction and depending on the individuals, a full contact introduction can follow. The length of time for the introduction(s) will vary depending the nature, complexity and degree of socialization of the individuals during the introduction. It should be noted aggressive encounters are likely and individuals may require time to resolve differences to allow compatibility. Any encounters which are aggressive should be terminated prior to serious injuries occurring.

Kleiman *et al*, (1996) the temporary use of drugs can be considered in reducing aggression.

When the individual is to be introduced to a group, commence with the initial introduction with the new individual to the lower ranked individual and gradually work up to the alpha individual. (Pers. obser) See targeted aggression in section 7.2 for re-introductions. Ring tailed lemur fights are **silent**; the aggressor chases the victim resulting in the aggressor grabbing and pulling out fur from the rump, thigh and tail areas of the victim, during this period both lemurs are vocal. Should the victim be grabbed and held, the victim is brought down, resulting in both lemurs curling / balling up on the ground, grappling with one another with hands / feet and inflicting potentially serious bite wounds. Due to the nature of the incisor teeth, deep lacerations can occur. With care, the individuals are to be separated, ensuring the keeper does not place themselves in a position to be potentially bitten. Whilst introductions are taking place no feeding of any individuals is to take place by the keepers involved.

11.4 Indicators of female's oestrus

The females have a visible oestrus, with the perineum swelling and turning a pink colouration. The female presents to the male her hindquarters as a sign of sexual solicitation (Evans *et al* 1968, Cowgill *et al* 1962 as cited in Jolly 1966)

The female's genitalia prior to the breeding season are approximately 1.5 cms long, black and resemble a elongated pear, the vulval lips fused above and the clitoris below. The female's genitalia swell from approximately 1.5 to 3 cms in length and develop a light followed by a pink centre. Classification of the genitalia occurs according to the size and colour of the centre and not the whole of the genitalia. The following categories were provided in relation to oestrus stages:

- Black: out of oestrus
- Small light: centre smaller in diameter than black edge
- Large light: centre larger in diameter than black edge
- Small pink: flushed small centre
- Large pink: flushed large centre
- Bright pink: large, very flushed centre. The vulval opening may be visible as a distinct hole.

During a wild study a number of females displayed a pink phase 3 to 4 weeks before the week of mating, the colouration faded before mating and then flushed again. An initial oestrus or pseudoestrus period may occur one month prior to the true breeding season. The oestrous cycle lasted two weeks or less, with oestrus - mating for a female lasting for approximately a day (Jolly 1966).

11.2 Age at First Breeding and Last Breeding

Females generally breed from 2 to 26 years of age.

Males generally breed from 1.5 – 25 years of age. (ASMP studbook data Tyler09)

11.3 Ability to Breed Every Year

Females are capable of producing offspring every year, as lactation time is relatively short in this species.

11.4 Timing of Breeding

Ring-tailed Lemurs are strict seasonal breeders and give birth to co-occur with the end of the dry season and the beginning of the wet season so that the births are timed during periods of high food abundance. This seasonality is related to the photoperiod sensitivity and out of season births can occur when light cycles are manipulated in captivity. Here at TWPZ out Ring-tailed Lemurs are exposed to natural light cycles of the southern hemisphere. Mating in Madagascar commences approximately mid April and young are generally born in mid-August/September.

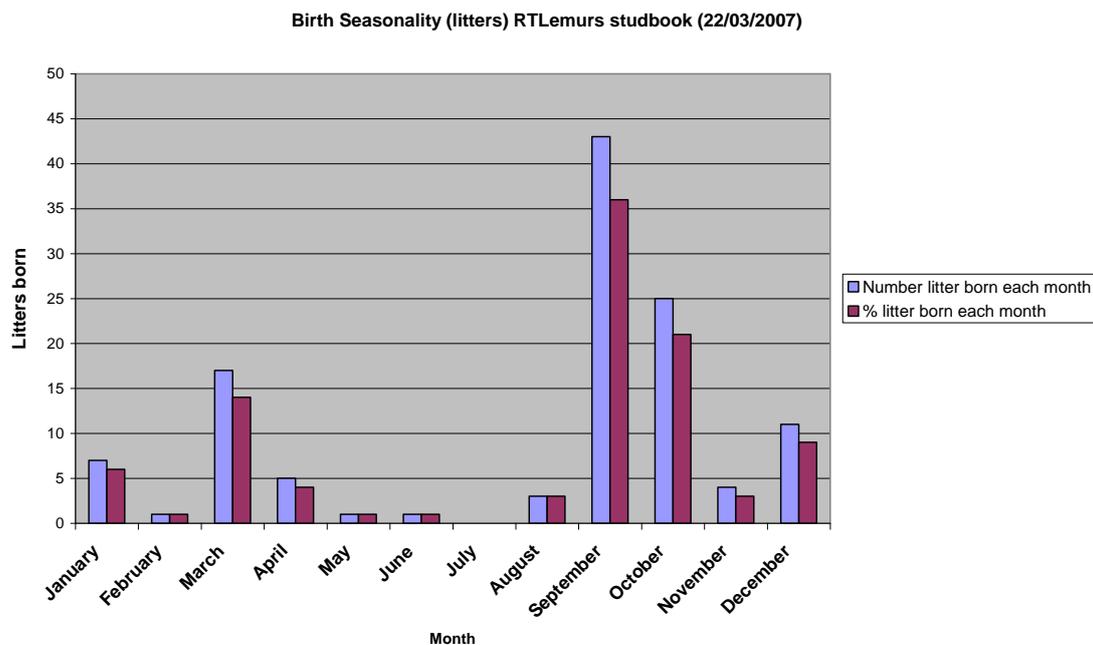


Table 1: Breeding and Birthing seasonality (From RTL studbook 22./3/2007 Tyler 09)

Data from the Australasian studbook indicates a variation, with mating occurring in approximately May, and young generally born in September and October. Should the first mating period be missed, a second mating period has been observed in the studbook.

11.5 Ability to Breed More Than Once Per Year

Due to the very short timeframe of female seasonality, it would be rare for a female to produce two separate litters from the same breeding season. If a female's first mating of the season does not result in a positive pregnancy, she has the ability to cycle again in the same season.

