

Husbandry Guidelines for White fronted brown lemur *Eulemur fulvus albifrons*



Class:	Mammalia
Order:	Primates
Family:	Lemuridae

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Date of Preparation:	2009
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Course Name and Number:	Captive Animal Management <u>2S1068FX8TU</u>
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Occupational Health And Safety When Working White Fronted Brown Lemurs (*Eulemur fulvus albifrons*).

Non-human primates and humans have a very close Phylogenetic relationship, thus there are a number of pathogenic organisms that can be transmitted from them to humans and vice versa.

Maintain good sanitary standards. Wash hands after working with any nonhuman primate or caging and other equipment.

BE ALERT at all times! When working in close proximity to a nonhuman primate, always keep your eyes on the animal. It only takes a split second for a lemur to grab you and inflict an injury.

Staff receiving bites, wounds or scratches should immediately wash the wound thoroughly with an antiseptic soap (e.g., Betadine scrub); and rinse the wound with water.

All staff should maintain good vaccinations records for themselves.

PPE such as gloves and boots should be utilized at all times.

Annual cycle of maintenance for White fronted brown lemur (*Eulemur fulvus albifrons*) exhibit

January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								

Key to cyclic duties

Mow grass on exhibit
Check and trim trees to prevent escape risks
Turn on heating and service heating element if needed
Turn off heating (for warmer months)
Reconfigure climbing ropes
Check all safety equipment (rescue ring, rescue pole for wet moat)
Lubricate all hinges, padlocks, slides, pulleys
Check wet moat level and top up if needed

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1 Introduction

White fronted brown lemurs (*Eulemur fulvus albifrons*) are held in only one institution within the Australasian region; Taronga Western Plains Zoo, Dubbo. The species is listed as delete by attrition and is represented by 1.2 individuals. The species is unlikely to be transferred out of the region and new individuals are unlikely to be transacted in.

Despite the uncertain representation of the species in this region, White fronted brown lemurs play a critical role as ambassadors for the many other threatened lemur species of Madagascar. As a charismatic species White fronted brown lemurs provide members of the general public with a chance to understand and engage with an animal they might not otherwise have access to. It is this positive educational experience that will influence the choices our visitors make in their daily lives.

1.1 ASMP Category

ASMP Primate TAG; Phase Out; Management Level 3.

This species does not have a studbook keeper.

1.2 IUCN Category

Vulnerable

2. Taxonomy

2.1 Nomenclature

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Primates

Family: Lemuridae

Genus: *Eulemur*

Species: *E. fulvus albifrons*

2.2 Subspecies

The following subspecies are listed by Primate Info Net (2009)

Eulemur fulvus albocollaris

Eulemur fulvus collaris

Eulemur fulvus coronatus

Eulemur fulvus fulvus

Eulemur fulvus macaco

Eulemur fulvus mongoz

Eulemur fulvus rubriventer

Eulemur fulvus rufus

Eulemur fulvus sanfordi

2.3 Recent Synonyms

Petterus and *Prosimia* have both been suggested Genus alternatives, however the International Commission on Zoological Nomenclature rules *Eulemur* to be the valid Taxon (Yoder, 2009).

2.4 Other Common Names

White fronted brown lemurs

Sanford's lemur

Red-fronted lemur

Red-bellied lemur

Mongoose lemur

Black lemur

Common Brown lemur

Crowned lemur

White-collared lemur

Red-collared lemur

(Mittermeier et al, 2003)



Figure 1.1 A female white fronted brown lemur. Picture taken at Taronga Western Plains Zoo, May 2007.

3. Natural History

The White fronted brown lemur (*Eulemur fulvus albifrons*) is a prosimian primate. The prosimians, were the first of the primate suborders to evolve. Subsequently, they are often called the "lower primates." The word prosimian literally means "pre-monkey." The suborder Prosimii includes lemurs, tarsiers and lorises. Interestingly lemur in Latin means "ghost" and many of the people of Madagascar, the lemurs' home range, believe lemurs are similar to spirits or ghosts because of their haunting stare and night-time activity. (Duke University Lemur Centre)

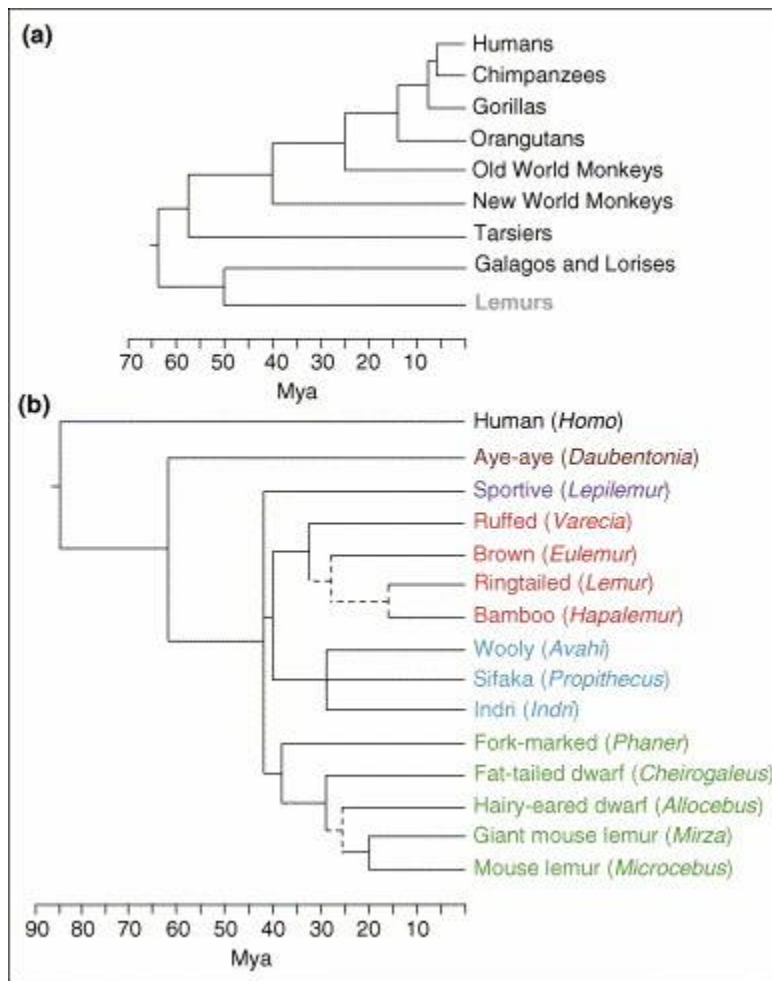


Figure 1.2 Chart showing the phylogenetic relationship between lemurs (prosimians), monkeys and apes. Part A indicates the common ancestor of lemurs and higher order primates existed some 65 millions years ago (Mya). Part B shows *Eulemur* spp. split from its closest lemur relatives 30-35 million years ago. Taken from the Duke Institute for Genome Sciences and Policy at <<http://www.genome.duke.edu/labs/WillardLab/lemur.html>>

White fronted brown lemurs are cathemeral, meaning that they are active for brief periods throughout the day and night. Their natural predators are large snakes and fossas when visiting the ground and lower levels of the trees.

These lemurs have a horizontal posture, which is suited to its predominantly quadrupedal mode of movement. They are also capable of leaping considerable distances, their long furry tails assisting them in maintaining their balance (Animal Diversity Web, 2009).

Anatomy:

The thumb of the hand and the great toe of the foot are well developed and opposable. The eyes face forward enabling stereoscopic vision, or depth perception. Their tails are not prehensile.



Figure 1.3 Picture showing well developed and opposable great toe on male White fronted brown lemur. Photo taken at Taronga Western Plains Zoo, August, 2009.

The second digit of the hind feet also has an enlarged "toilet claw" used in grooming (Gould and Sauther, 2006).

All lemur species have a tapetum; a reflective layer over the retina that causes their eyes to shine at night (Gould and Sauther, 2006).

Lemurs depend heavily on the sense of smell and have large nasal cavities and moist noses (Gould and Sauther, 2006).



Figure 1.4 Skull of a common brown lemur (of which White fronted brown lemurs are a subspecies). Note the enlarged pointed canine tooth and significant orbital sockets (White, 2007).

Dentition:

The dental formula is $2/2, 1/1, 3/3, 3/3 = 36$. The upper first incisors are separated from each other by a wide space, and the first lower premolars are canine-like. White fronted brown lemurs have a dental comb; their lower front teeth are fused and tilted forward, making a tool that is used to groom their fur (White, 2007).

Social order:

White fronted brown lemurs live in matriarchal societies; females are dominant over males. As this is a rare social structure within mammals a number of hypotheses have been put forth for the evolution of female dominance;

1. The Energy Conservation Hypothesis: males subordinate to females to conserve energy for the intense male-male competition experienced during lemur's very short breeding season
2. Male behavioral strategy: males defer as a parental investment because it ensures more resources in the harsh unpredictable climate of Madagascar for the female, and thus, the male's future offspring.
3. Female behavioral strategy: dominance helps females deal with the unusually high reproductive demands; they prevail in more social conflicts because they have more at stake in terms of fitness.

To date, little field work has been carried out with this particular species so the average group size is uncertain, however it is thought to be from 7-10 individuals.

(Gould and Sauther, 2006)

3.1 Morphometrics

3.1.1 Mass and Basic Body Measurements

Head-Body length	43 – 50cm
Tail length	41.5 – 51cm
Total length	84 – 101cm
Weight	2 – 3kg

(Animal Diversity Web, 2009)

3.1.2 Sexual Dimorphism

White fronted brown lemurs are sexually dichromatic.

Males have gray-brown upper parts, with darker lower limbs and tail, paler gray upper parts, gray head and face and a darker crown. Females have redder-brown upper parts, paler under parts and darker feet than males. The cheeks and beards are white, bushy and pronounced in males, reddish-brown and less bushy in females. The head, face and muzzle of the female are dark gray, but without the bushy cheeks of the male. Both sexes possess stunning dark amber eyes.

(Animal Diversity Web, 2009)



Figure 1.5 Female (left) and male (right) white fronted brown lemur showing sexual dichromatism. Photo taken at Taronga Western Plains Zoo, July, 2009.

3.2 Distribution and Habitat

Worldwide Distribution

The white fronted brown lemur is found only on the island of Madagascar. Its range is throughout the rainforest remnants of northeastern Madagascar. This lemur occurs as far north as the Bemarivo River near Sambava, and as far south as the Betampona Nature reserve near the port of Tamatave. They may range as far west as Tsaratanana.

Habitat

Mostly found in lowland and sub humid moist broad leaf forests, an arboreal species that spends 95% of its time in the upper layers of the forest.



Figure 1.6 (left) Distribution of the white fronted brown lemur in Madagascar (shown in red)
 Map taken from
<http://www.aquanet.de/privat/albering/madagascar/madagascar.jpg>

3.3 Conservation Status

The white fronted brown lemur was assessed in 2000 as Lower Risk Near Threatened. Threats to their existence include;

- Habitat Loss/Degradation –
- Agriculture - Crops - Shifting Agriculture – Slash and Burn
- Hunting
- Illegal pet trade

There are currently conservation programs occurring in Zahamena, Marojejy and Betampona Nature Reserves and Nosy Mangabe Special Reserve where it was introduced and has established a healthy status.

They are protected under CITES as: Appendix 1, no hunting or trade allowed.

(CITES, 2009)

3.4 Longevity

3.4.1 in the Wild

- 20 – 25 years

3.4.2 in Captivity

- Up to 36 years

3.5 Techniques Used to Determine Age in Adults

Close physical inspection under anesthesia is the only reliable method of aging lemurs. Outward appearance such as coat luster and activity levels may be due to environmental factors or diet rather than age.

Tooth erosion, reduction in breeding, osteoporosis, arthritis and cataracts suggest an aging animal (Wolfensohn and Honess, 2005).