However, current literature suggests that female Ring-tailed Lemurs produce one litter per year. Despite this there are many instances of records of a female producing two litters per year within the Ring-tailed Lemur studbook. This is noticeable in areas such as New Zealand, Melbourne and Europe where temperatures may have been cooler. Several instances where all females produced a litter that year were found. This would suggest that at least one female had indeed had two litters that season. (Tyler, 2008a)

Females are polyestrous if not impregnated on the first cycle, with the average length of cycle being approximately 39.3 days with a breeding season possibly lasting up to three months (Jolly *et al.*, 2002). A birth interval of approximately: 12 – 24 months (Richard 1997 as cited in Rowe 1996).

11.6 Nesting/Hollow or other requirements

Pregnant females should be provided with elevated nesting areas or plenty of sheltered trees or grassy tussocks on the ground.

11.7 Breeding Diet

Individuals separated from their social group during breeding season may be stressed and lose their appetite for a short period of time.

Individuals introduced for breeding for a short periods of time may also go off their food. Plenty of high yield food should be offered to simulate times of plentiful food in the wild.

11.8 Gestation

The gestation of Ring-tailed Lemurs is approximately 134 days.

11.7 Litter Size

- Mean – 1
- maximum litter – 3.
- Sex ratio at birth - 50/50

Females in literature are indicated as promiscuous (Rowe 1996), with a mean litter size of 1.3. Data indicated single offspring occur 66% and twins occur approximately 34% (ASMP Ring-tailed Lemur studbook data 22/03/2007)

Range 1 -3. Triplets have been successfully raised in captivity at the Duke Primate Centre on three occasions (Harcourt *et al*, 1990).

11.8 Age at Weaning / Fledging

Weaning begins at week eight and the mother begins to reject dorsal riding during week 12. By week 16, infant ring-tailed lemurs only nurse about 8% of their total time (Gould 1990).

Schilling (1979) as cited in Rowe (1996) indicated weaning at 105 days and taking solid food at two months of age. Pereira (1993) as cited in Rowe (1996) indicated juvenile status at 16 months.

In years of drought, infant mortality can be as high as 80% while normal infant mortality within one year after birth is around 37%

Infant mortality is high; at the Beza Mahafaly Reserve about half of all infants die in their first year and only 40% reach maturity (Sussman, 1991). *Lemur catta* alarm calls distinguish between terrestrial and avian predators, indicating that predation may be a factor in infant mortality.

11.9 Young Weights

Ring tailed Lemurs birth weight Average 69-122g (ZIDN).

11.10 Age of Removal from Parents

Female offspring remain within the natal group for life unless the female group splits with targeted aggression (Cavicchio *et al* 2005). Female Ring-tailed Lemurs generally breed from 2 years of age. Should the dam be recommended for breeding the following year, female offspring should be considered for contraceptive implant from the age of 1.5 year onwards, to prevent possible inbreeding or non recommended breeding.

Male offspring remain within the natal group for approximately 1.5 years before being forced out of the group by the dominant male during the subsequent mating-season. With reintroductions being generally unsuccessful, males are then transferred to a bachelor group as per species coordinator recommendations.

Removal of offspring may be considered when undue stress is directed towards any offspring, by an individual(s), or should the offspring be abandoned.

12.0 ARTIFICIAL REARING

Hand rearing considerations for TWPZ

Occasionally an animal may need hand rearing due to the Dam's inability or reluctance to rear the offspring. The decision to hand rear has significant implications from both a Curatorial and resource perspective. The decision to hand rear must be determined in the birthing plan for any significant pending birth. It needs to include both the Curatorial and Operational implications of the recommendation. Where considerable resources are required or the Curatorial and Operational recommendations are not aligned, the GM's of both Divisions will determine the outcome.

The full policy for hand raising Considerations for TWPZ can be found in Appendix 5.

12.1 Housing.

The basic requirements are a regulated heat source, a thermometer to monitor temperature, and a secure enclosure that is easy to clean. Incubators are preferable especially for very young animals. Animals should be housed singly in the incubator unless the incubator can be divided, as over suckling of digits or other body parts may occur in group-housed neonates. For infants older than a month, a heat lamp or warm-water circulating heat blanket may be sufficient if an incubator is not available. Standard heating pads are not recommended because temperature gradients can become hot enough to burn infants.

It is important that clinging species of Lemur such as Ring-tailed Lemurs be provided with a sort surrogate on which to cling. Ideally, surrogates should allow the infant to cling in a position that mimics that on the mother. While a variety of surrogate designs have been described for primates, washable stuffed animals are readily available and well accepted by most infants. Once infants are moved out of the incubator to a larger enclosure, branches, chains, ropes and/or boxes may be added to encourage jumping, leaping and swinging behaviours.

12.2 Temperature Requirements

Offspring having to be artificially reared must be kept in a warm environment for the first month or so of development and always have a heated area available. They are not able to self-regulate their own body temperature for the first month of their life.

Humidity should be set at 50-65% and surrounding air temperatures at 35.5-36.7 Degrees Celsius (Gage 2002) for neonates, and adjust as needed to maintain body temperature between 35.5-36.7 Degrees Celsius. Temperatures are gradually decreased as the infant ages and its ability to thermoregulate improves.

It should be noted heated concrete shelving can be utilized within these areas to provide the required heating during the winter months. The shelters need to be of sufficient size and number to the group needs to prevent dominant animals denying access to subordinate animals (NSW Agriculture Department 2000)

12.3 Diet.

Based on one sample collected for *L. catta*, milk composition is probably similar to *Eulemur* – dilute like other anthropoids.

Composition: (n=1) at 62 days postpartum: 10.9% DM,
 1.8% fat,
 2.0% protein,
 8.1% sugar, .
 60kcal/g (Tilden and Oftedal, 1997).

Artificial formulas should approximate as closely as possible to the maternal milk composition. While Lemurs have been successfully on cow-milk formulas, formulas using human infant formula or Zoologic Milk Matrix as a base are preferable because the balance of vitamins, minerals and micronutrients is likely to be more appropriate to young, growing primates. Supplemental or pediatric vitamins should be avoided as the combination of vitamins and human or milk matrix formulas can lead to overdoses of certain vitamins and minerals, particularly that of iron. When using human formulas, they must be low iron formulations.

Suggested Formulae (Gage 2002)

Formula 1: 30ml human infant formula prepared according to directions, 30 ml nonfat milk, 3ml 50% dextrose.

Formula 2: Zoologic Milk Matrix 20/14-10g powder to 100ml water.

For the first 24 hours give warmed electrolyte solution containing dextrose every one to two hours orally at a volume of 1-2 ml/100g body weight. Saline with dextrose added to 10% is preferred but Pedialyte alone may be used in a pinch. If after the first day nutritional support is still required, transition infants to formula by feeding half-strength formula and electrolyte solution (or Pedialyte) for 24 hours, three-fourths-strength formula for another 24 hours, and finally full-strength formula. Normal stools and a lack of abdominal indicate tolerance of the formula. Normal stools of Ring-tailed Lemur infants are semiformal and yellow to brown in colour.

If Lemurs being hand raised have not received colostrum from mother before being pulled for hand raising they are at a significant disadvantage as they will not have antibodies for immune protection. In many cases, colostrum can be manually expressed from the mother and fed to the infant by a syringe.

12.4 Temperature of food.

The temperature of the formula is very important. Infants generally prefer formula at body temperature and may reject formula that is too hot or too cold. Always test the temperature by dropping a few drops of formula on the inside of your wrist prior to feeding.

Warming formula in the microwave of water bath may result in overheating or uneven heating (hot spots). Formula must be thoroughly mixed before testing temperature. Be careful not to put too many air bubbles into the formula when mixing. A gentle side to side mixing technique should be used rather than shaking the formula to prevent air bubbles.

12.5 Nursing Techniques

Feeding and handling techniques should replicate the natural feeding position and nipple size of the mother as much as possible. Ring-tailed Lemur infants cling to their mothers' abdomen in an upright position when feeding. Most infants will come to accept a artificial nipple readily. 3-6ml nipples should be used for Ring-tailed Lemur infants.

It is easier to control the delivery rate and to track the amounts consumed if infants are fed by syringe. A red rubber feeding tube can be cut to size and attached to the syringe tip to serve as a nipple. Even though the infant may suckle on the nipple, the person feeding can control the rate of delivery of the formula with the syringe.

Initially, infants may be too weak and have a depressed suckle reflex. If this is the case fluids can be slowly dripped from a syringe or eyedropper onto the edge of the infants mouth. Some have also had some success with allowing the infants to lap fluids from a sterilized dish.

If an infant refused the nipple altogether and must be tube fed to survive. Size 8-12 French red rubber catheters make ideal stomach tubes.

Directions for use from Gage 2002.

Firstly the distance from the nose to the last rib of the infant must be measured to determine how far to insert the tube. Mark the distance with a non toxic marker or some tape. With one person holding the infant, a second inserts the tube in the infant's mouth and slowly guides the tube over the base of the tongue, past the gag reflex, ad down the throat. Once past the gag reflex, the tube should advance easily into the stomach. If the tube does not advance easily to the measured length, withdraw it and start again. Infants may not always cough or gag in

response to the tube entering the trachea. Once inserted, the proper position of the tube in the esophagus can be verified by palpation of the tube in the neck just alongside the trachea. Older infants may need to be swaddled in a towel to prevent them from grabbing the tube and pulling it out of their mouth. Deliver the formula slowly by syringe. Extreme care must be taken not to overfill the stomach. Initially, feed only 75% of the volume that would be fed by bottle or syringe and increase gradually only if the infant seems to accept the increases easily. With the tube still in place, flush the remaining formula from it with a small amount of water and kink the tube before removing to prevent backflow.

Hand-fed infants are at risk of developing aspiration pneumonia if formula or fluids are fed too quickly. Careful attention should be given to the rate at which formula is fed and to using proper techniques whilst feeding. For consistency, the number of people feeding an infant should be limited initially.

12.6 Frequency of feeding and Amounts to Feed

Newborns should be fed every two hours around the clock for the first week. Once the infant is gaining weight sufficiently, formula quantity and the time between feedings can be gradually increased. Ring-tailed infants ride on their mothers and tend to nurse for long periods and it is important to spread out feedings very gradually when hand feeding. Feedings should be administered on a body-weight basis with the frequency and amount adjusted according to individual tolerance and weight gain. The amount of formula consumed daily as a percentage of body weight will vary but 25% is a good target amount.

12.7 Expected Weight Gain

After an initial one-to-two day period of adjustment, infants should gain weight and increase formula intake on a daily basis. If a progressive increase in both is not seen, an assessment of the health and diet of the infant is required. Growth rates are usually slower in the first month of development and will increase afterwards. There are accelerated growth periods during weaning when animals begin consuming solid foods.

Ring-tailed Lemurs average 4-7g/day through the first four months.

Weight gain of formula fed infants should ideally approximate that of maternally raised infants. (Table)

12.8 Hygiene

Infants being hand-raised will need to be kept in quarantine as they are not receiving the antibodies in the mother's milk. Therefore, care must be taken to minimize their exposure to potential pathogens. Personnel handling the infants should wear clothing designated for that particular infant including gloves and a clean lab coat or apron or gown. Clothing should be changed between handling different infants. Personnel with upper respiratory infections, flu-like symptoms, or active herpes lesions should not have any exposure to the infants. The incubator, bedding and towels should be changed and sanitized daily.

12.9 Toileting

Mothers groom the anal-genital area of neonates to stimulate urination and defecation. In hand-reared infants, gently rubbing a cotton ball dipped in warm water across the anal-genital area after feeding accomplishes the same purpose and should be done after every feeding. Mother will provide grooming for supplemented infants that are returned after feedings.

12.10 Socialization

Social interaction such as grooming, playing and bonding interactions are important to normal Lemur development. A ideal time to provide social stimulation and encourage physical activity in hand-raised infants is after feeding. Grooming a infant with a toothbrush not only helps to keep it clean, but also provides tactile stimulation it would normally receive from its mother or other Lemurs. If multiple infants are being raised (as they should be raised in at least pairs) they can be housed together starting at 1.5 – 2 months of age. It is at this age that infants will begin to make small jumps from branch to

branch and it is important to provide them with opportunities to do so for their physical development and co-ordination.

Older infants will require access to natural lighting, especially during the early part of the day to have access to sunlight for thermoregulation and absorption of vitamin D.

12.11 Identification Methods

Animals can be identified easily from their different facial markings and coat colour. It is best to have individuals micro chipped between the shoulder blades for more definitive identification. Ear tags have been used for identification. In the past, however as the animals grow and are more active, the ear tags quite often fall out or are ripped out by others. As ear tags age, the different colours used for identification fade, making it difficult to make an accurate identification of an individual.