4. Housing Requirements

4.1 Exhibit Design

According to the Policy on Exhibiting Primates in New South Wales (2009) the following shall be taken in to account when designing an enclosure;

1. Enclosures may be open, semi-enclosed or totally enclosed or consist of islands surrounded by water.
2. Enclosures must be well constructed and maintained in good repair. Particular attention must be given to eliminating sharp edges and broken wires.
3. Sufficient shelter must be provided to allow protection from wind, rain and extremes in temperature.
4. Access to both shade and sunlight must be provided.
5. Primates must be exhibited in a setting which will educate the public about the primate's natural habitat and provide for its behavioural and physical well-being.
6. All exhibit enclosures for primates must include living or fresh vegetation.
7. Routine feeding, watering and movement of animals between enclosures must be able to be carried out by the keeper with minimal disturbance to the group.

Taronga Western Plains Zoo manages lemur exhibits as islands. The wet moats provide a natural barrier to animal escape whilst providing the lemurs and the public with a naturalistic more aesthetically appealing environment.



Figure 1.7 Photograph of White fronted brown lemur island at Taronga Western Plains Zoo. Note the provision of natural climbing structures (trees) as well as artificial structures (ropes). Photo taken November, 2009.

4.2 Holding Area Design

Off-exhibit holding areas where animals are held for longer than six weeks, or routine management enclosures where animals would normally spend more than half of any 24 hour period, must meet the minimum space, furniture and enrichment requirements for exhibits (Policy on Exhibiting Primates in New South Wales (2009)).

4.3 Spatial Requirements

The Policy on Exhibiting Primates in New South Wales (2009) dictates that sufficient space must be provided, both horizontally and vertically to enable the animals to take exercise, to protect animals from undue dominance or conflict and to provide for their social, breeding and behavioural needs. Sufficient exhibit furniture must be provided to meet these requirements.

Lemur exhibits should be a minimum of 4.5metres in width, 6.5metres in length with a minimum height of 3.5metres.

4.4 Position of Enclosures

The Policy on Exhibiting Primates in New South Wales (2009) stipulates that

1. The majority of the enclosure must be out of visual range of any neighboring exhibits housing potential predator species or other groups of the same primate species if the species is territorial. Where visual contact is available, and signs of distress are observed, action must be taken to alleviate this distress.
2. Primate enclosures must be constructed so that the enclosed animals can rest at least 2 body lengths above the eye level of any member of the viewing public. Monkey pits are therefore not acceptable housing for any primate species.

4.5 Weather Protection

The Policy on Exhibiting Primates in New South Wales (2009) requires enclosures to provide animals with access to shelter from climatic extreme.



Figure 1.8 White fronted brown lemur island at Taronga Western Plains Zoo. Islands provide a naturalistic method for containing animals using a wet moat rather than traditional caging. Photo taken November, 2009.

4.6 Heating Requirements

Depending on the location and ambient temperature of the exhibit, alternative means of heating or cooling should be provided (ideally thermostatically controlled). Shelters should be maintained between 18 and 30 degrees Celsius (Wolfensohn and Honess 2005).

4.7 Substrate

To comply with the Policy on Exhibiting Primates in New South Wales (2009) the enclosure must be well drained. A mixture of artificial and natural, or all natural substrate must be provided, to allow for normal behaviours, such as foraging and scent marking. Importantly, the substrate must be effectively managed to avoid disease.

A suitable example would be a mixture of soil, bark chip and grass, providing a range of substrate choices for lemurs to interact with.

4.8 Nest Boxes or Bedding Material

Ample nest boxes should be provided bearing in mind dominance and group conflict. Bedding can be clean shredded paper, straw or similar (Policy on Exhibiting Primates in New South Wales 2009).



Figure 1.9 Purpose built nest boxes, erected in trees on exhibit provide lemurs with a naturalistic den to retreat to. Photo taken at Taronga Western Plains Zoo, November 2009.

4.9 Enclosure Furnishings

The Policy on Exhibiting Primates in New South Wales (2009) requires that enclosures be furnished with horizontal, vertical and sloping pathways, shelves and perches above ground level. It also states:

1. Resting places and perches sufficient to accommodate all members of the group must be provided in a manner that is appropriate for the species.
2. Surfaces of resting places and perches must be roughened, or otherwise textured, so that they are not slippery when wet. Walls, floors and ceilings must be impervious and easily cleaned.
3. Ropes must be maintained in good condition. The ends must be sealed against fraying and be heavy enough to remain taut when the animals are actively using them.
4. There must be areas within the exhibit for any animal to withdraw from the group, (e.g. to hide from an aggressor) and from the public. This may be provided by visual barriers.

5. General Husbandry

5.1 Hygiene and Cleaning

The guidelines for cleaning set out by The Policy on Exhibiting Primates in New South Wales (2009) are

1. Hard-surfaced enclosure substrate and furniture must be washed as frequently as necessary to keep them free from contamination.
2. Where cleaning will disrupt scent marking behaviour in particular species, areas of the enclosure must be cleaned in rotation.
3. Perches, shelves and nest boxes must be cleaned frequently enough to prevent the accumulation of faecal matter and urine.
4. Soil or other natural substrates must be spot-cleaned daily to remove organic waste.
5. Feeders, watering devices, feeding equipment and other metal or plastic equipment, if disinfected after cleaning, must be rinsed thoroughly.
6. Animals must have access to dry areas during and after the cleaning process.

The use of chemicals when cleaning should always be under veterinary advice; however a number of commercially available cleaners such as Castrol Wonderclean (Appendix 1.2) and Bleach (Appendix 1.3) are routinely used at facilities such as Taronga Western Plains Zoo. F10 Veterinary Disinfectant (Appendix 1.4) is useful for disinfecting tools and equipment when used between multiple exhibits or animals.

5. General Husbandry

5.2 Record Keeping

According to the Policy on Exhibiting Primates in New South Wales (2009) the following records shall be maintained;

:

1. identification number, common name, scientific name, any personal name and any distinctive markings;
2. origin (details of parents and their origin and of any previous locations);
3. dates of acquisition and disposal, with details of circumstances and addresses;
4. date of birth;
5. veterinary records, including results of physical examinations, details and dates of any treatments, results of routine health examinations;
6. breeding (including mating, reproductive and behavioural cycles, parenting ability) and details of any offspring;
7. date of death and cause including results of post mortem reports;
8. normal diet;
9. any other specific details pertaining to the individual such as changes in behaviour or diet.