12.12 Hygiene and Special Precautions.

12.12.1 Preparing formula

Formula must be prepared in a consistent and hygienic manner. It will spoil quickly so prepare only what is required for 24 hours and refrigerate unused portions. Heat only the portion to be fed during a single feeding and discard heated formula that is not consumed.

Sterilize mixing bottles before preparing formula. Syringes, feeding tips and other equipment can be washed and soaked in dilute chlorhexidine disinfectant, and rinsed well between uses.

12.12.2 Disease Risk to Humans

Gastrointestinal bugs (*Giardia*, *Salmonella*, *Shigella* and *Campylobacter*)

Transmission can occur through contact with infected lemur faeces. Lemurs can carry all of these gastrointestinal bugs listed.

Risk is minimal if animals are routinely tested to be negative. All four listed can be regularly tested for.

12.12.3 Common Medical Problems

Hypoglycemia, hypothermia, and dehydration are common problems in Lemur infants. Lethargy and anorexia are commonly seen when one or a combination is present. Giving oral 10% dextrose is appropriate even if blood cannot be obtained to check the glucose level. If glucose cannot be given orally, 5% dextrose in fluids is an alternative. Hydration status is difficult to assess in young Lemurs and prophylactic treatment for dehydration with warmed subcutaneous fluids is appropriate. Both lactated Ringer's solution and 0.9% sodium chloride are good choices.

Gastrointestinal problems can result from improper feeding of formula composition. If care is not taken to remove air from syringes and feeding tubes, it accumulates in the stomach causing the infant to become fussy or refuse feedings. Gas in the stomach is easily verified on radiographs. Passing a stomach tube and using a 5-10ml syringe to apply light suction, effectively removes gas retained in the stomach. Gas can also accumulate diffusely throughout the gastrointestinal tract leading to abdominal distention and discomfort. Gas accumulation is secondary to decreased gastrointestinal motility resulting from enteritis, improper formula composition, or intestinal obstruction. Drugs that enhance gastrointestinal motility are rarely beneficial and are contraindicated in cases of suspected obstruction. Therapy is aimed at correcting the underlying problem.

Diarrhea is a common problem in hand-reared lemurs. Following strict hygienic protocols when making formula and handling infants is the best prevention against infectious causes of diarrhea. Stool cultures for *Salmonella*, *Shiella*, *Yersinia*, and *Campylobacter* help rule out diarrhea caused by pathogenic bacteria. When performing fecal parasite exams, give particular care to rule out *Cryptosporidia* and *Giardia*. Diarrhea can also be a sign that the formula or recently introduced solids are not well tolerated. To combat diarrhea, first dilute the formula or decrease the amount fed. In some cases soy-based formulas are better tolerated than one based on casein or cow's milk. Restrict solids to small amounts of those tolerated well before the onset of diarrhea. Limiting fruit alone may solve the problem.

12.13 Behavioral Considerations.

The complex social structure of the species suggests that hand rearing of an individual would not be beneficial for either the individual or the species as a whole and is likely to compromise the ability of the individual to parent any subsequent offspring.

ARAZPA has recommended the euthanasia of offspring that are not able to be parent reared. The recent Ring-tailed Lemur ASMP workshop (09) agreed that if the offsprings' genetic information was vital to the population and there are twins, then it would be acceptable to attempt to hand raise the pair.

12.14 Use of Foster Species.

There has been no evidence found suggesting Ring tailed Lemurs would be suitable for being raised by a foster species. Abandoned young may however be raised from a suitable age (not newborn) by other Ring-tailed Lemur mothers if it does not cause significant aggression between the group.

Infants that are rejected by their mothers and hand-reared are notoriously sickly. Whenever possible, rejected infants should be fostered on another mother; lemurid mothers can easily rear two young at once.

12.15 Weaning

According to the Exotic Rearing of Young (TWPZ 96), Ring tailed Lemurs would start to be weaned at 4 weeks and be weaned by 16 weeks.

12.16 Reintroduction Procedures

Reintroducing Ring-tailed Lemur infants to their mother or natal group must be undertaken with care as both males and females will frequently kill young they do not recognize as their own. In general, longer separations are tolerated for older infants than for younger infants. Dams separated from their offspring at birth may become aggressive in as little as 24-48 hours if they are out of visual and auditory contact. During reintroductions, providing visual, auditory, and olfactory contact is a good way to assess the level of aggression directed toward a youngster by an adult. If no signs of aggression are noted, contact is gradually increased until the animals have full continual contact. The rate at which reintroductions can be accomplished varies greatly depending on the age and relationship of the animals being introduced.

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(Accessed 16 November 2007)

14.0 GLOSSARY

- Agonistic Behaviour:** any behaviour which is associated with or elicits aggression.
- Arboreal:** an adjective used to describe a species which, in the wild, lives primarily in trees.
- Behavioural enrichment:** any device, mechanism or process which provides positive physical or psychological stimulation to an animal and promotes natural behaviours.
- Body length:** the head to rump length of a primate (see Schedule 1).
- Browse:** leaves, bark and branches of trees, bushes and shrubs.
- Conspecifics:** individuals of the same species.
- Disease:** any condition suffered by an animal such that normally accepted parameters of health are not met.
- Distress:** occurs when the animal's mechanisms for coping with stressors have been over-extended and are breaking down. May be short ('acute') or long term ('chronic'). Chronic distress results in increases in the animal's susceptibility to disease and reduces its capacity to grow and reproduce. Signs may include hair loss, dermatitis, weight loss, stereotypic behaviour, abnormal ingestion, scouring, increased incidence of disease, self-mutilation, abnormal activity levels, depression, elevated aggression levels and inhibited digestion.
- Diurnal:** a species which is normally active during the day.
- Enclosed** (in relation to an enclosure): indicates that a fenced enclosure is fully roofed.
- Enclosure:** any facility that, by use of physical barriers, enables loose confinement of an animal within a given area.
- Environmental enrichment:** (see Behavioural enrichment).
- Exhibit:** any enclosure designed for the display of animals to the public.
- Family Group:** a group of related animals which contains one or more parents and their offspring.
- Fence:** any structure that comprises an upright physical barrier used either to prevent passage or direct passage of any person or animals.
- Monkey:** a member of the Order Primates other than humans, apes and prosimians
- Rat Lung Worm** (*angiostrongylus Cantonensis*) This parasite travels in the blood to the edge of the brain, then bursts through the brain's defensive lining, causing haemorrhaging and tissue damage.