The policy also states where an Australasian or international studbook exists for a white fronted brown lemurs, records must be provided to the studbook keeper at least yearly or as required by the studbook.

All documents, records and other information pertaining to each animal including those from previous locations must be kept safely and maintained for the life of the primate plus five years.

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

5.2 Methods of Identification

- Microchips
- Ear tags
- Tattoos

As outlined by the Policy on Exhibiting Primates in New South Wales (2009), each individual must be permanently identified by one of the above methods.

The type of identification used needs to be permanent, easy to apply and relatively painless to apply, clearly visible and unalterable. It must not effect the mobility of the primate in any way.

5.3 Routine Data Collection

Animal records form the permanent history of an institution's animal collection and are indispensable in the population management of zoo animals.

Internally, the records are vital to daily husbandry practices, veterinary treatments and on analysis over time, allow monitoring of any potential welfare problems.

Externally records are required for sharing the information with other Zoological parks. These records are used for cooperative breeding programs and play an important role for studbook keepers.

ARKS, the electronic system currently used to record and store animal data, is part of a larger system called ISIS (International Species Information System). Over 600 zoo and aquaria lodge information into the ISIS database, facilitating the cooperative work of zoos worldwide and providing an invaluable information database.

Daily reports should be written using the following ARKS codes;

ACQ: ACQUISITION

Any importation from outside the collection, public
donation, or capture from grounds or from the wild

B/H: BIRTH/HATCHING

Birds: generally recorded as hatch date. If date of leaving the nest is used it must be noted as such under Information column

Marsupials: The day on which the animal is permanently out of the pouch or the day a juvenile is thrown from the pouch

Placentals: The day on which they are born

D/30: DEATH WITHIN 30 DAYS

Death/Euthanasia within 30days of birth hatching or acquisition

D/E: DEATHS ESTABLISHED

Death/Euthanasia of any animal which has been resident in the collection for longer than 30 days

DIS: DISPOSITION

Includes exports from the collection, releases, sales, escapes

BRD: BREEDING

Reproductive details/observations: Any nesting, laying of eggs, oestrous, menstruations, matings, courtship, pouch checks, sexing of previously unsexed individuals or any other reproductive matter

INT: INTERNAL MOVEMENT/TRANSFER

Any movement of an animal from its residing enclosure be it within a section or to a different section.
Transfers/exports out of the collection NOT included

TAG: TAGGING

Animal identification by banding, tagging, notching, tattooing, naming or any other method of identification

W/L: WEIGHT/LENGTH

Weight or length measurement

Rx/Tx: TREATMENT

Any medical treatment administered to animals, either by Vets, or continuing treatment administered by animals care staff. Include observations of anything related to treatment. Flag if veterinary examination is required using VET code.

VET: VET EXAMINATION REQUIRED

Note if veterinary treatments/examination require

OTH: OTHER

Any notable observations made in reference to daily routine or animals, e.g. behaviour, change to routine etc. Also anything else of interest e.g. animal management procedures, diet change, maintenance

6. Feeding

6.1 Wild Diet

White fronted brown lemurs are frugivorous lemurs, though during the dry season their diet is bolstered by flowers (Vasey, 1997). They also feed on nectar and supplement their diet with millipedes and centipedes. Bark and soil has also been shown to make up part of their diet, their attraction perhaps due to tannins and other trace minerals required for optimal health.

6.2 Captive Diet

Currently the only institution in Australasia to house white fronted brown lemurs is Taronga Western Plains Zoo, Dubbo, NSW. The current diet used is shown in figure 2.0.

Daily:	400g Apples 250g Carrots 200g Celery 400g Bananas 300g Lettuce 100 g Corn 100 g Pineapple/ Stone fruit 200 g Rock melon/ Watermelon	100 g Tomatoes 150 g Pears 100 g Grapes/ Tinned peaches 100 g Beans 150 g Sweet potato 400 g tin Kidney beans (Tues, Fri, Sun)* 3 ea Eggs (Friday) 50 g Shelled almonds (Monday/ Thursday)
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Figure 2.0 Daily diet rations for group of 3 white fronted brown lemurs. Taronga Western Plains Zoo Diet Summary sheet for white fronted brown lemurs, 2008.

Browse is an important part of this frugivorous species, and the following are commonly offered ad lib:

willow	acacia
bamboo	roses
mulberry	pansies
fruit trees	nasturtiums
kurrajongs	marigolds
banana leaves	fuchsias
lily pilly	hibiscus

White fronted brown lemurs at Taronga Western Plains Zoo are offered "Lemur Cakes" as part of their daily diet. These purpose made cakes are utilized as a training tool as they are a favored food item. The recipe for Lemur Cakes may be found in Appendix 1.1.

6.2.1 A special note on iron absorption in lemurs

Captive diets need to be carefully monitored as excessive iron accumulation (hemosiderosis) has been described in many captive lemurs. The principal reason behind the development of the disease in captivity is the high level of iron and low level of tannins present in the captive diet. (Note: tannins - often found in tree barks, reduce the body's ability to absorb iron).

Hemosiderosis occurs when the circulating level of iron in the blood becomes too high and so, it is stored in vital organs (e.g. liver) reducing their ability to function, in some cases with fatal consequences. As a result iron accumulation is a serious and persistent threat in captive lemurs. Lemurs should not be given vitamin or mineral supplements containing iron. Also, foods high in vitamin C should be avoided as vitamin c enhances lemurs' abilities to absorb iron.

Food items rich in tannins can be offered to reduce the ability to absorb iron. Commonly black tea and tamarind pulp is used.

(Iron Storage Disease in Lemurs, A Report to the Prosimian Taxon Advisory Group, 2003)

6.3 Supplements

Taronga Western Plains Zoo offers "Lemur Cakes", a purpose made product as a supplement to lemur diets. This item is particularly useful for training purposes as it is a favored food item. See Appendix 1.1 for recipe and Appendix 1.12 for a list of suppliers for ingredients.