Sources of Products Mentioned

PetAg Inc., 261 Keyes Ave., Hampshire, IL 60140. www.petag.com

PMI Nutrition International, Inc., Brentwood, MO

Ross Products Division, Abbott Laboratories, Columbus, OH. www.abbott.com, www.ross.com

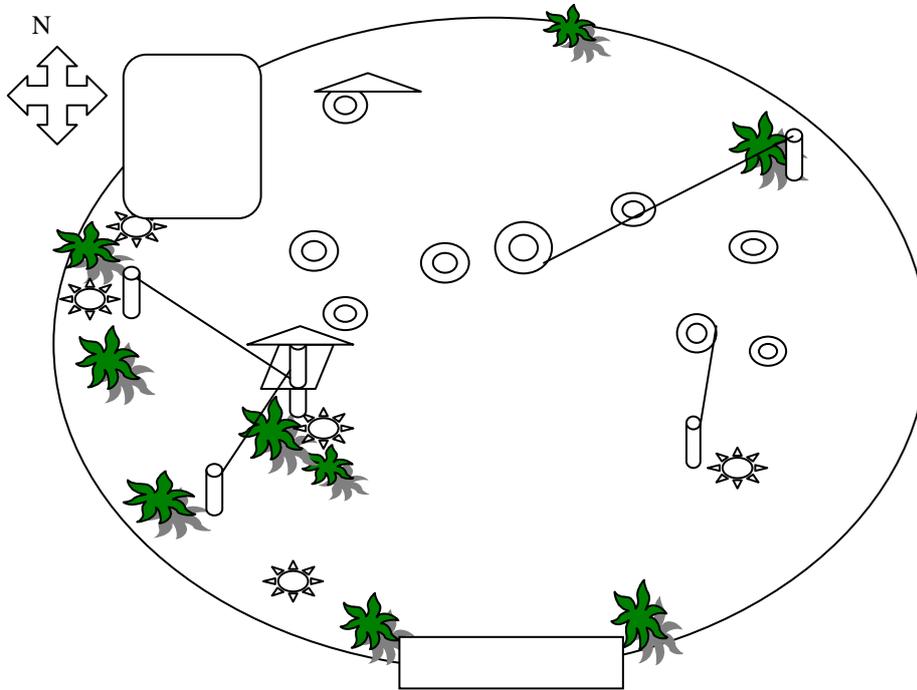
ACKNOWLEDGEMENTS

I would like to acknowledge a number of fellow students and TAFE teachers from Richmond TAFE College as well as staff of Taronga Western Plains Zoo who read through drafts of this manuscript and provided many useful comments.

I would also like to acknowledge Mark Tyler from Perth Zoo as I referred to his ASMP species workshop briefing documentation as part of this review.

Appendix 1: Exhibit Design

Ring-tailed Lemur Island Design

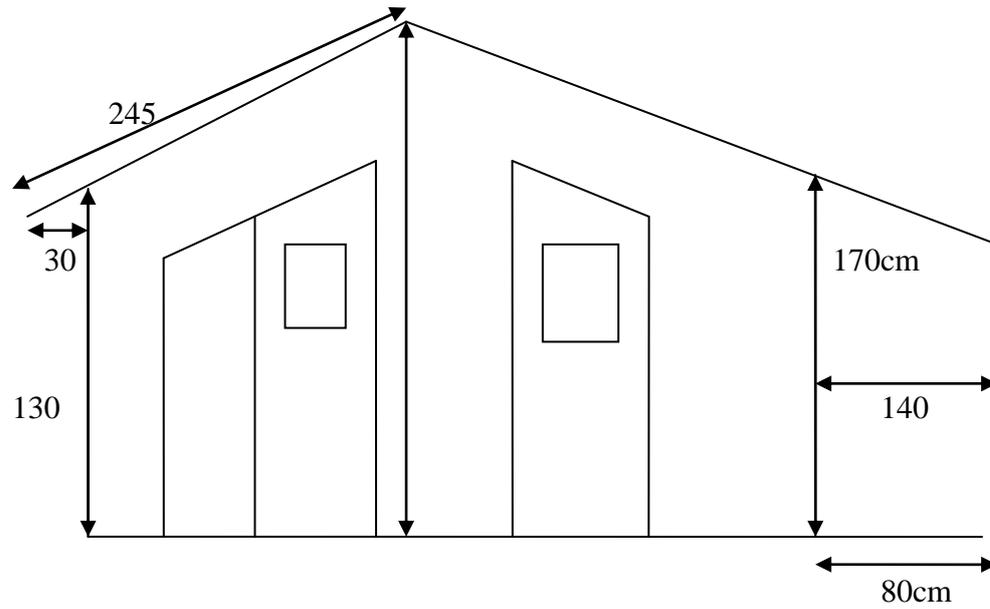


Scale: 1: 100 **TWPZ** **Student:** Kelly Taylor

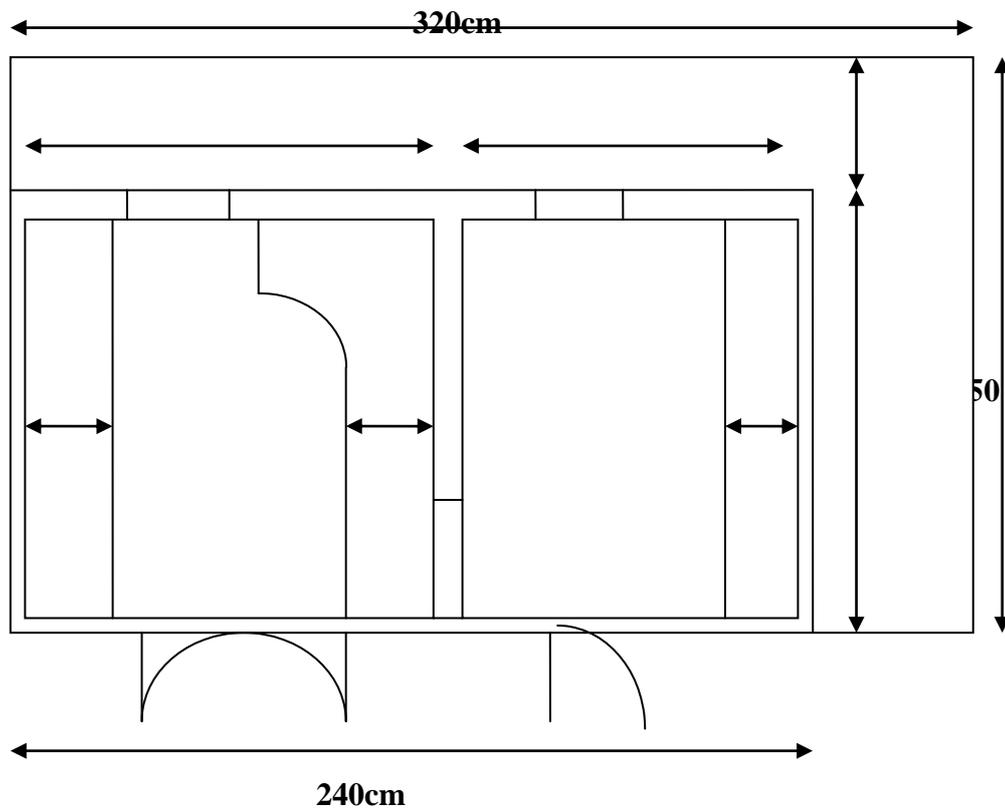
Legend:

-  Existing Trees – all quite tall
-  New plants – grasses
-  New trees.
-  Boat Dock
-  Nighthouse
-  New Vertical Poles
-  Elevated platform 1.5m above ground level.
-  New Elevated shelter (1 within lge tree, 1 over platform)
-  Connecting ropes.

Current Nighthouse – Keeper access view. (not to scale)



Internal View



Appendix 2: Targeted aggression

(From ASMP Workshop briefing documentation Embury et al 09)

Targeted aggression has been indicated in literature as a concern for institutions with a breeding group comprising six or more individuals. *The following is a brief background into targeted aggression.* Targeted aggression generally takes place most often during the pre-mating and birthing season. Females tend to fight for dominance during the birth season with males tending to be aggressive toward each other during late autumn, the pre-mating season. It is suggested that targeted aggression may be considered a form of direct reproductive competition, with females initiating targeted aggression towards males and other females. It was noted that targeted individuals were usually high-ranking animals within the social structure. The period of targeted aggression, ranged from a brief period of a few days to that of several months and generally resulted in the eviction of the targeted individual. Targeted aggression appears to be an important phenomenon for the well-being of a wild group (Cavicchio *et al* 2005). Research into wild populations of Ring-tailed Lemur have indicated that naturally-occurring targeted aggression appears to be an important mechanism for facilitating fission of a group whenever a group becomes too large in size. Episodes were noted as non-random with concern to season, group size (at least six individuals), sex ratio, kinship, age and gender of targets. Targeted aggression in captivity has consequences for the management of the species in the Australasia region. Studies have shown that, the removal from the original group of the main aggressor, the victim and supporters of the aggressor, results in the original group settling (Cavicchio *et al* 2005). After a period, ejected group members were reintroduced at the same moment. Should the problem of targeted aggression continue, it is recommended that permanent removal of the group members of concern will allow for a reduction of the group size and therefore, targeted aggressive behaviours (Cavicchio *et al* 2005 as cited in Tyler 2007).

Personal correspondence with the Apenheul Primate Park (Grietje Grootenhuis) The Netherlands – provided the following details:

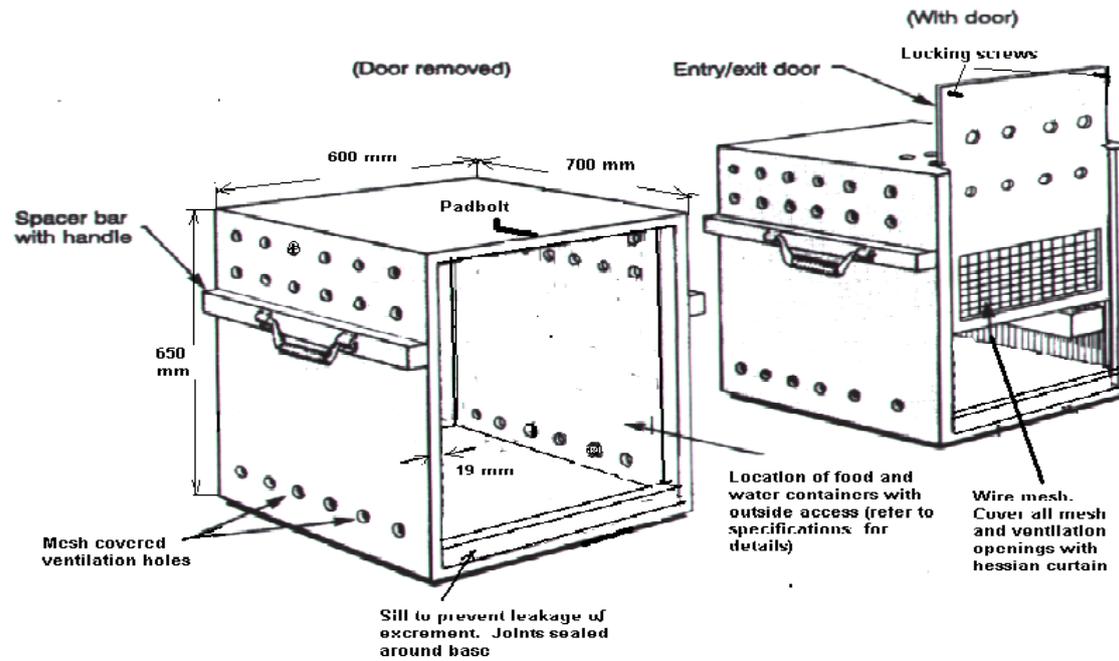
When males are 1.5 years old they are forced out of the group by the dominant male during the mating-season with reintroductions being generally unsuccessful. During the birthing season, as females give birth, they start to fight, resulting in targeted aggression.

The following recommendations were provided concerning reintroductions:

1. Separate the aggressor
2. Put the aggressor and her victim together in a cage, separate from the other ringtails. Leave the animals for a night (or more) and the relationship between the two improves.
3. Start by (re)building the group with “easy” animals: young animals, males and low ranking females.