Lemurs should not be given vitamin or mineral supplements containing iron. Also, foods high in vitamin C should be avoided as vitamin c enhances lemurs' abilities to absorb iron.

Food items rich in tannins can be offered to reduce the ability to absorb iron. Commonly black tea and tamarind pulp is used.

6.3.1 Enrichment food items

Food items commonly offered to white fronted brown lemurs include the following. It should be noted that enrichment food items should not make up a significant portion of the lemurs caloric intake, and as such recommended WEEKLY quantities are included below.

Lite popcorn - 1 small handful per animal	Vegemite smears
Diet jam – 1/3 jar between lemur islands	Fruit bread – 1 slice/animal/wk
Diet jelly – 1 sachet between the lemur islands	Mixed dry fruits – 40 g/lemur/day
Shredded coconut – 12 g/animal	Peanuts in shell – 20 g/lemur/day
Diet cordial	Natural muesli – 12 g/lemur
Honey smears	Sunflower seeds – 10 g/lemur
Peanut butter smears	

Enrichment items for White fronted brown lemurs, taken from Taronga Western Plains Zoo Diet Summary sheet for white fronted brown lemurs, 2008.

See Appendix 1.12 for a list of suppliers for these commonly offered food items.

6.4 Presentation of Food

Foraging and feeding time makes up a significant percentage of the daily activity of white fronted brown lemurs in the wild. As a result feeding in captivity should encourage, as much as possible, a similar activity pattern.



Figures 2.1 and 2.2 Male white fronted brown lemur accessing food from a ‘bird proof’ feeder. Note the plastic flaps which are easily pushed aside by the lemur, but too challenging for most birds to manipulate. Photo taken at Taronga Western Plains Zoo, July, 2009.

To encourage activity, food should be delivered in many sessions over the course of the day, ideally 3-4 separate occasions. Offering least preferred food items earlier in the day may encourage their consumption as animals are often hungry at first morning check.

Food should be chopped in to small sizes to allow all members of captive group’s access to a variety of food stuffs. For example, a group may require only 1 apple between all animals, and slicing the apple will prevent dominant animals from monopolizing the fruit.

Consideration to the natural feeding behaviour of the lemur should be given, and as such food should be either spiked in trees or fed from feeders suspended in tree or from ropes.



Figure 2.3 Presentation of daily food. Note food has been chopped in to smaller sizes. Photo taken at Taronga Western Plains Zoo, July, 2009.

As food delivered to lemurs can also attract unwanted pest species, specially designed ‘bird proof’ feeders may have to be constructed. Figure 2.1 shows a male white fronted brown lemur accessing food from a bird proof feeder. Feeders should be washed out thoroughly every day to prevent pest species such as fruit fly accumulating.



Figure 2.4 A hanging feeder designed to encourage a lemur’s natural suspensory feeding habits. Note also the cylindrical browse holder attached to the tree behind. Photo taken at Taronga Western Plains Zoo, July, 2009.

7. Handling and Transport

7.1 Timing of Capture and Handling

White fronted brown lemurs are most active during the early morning and evening, interspersing periods of rest and activity throughout a 24-hour day.

Daylight hours are the most opportune time to attempt to capture the lemur, especially in the cool of the morning. Early morning catch ups also allow for more daylight hours when reintroducing an animal back to its exhibit and reintroducing it to cohabitants.

7.2 Catching Boxes

Pet packs of medium size available for use with domestic animal species make fine catch up boxes for white fronted brown lemurs. Kramar “Vari Kennels” are approved for travel by IATA with all domestic and international air carriers. The Intermediate size (L80 x W55 x H57cm) or large size (L90 x W60 x H65cm) are most appropriate. See Appendix 1.5 for contact details for Kramar.

7.3 Capture and Restraint Techniques

A well designed behavioural program that conditions lemurs and utilizes positive reinforcement, repetition, and consistency are more favorable than manual catch ups. Successful conditioning programs, where lemurs are encouraged to enter pet packs of their own accord, alleviate stress and potential handling injuries to animals and keepers.

Encouraging white fronted brown lemurs to enter a pet pack for a food reward on a daily basis will facilitate catch ups needed on short notice for veterinary work etc. Catch ups using nets, poles and heavy gloves usually induce a fear response from lemurs and should be avoided from a welfare perspective.

However, should manual restraint be needed to catch up lemurs, care should be taken as they can become quite dangerous to the handler. The arms, legs and teeth must be restricted from access to the handler. Restraint of animals should be both effective and as gentle as possible, with emphasis on protecting animals and handlers from injury (Reinhardt et al., 2009).

Figure 2.5 Diagram showing a keeper successfully restraining a primate in the method suitable for lemurs.

Note the use of PPE: thick gloves.



Lemurs may be caught using the base of the tail. Thick gloves should be worn. A second keeper may be required to assist in the catch-up as lemurs will swing around and up to try to release their tail. Lemurs may be effectively restrained by pinning their arms behind their backs. Once restrained lemurs may then be chemically restrained with anesthetic.



Figure 2.6 Female white fronted brown lemur entering pet pack as part of daily conditioning program to facilitate catch ups. Photo taken at Taronga Western Plains Zoo, July, 2009.

7.4 Weighing and Examination

White fronted brown lemurs should be chemically immobilized, using anesthetic drugs (e.g.: ketamine), if close examination is to be performed. Non-anesthetized animals will tolerate close visual inspection, and if conditioned to desired behaviours, may present body parts (e.g.: arms for inspection).

Lemurs may be weighed on conventional scales once anesthetized.

7.5 Release

If anesthetized for a veterinary procedure, lemurs should be recovered in a dark, warm location and transported back to their exhibit only once fully alert and awake. By holding a portion or majority of the lemurs' daily rations back from the rest of the group, it may

be used as a tool during reintroductions. Food may be used to distract co inhabitants when reintroducing a lemur to the exhibit.

It is preferable for the lemur to be reunited with the group as soon as feasible and in daylight hours.

The pet pack should be placed on the ground, mouth facing away from wet moats, obstacles or other potentially hazardous obstacles, and the lemur released quickly and quietly. The base of a sturdy tree may provide a safe haven for a newly released lemur to climb.

7.6 Transport Requirements

7.61 Box Design

According to the IATA Live Animal Regulations all primates must be transported in closed containers. The container must be strong enough to withstand bumps and knocks from other freight during shipping. The container must be adequately ventilated on at least 3 sides, with the majority of the ventilation being provided on the upper part of the container. The door must be constructed to prevent accidental opening.

Plastic pet packs are suitable for transportation of lemurs providing they comply with the following IATA regulations

- A slatted floor must be firmly fixed to the base of the container which must be covered with absorbent material
- A low resting shelf or branch like structure must be fixed to the back of the container
- The method of closing the container must be completely tamper-proof. The use of padlocks is preferred over the use of clasps or clips
- Fine wire mesh must be securely fixed over the door grill and all ventilation openings, these must also be covered with a muslin or similar material
- Separate food and water containers with outside access must be fixed to the upper part of the door grill in order that the animal cannot sit on them. Water must only be offered when required and must not remain in the container after use but must be siphoned out; the container must be correctly labeled
- If the container has wheels, they must be removed or rendered inoperable
- The container must be correctly labeled. Labels are to be affixed to the container of not less than 20cm in length and 14cm in width on which is clearly, legibly and indelibly printed in capital letters the words: "LEMUR", "LIVE ANIMAL", "HANDLE WITH CARE" and "THIS WAY UP".

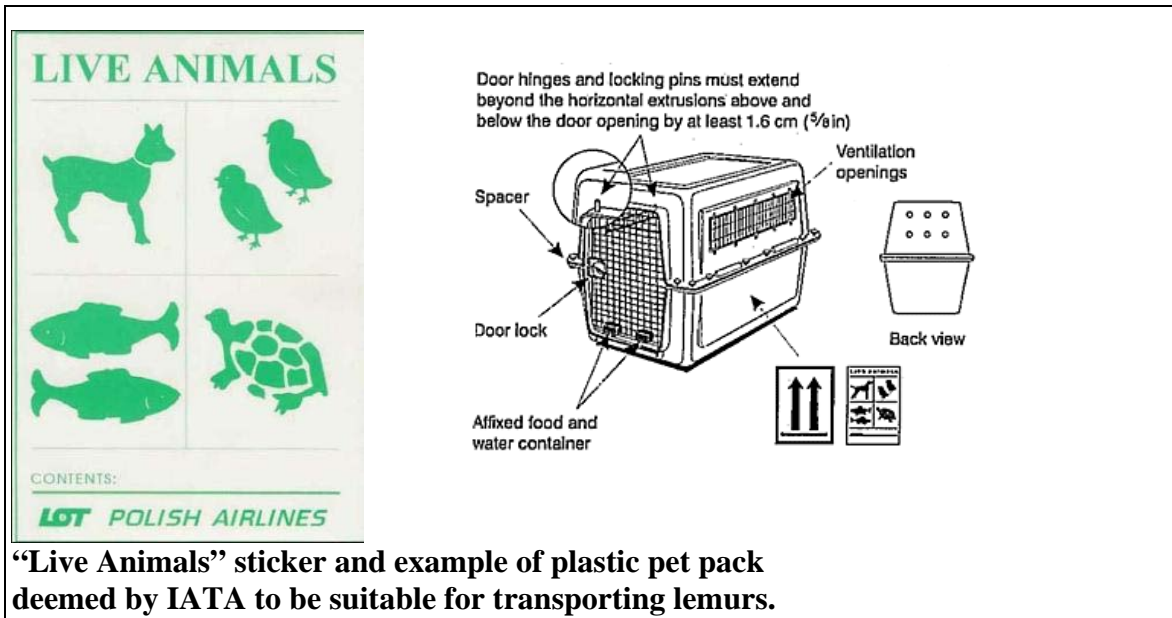


Figure 2.6 IATA Transportation requirement for lemurs.

7.62 Furnishings

According to the IATA Live Animal Regulations absorbent bedding must be provided inside the box, however straw is not acceptable as it is prohibited to import in to many countries.

7.63 Water and Food

According to the IATA Live Animal Regulations, food and Water containers must be provided, either fixed inside the container or attached to it with means of access provided, incase of undue delays in the journey. These containers must have rounded edges and be made of non-toxic materials suitable for the species. Instructions for feeding and watering must be given in writing when transporting the animal.

Animals do not usually require additional feeding or watering during the 24hours following the time of dispatch.

If feeding or watering is required due to an unforeseen delay, cereal or appropriate primate food, bread and non-citrus fruits, must be provided but care must be taken not to over feed. After offering water, the water container must be emptied or removed.

7.64 Animals per Box

According to the IATA Live Animal Regulations animals of the same species and size may be shipped together only if they have previously been contained together.

7.65 *Timing of Transportation*

Due to the potential for stress and animal welfare concerns, lemurs should be transported from evening until early morning if possible.

7.66 *Release from the Box*

Animals must be released from the container as soon as practical once they have reached their destination. It is preferable to release the animals into an area clear of any wet moats, obstacles or other potentially hazardous obstacles, and the lemur released quickly and quietly. The base of a sturdy tree may provide a safe haven for a newly released lemur to climb. Once the container is opened, lemurs should be left to exit at their own pace. Containers may be left in the new exhibit or holding facility until the next day when the animals are more settled.

8. Health Requirements

8.1 Daily health checks

Daily health checks should be undertaken as a matter of course when first viewing the animal in the morning (i.e. when completing a head count) and then opportunistically through out the day. A thorough visual check over of the animal may occur when the enclosure is being serviced and the animals are being fed. Visual checks should be incorporated as a standard daily procedure (Wolfensohn and Honess 2005).

Catching lemurs is a inherently stressful procedure, and should only be necessary one a year at annual vaccinations and TB tests or if visual checks alert to a veterinary or behavioural problem warranting further clinical investigation.