Some aggressors are not re-introducible, they stay aggressive towards the targeted individuals and removal from the group is required. Usually the aggressor is a dominant female, with the targeted female being forced out from the natal group. If the dominant female (aggressor) chases a lower ranking female (targeted female) out of the group, she may find another victim and continue this behaviour. Removal of the (dominant) aggressive female may need to be considered.

Appendix 3: Ring-tailed Lemur Transport box design



Solid wooden transport container.

The above crate is an example only (IATA 1998)

(NB: Full Container Requirement 31 written guidelines for: Container Construction, Preparation before Dispatch, Feeding and Watering Guide, General Care and Loading, are obtainable in NSW Agriculture 2000 and IATA Regulations.)

Appendix 4 Daily Target Nutrient Levels

Table 3: Daily Target Nutrient Levels for *Lemur catta* diets and Nutrient Concentration in diet

Energy (kcal/KgBW)	not less than 100
Crude Protein (%)	not less than 16.7
Fat (%)	-
Fiber (% NDF)	10-20 b
Linoleic Acid (%)	1
Vitamin A (IU/g)	14
Vitamin D (IU/g)	2.2 c
Vitamin E (mg/kg)	56
Riboflavin (mg/kg)	5.6
Niacin (mg/kg)	55.6
Pyridoxine (mg/kg)	2.8
Folacin (mg/kg)	0.2
Vitamin B-12 (mg/kg)	0.6
Pantothenic Acid (mg/kg)	16.7
Thiamin (mg/kg)	5.6
Choline (mg/kg)	-
Biotin (mg/kg)	0.1
Vitamin C (mg/kg)	111
Calcium (%)	0.6
Phosphorus (%)	0.4
Magnesium (%)	0.2
Potassium (%)	0.9
Sodium (%)	0.3
Iron (mg/kg)	80-200
Zinc (mg/kg)	11.1
Copper (mg/kg)	1.5
Manganese (mg/kg)	44.4
Selenium (mg/kg)	-
Iodine (mg/kg)	2 d

a Based on NRC requirements for Old World primates (1978) and human RDA values (1989).

b Based on suggested guidelines from Oftedal and Allen (1996).

c If animals are not housed where they have access to appropriate amounts of the correct spectrum of UV light, it is essential to provide adequate Vitamin D in the diet.

d NRC may have overestimated the quantity needed. For most other animals, the requirement is approximately 0.1 ppm.

-Information on this nutrient is not present in NRC (1978).

Appendix 5: Sample Diets

DIET SUMMARY SHEET TWPZ

Ring-tailed lemur *Lemur catta*

Natural diet:

Mostly fruits, also leaves and flowers, occasionally insects.

Current recommendations:

Specific dietary requirements have not been determined for most lemur species. Traditionally, lemurs are maintained in captivity on commercial primate kibble supplemented with produce and browse. Prosimians are capable of vitamin C synthesis so supplements are unnecessary. It has been suggested that vitamin C should be restricted in lemur diets to help prevent iron storage disease (vitamin C enhances the absorption of iron across the gut). Citrus should not form a significant proportion of lemur rations for this reason. Lemurs may be susceptible to metastatic calcification where moderate to high levels of vitamin D & or calcium are offered.

Diet: (per 5 animals)

Daily:	750 g apple 350 g carrot 200 g celery 600 g banana 1 kg lettuce 300 g sweet potato 400 g Rock/ Watermelon	150 g tomato 100 g Grapes (tinned peaches when not available) 400 g Pears 200 g Pineapple/ Stone fruit when in season 200 g Corn 5 boiled eggs (Fridays only) 400 g tin kidney beans (Tues/ Fri/ Sun)* 100 g Shelled almonds (Monday/ Thursday) 1 portion lemur cake (golf ball size-approx 12g)
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* 1 tin shared between all lemur species

Enrichment :

Browse ad lib (willow, bamboo, mulberry, fruit trees, kurrajong, bana leaves, lily pilly, acacia)
Flowers (roses, pansies, nasturtiums, marigolds, fuschias, hibscus)
Lite popcorn - 1 small handful per animal
Diet jam – 1/3 jar between lemur islands
Diet jelly – 1 sachet between the lemur islands
Shredded coconut – 12 gr/animal
Diet cordial
Honey
Peanut butter
Vegemite
Fruit bread – 1 slice/animal/week
Mixed dry fruits – 40 g/lemur/day
Peanuts in shell – 20 g/lemur/day
Natural muesli – 12 g/lemur
Sunflower seeds – 10 g/lemur
Tamarind pulp
Black tea

Supplements (per animal, per day)

None

Updates

<i>Date</i>	<i>Comment</i>
31.12.03	White Tail lemur is thin + worn teeth on clinical exam. To incorporate the following changes into his ration UFN: -2 x boiled eggs twice weekly. -1 x buttered slice fruit loaf 2 x weekly. -400g banana daily -cook all sweet potato
17-8-05	New items introduced to diet – pears, pineapple/ stonefruit, corn, melon. Other item quantities reduced.
10-11-06	150 g cheese replaced with 100 g almonds (Monday/ Thursday) as per diet change form. AR
13-7-07	500 g oranges removed as per diet change form – iron storage issue. AR
27-2-08	Removal of kiwifruit and spinach from diet following ongoing research into iron storage levels in lemurs. AR
29-04-08	Following trial of tamarind, tinned beans and black tea, the following changes made: Addition of 400 g tin kidney beans 3 times a week. (between all 3 species) Increase Pears from 200 g to 400 g daily Rockmelon from 150 g to 400 g daily Bananas from 500 g to 600 g daily Substitute tinned peaches when grapes are not available Tamarind pulp & black tea to be used as enrichment items. AR

Ring-tailed Lemur Sample Diet Sheet Hamilton Zoo 2008

RING-TAILED LEMUR (*Lemur catta*; 0.15) DIET – AS AT FEB 2008

DAILY BREAKFAST: 5 APPLES
 2 CARROTS
 5 TUX (broken into 3 pieces each)

	MON	TUES	WED	THURS	FRI	SAT	SUN	TOTAL
APPLES	12	12	12	12	12	12	12	84
BANANAS	5	5	5	5	5	5	5	35
CARROTS	2	2	2	2	2	2	2	14
MELON or equivalent seasonal fruit	¼	¼	¼	¼	¼	¼	½	2
PINEAPPLE					1/4		1/4	1/2
CUCUMBER			1					1
LETTUCE		1/4		1/4		1/4		3/4
BROCCOLI	1		1		1			3
CAULI- FLOWER							1/2	1/2
BEETROOT						1		1
PARSNIP				2				2
POTATOES (cooked)		2				2		4
KUMARA (raw or cooked)	½		½		½		½	2
EGGS (boiled)	4			4				8
MONKEY MIX	½ cup		½ cup		½ cup		½ cup	2 cups
BAKED BEANS (well washed)	1 can	7 cans						
PEANUTS	250 g	1750 g						

◆ ITEMS CAN BE SUBSTITUTED OR SUPPLEMENTED WITH SEASONAL FOODS AS AVAILABLE.