Figure 2.7 Keeper at Taronga Western Plains Zoo asking a male White fronted brown lemur to stand enabling good visual check of limbs, abdomen and chest. Photo taken November, 2009.

Visual checks should take note of:

- whether the animal is moving freely, using all four limbs freely without signs of lameness or imbalance

- skin and fur do not show signs of infection or alopecia (baldness) which could be a sign of parasites, bacterial infections or physiological problems (such as fur plucking or over grooming)
- body condition
- head and eye movements, eyes are fully open and clear
- any unusual swellings, discharges or wounds
- presence of external parasites (fleas)

Health checks should not be restricted to the physicality of the animal but also include its behaviour. This is where keepers having an intimate knowledge of the individual animal is important. Certain individuals may exhibit patterns of behaviour that are unusual for the species, yet not for that specific animal (Wolfensohn and Honess, 2005).

Faeces and urine should be carefully monitored for signs of diarrhoea, looseness and parasites (such as worms). The absence of faeces in a lemur's enclosure is a concern. Urine should be checked for signs of blood contamination and volume.

(Wolfensohn and Honess 2005)

8.2 Detailed Physical Examination

Once a year lemurs should be given a thorough clinical examination. This is usually carried out under anaesthesia allowing the animal to be safely handled with minimal danger and stress to the keeper, veterinary staff and the lemur.

Clinical examinations should record the animal's weight.

Under anaesthesia it should be possible to check that;

- the animals eyes have even pupils facing forwards
- the ears and pinna should not be swollen
- the nostril should be clean and even in size
- gum colour should be pink and canines and incisor teeth free from damage

By moving the hand down the length of both fore limbs and then both hind limbs sequentially it is possible to detect differences in length, unusual swellings and thickness of the joints, Fingers and toes should be checked and nails may be trimmed using nail cutters if needed.

Blood and urine samples may be collected. Full blood counts should be completed yearly.

(Wolfensohn and Honess 2005)

8.3 Routine Treatments.

Lemurs require yearly TB inoculation. This is best administered in conjunction with general anesthesia during their thorough clinical exam.



Figure 2.8 Male White fronted brown lemur undergoing general anesthetic in conjunction with annual health check. Photo taken at Taronga Western Plains Zoo, August, 2009.



Figure 2.9 Male White fronted brown lemur undergoing general anesthetic in conjunction with annual health check. Note abdominal ultra sounding being performed. Photo taken at Taronga Western Plains Zoo, August, 2009.

8.4 Known Health Problems.

Hemosiderosis

Causes

The European Zoos Nutrition Centre, Iron Storage fact sheet (2009) states captive diets need to be carefully monitored as excessive iron accumulation (hemosiderosis) has been described in many captive lemurs. The principal reason behind the development of the disease in captivity is the high level of iron and low level of tannins present in the captive diet. (Note: tannins - often found in tree barks, reduce the body's ability to absorb iron).

Signs

Hemosiderosis occurs when the circulating level of iron in the blood becomes too high and so, it is stored in vital organs (e.g. liver) reducing their ability to function, in some cases with fatal consequences. As a result iron accumulation is a serious and persistent threat in captive lemurs.

Treatments and prevention

Food items rich in tannins can be offered to reduce the ability to absorb iron. Commonly black tea and tamarind pulp is used. Lemurs should not be given vitamin or mineral supplements containing iron. Also, foods high in vitamin C should be avoided as vitamin c enhances lemurs' abilities to absorb iron.

Helminths (Parasitic worms)

Causes

White front brown lemurs like all primates are susceptible to internal worm burdens. Particular worm species include roundworm, tapeworm and whipworm. Worms live inside the host lemur and can cause disruptions to nutrient absorption which can lead to weakness and disease.

Signs

Diarrhoea and loose faeces often indicate worm burdens. Lemurs may also 'scoot' their hindquarters along branches or platforms to relieve itching.

Treatment and Prevention

Worms may be diagnosed by carrying out a faecal examination. This is usually done by completing a faecal float and looking for worm eggs.

Good hygiene and standards of cleanliness in the lemur enclosure will assist in keeping worm burdens low. Regularly removing faeces and washing cleaning implements will help to reduce the spread. Lemurs may be treated using commercially available human worming products.

Tuberculosis (TB)

Causes

Tuberculosis is caused by the pathogenic bacteria *Mycobacterium tuberculosis*. It does not occur naturally in primates; rather it is usually caught from human outbreaks. In a

captive environment it is most likely to be transmitted via animals being transacted into a facility which is why strict quarantine measures are so important.

Signs

Clinical signs may be absent until the disease has become advanced as the disease progresses quite slowly. The most common sign is a cough. Secondary signs can be weight loss, fevers and poor colour in the gums.

Treatment and Prevention

The single most effective treatment is prevention. Tuberculosis may be diagnosed through an intradermal injection into the upper lid of the eye with a protein derivative of TB. This test measures the delayed hypersensitivity response in the eyelid of the lemur. Generally no swelling of the eyelid is regarded as a negative result, whereas swelling and a drooped or closed eyelid is regarded as a positive result.

An animal that tests positive for TB and all conspecifics should be immediately quarantined from all other primates. Staff working these animals should adopt quarantine procedures as detailed in the next section. Staff should be extra vigilant of the disease presenting in other primates held at the facility.

(Wolfensohn and Honess 2005)

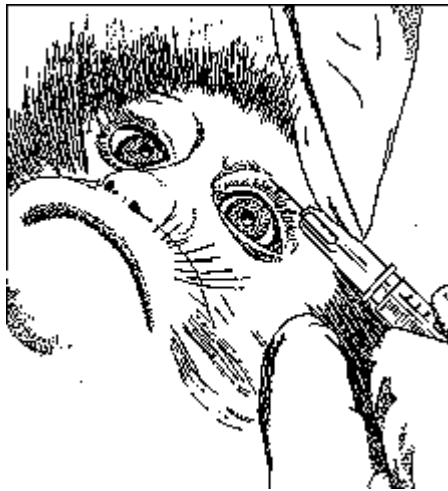


Figure 3.0 Diagram showing intradermal injection for TB testing in a primate. Primates require anesthesia for this procedure.