◆ DO NOT FEED LEMURS CITRUS FRUITS (ORANGES, KIWIFRUITS, ETC.)

◆ BREAKFAST SHOULD BE SCATTERED INTO THE EXHIBIT FROM THE PUBLIC BOARDWALK AT THE FRONT; FOR ALL OTHER FEEDS, SCATTER A SMALL AMOUNT IN FROM THE BOARDWALK 1ST, THEN GO INTO THE ENCLOSURE AND HAND FEED / SPREAD THE REMAINDER OF THE FOOD AROUND (*THIS WILL ENCOURAGE THE GIRLS TO HANG AROUND IN VIEW OF THE PUBLIC, RATHER THAN WAITING FOR FOOD NEAR THE KEEPER GATE, OUT OF PUBLIC VIEW*).

- ◆ BANANA SHOULD BE HAND-FED IN ENCLOSURE EVERY DAY, SO EACH INDIVIDUAL CAN BE INSPECTED UP CLOSE.
- ◆ GRAPES CAN BE USED TO TRAIN WITH OR FOR EYE TO EYES

Appendix 6: Hand Raising Considerations for TWPZ

Occasionally an animal may need hand rearing due to the Dam's inability or reluctance to rear the offspring. The decision to hand rear has significant implications from both a Curatorial and resource perspective. The decision to hand rear must be determined in the birthing plan for any significant pending birth. It needs to include both the Curatorial and Operational implications of the recommendation. Where considerable resources are required or the Curatorial and Operational recommendations are not aligned, the GM's of both Divisions will determine the outcome.

The full policy for hand raising Considerations for TWPZ can be found in Appendix 5.

Curatorial:

Some species are more prone than other to imprinting. The individual could become imprinted and thus of significant less value to the breeding program. The potential value of the individual animal and the potential for imprinting will be assessed by the relevant Curator.

Husbandry resources:

The decision to hand rear can have implication on staffing and in worse case scenario may require a substantial staff commitment including night feeds. The Precinct Manager of the relevant Precinct will determine the scope of costs and availability of suitably trained staff if hand rearing is required.

Veterinary:

The individual animal will be assessed by the vets to ensure that significant illness or otherwise compromised health does not preclude the animal from becoming a successful breeder in the future. The veterinarians will also identify if any cost of treatment could become prohibitive.

Hand rearing may be considered when:

- The offspring is abandoned by the Dam either through inexperience or illness.
- The offspring is of a significant species and the particular offspring of the dam and sire has the potential to add to the regional and or global gene pool.
- The offspring is likely to be able to be re-introduced to the group if of a social species.
- The specimen could potentially be placed in a breeding situation in the future and would likely be able to rear its offspring.
- Suitably trained staff are available to hand rear the individual.
- The health assessment of the animal does not indicate considerable illness or compromised potential as a future breeder.

Process:

- Identify in Birth Plan if hand rearing will be considered. Curator and Precinct Manager to recommend position.
- Curator and Precinct Manager to advise their GM of the recommendation.
- GM's to provide joint decision to Curator and Precinct Manager prior to birth taking place.
- Veterinarian to be advised of Birth Plan.
- If any concerns after birth, the decision to hand rear to be made jointly by Precinct Manager, Curator and Veterinarian if circumstances allow.
- Curator to identify likely future for the individual concerned i.e. in-house breeding program, transfer or other.
- If the recommendation is NOT to hand rear a plan must be in place to advise the Veterinarians that the individual may be required to be euthanased.

Appendix 7:

Unacceptable / Toxic Browse

Arum lilies
Avocado
Azalea
Brachyglottis
Buxus
Castor oil plant
Cestrum
Cypresses
Daphne
Datura
Euonymus europaeus
Euphorbia sp.
Ginko
Hamlock
Holly
Horse chestnut
Hypericum
Inkweed
Ivy
Kalmia latifolia
Karaka – when in fruit
Kowhai
Laburnum
Lantana
Lycium – African boxthorn
Melia
Mothplant
Nyaio
Oleander
Pieris
Pinus
Privet berries
Prunus
Ranunculus
Rhododendron
Rhus
Robinia psuedoaccacia
Sambucus – Elder
Senecio
Solanum
Taxus – Yew
Tutu – Cori aria sp.
Yew

Appendix 8: Acceptable browse

HAMILTON ZOO - Toxic and non-toxic plants

ACCEPTABLE BROWSE	ACCEPTABLE BROWSE
Abutilon	Pseudopanax
Acacia - Wattle	Puka - Griselinia lucida or Meryta
Acer negundo - Ash-leaved maple	Sheoak or Casuarina
Agonis	Silver Fern
Alnus = Alder	Sugar Cane
Arbutus - Strawberry tree	Thistle
Arundo domax	Tilia - European lime
Ash	Tree lucerne
Bamboo	Wandering Jew
Banana Palm	Waterhousia - Lilly pilly = Monkey Apple
Banksia	Willow
Begonia	
Betula (Birch)	
Cabbage Tree	
Callistemon - Bottle brush	
Cemphor laurel	
Coprosma	
Crab-apple	
Elaeagnus	
Elm	
Entelea - Whau	
Feijoa	
Fig Tree	DEE SEDDON
Flax	
Forsythia	021-128 5137
Grapevine	
Green Phoenix Palm Fronds	OFFICE -7- 838-6961 x.1
Guava	
Hazelnut	
Hebes	
Hibiscus	
Jacaranda	
Kawakawa - Peppertree, Macropiper	
Liquidamber - Sweet gum	
Lophostemon confertus - Brush box	
Marigolds	
Meibaleuca	
Monkey Apple = Lilly pilly	
Mulberry - Morus	
Nasturtium	
Olearia	
Olive	
Ox Tongue	
Papyrus	
Pittosporum	
Plane tree	
Pohutukawa	
Poplar	