(Picture from; <http://www.iacuc.arizona.edu/training/primate/zoo.html>)

8.5 Quarantine Requirements.

In view of the high risk of primates carrying zoonotic diseases, quarantine requirements are stringent. White fronted lemurs being transferred in to the established collection will need to undergo a 30 day Quarantine period. Ideally quarantine should take place in an area completely separate from the existing lemur enclosures. This will protect existing

collection animals from diseases from the new arrival, and also the new arrival from diseases established in the collection.

The risk of zoonotic transmission (in both directions) between newly acquired lemurs and keepers will be greatly reduced by using PPE such as face-masks, gloves and gowns when in contact with the primates.

According to the “Quarantine and Health Screening Protocols For Wildlife Prior To Translocation and Release into the Wild” compiled by the IUCN Species Survival Commission’s Veterinary Specialist Group (2000) testing should include:

1. Faecal examination (direct and flotation) for endoparasites, especially *Entamoeba sp.* Primates should have three consecutive negative faecal examinations before release.
2. Faecal culture for *Salmonella sp.*, *Shigella sp.*, *Campylobacter sp.* and *Yersinia sp.*
3. Appropriate serology, based on history and origin, for toxoplasma, retroviruses, parainfluenza, measles, cytomegalovirus, Simian Immunodeficiency Virus (SIV) and Hepatitis A, B, C (HAV, HBV, and HCV).
4. Carry out serum/plasma chemistry profile.
5. Carry out urinalysis if possible.
6. Carry out complete Blood Count and PCV.
7. Blood smears should be examined for *Filaria sp.* and *Plasmodium sp.* (malarial parasites). Filarial Infections, however, seem not to be pathogenic.
8. Three negative tests for tuberculosis should be performed at two-week intervals using a tuberculin containing at least 1500 units/0.1 ml (e.g. Mammalian human isolate, Coopers Animal Health, Kansas City, Kansas, USA) or “old mammalian tuberculin” (Pasteur Institute, Paris, France). The tuberculin should be injected into the upper eyelid.
9. Check for ectoparasites.
10. Apply indelible tattoo or microchip for identification.
11. Ultra-freeze suitably labeled serum and tissue samples.

Record keeping should be thorough and include dates of quarantine testing required and results. Observations of daily activity may be noted on records and will provide a valuable source of information to keepers regarding normal behaviour for individual animals. Records may be clipped to the front of enclosures for ease of access and updating.

Quarantine enclosures should be built with materials that are easily cleaned and durable. This includes smooth cement, metals, rubber and other durable plastics. Woods and ropes can prove to be difficult to disinfect and should be avoided. Where these materials are used they should be discarded after use. Drainage and ventilation in the enclosure should be adequate.

Tools (such as dustpan and brush, bins, rakes, wheelbarrows) should be assigned for use only with the quarantine area. Waste materials such as food scraps, faecal matter and soiled bedding should be bagged and removed for destruction. These may either be collected by a commercial biohazard waste company, or buried on site if facilities to do so exist.

A quarantined lemur will also need environmental enrichment. This is even more so the case with individually housed animals without social stimulation. Enrichment is still possible in quarantine environments and may take the form of;

- easily disinfected products such as plastic puzzle feeders or balls
- disposable novel objects such as paper bags or cardboard boxes
- and presentation of daily food items in a variety of manners.

9. Behaviour

9.1 Activity

White fronted brown lemurs are a cathemeral species, meaning that they are active for brief periods throughout the day and night. The species is arboreal and moves quadrupedally throughout the forest canopy. These lemurs are also capable of leaping using their tails for balance.

An ethogram on brown lemurs recorded an activity budget of feeding (10-26%), travel (6-30%) and social or other activities (1-28%). White fronted brown lemurs are known to conserve energy by increasing time resting and feeding and traveling less as a survival strategy in periods when resources are scarce.

(Animal Diversity Web, *Eulemur fulvus* 2009)

9.2 Social behaviour

This species lives in multimale-multifemale groups. Group sizes can include up to 40 individuals. However social groups of 4 to 17 are most often seen for this species. Preliminary studies have suggested it is similar to the Red fronted lemurs which are characterized by female philopatry (females remain with their natal troupe) and male dispersal (Mittermeier et al, 1994).

White fronted brown lemurs will allogroom to both establish and maintain social bonds; the 6 lower procumbent teeth that form a dental comb are used to groom other individuals. Lemurs may also use this tooth comb to self-groom (Mittermeier et al, 1994).

Vocal and olfactory communication is used for communication within family groups and also to communicate with neighbouring groups. These lemurs have glands at the wrist and throat which facilitate olfactory communication. This type of communication is used for transmitting physical state, location, and individual recognition. Scents are laid by rubbing the glands on the wrists and throats on to solid objects such as nesting sites, territory boundaries and common pathways (Mittermeier et al, 1994).

Vocal communication in the white fronted brown lemur has been categorized in to 3 main sounds:

1. "OHN" - a short nasal sound used in maintaining group cohesion
2. 'CREE' - a longer, high pitched sound used as a territorial call
3. 'CROU' - a louder call, and is used as the alarm call

Body posture and facial expression are also likely to be important in communication.

9.3 Reproductive behaviour

The mating system of white fronted brown lemurs is yet to be described. However preliminary studies suggest it is polygynous like Red Ruffed lemurs (*Varencia variegata rubra*). Polygynous describes a mating pattern in which a male mates with more than one female in a single breeding season.

Unlike other members in the genus no subspecies of brown lemur display female dominance and as such it is not known how active participation females have in mate selection.

9.4 Bathing

Bathing is not necessary for this species.

Scent marking plays a very important role in communication in this species. Olfactory communication is very important between conspecifics and bathing may adversely affect this communication.

Special consideration should be given to this regarding frequency of chemically cleaning lemur enclosures. Enclosures may be spot cleaned and hosed daily, with detergent based cleaning only necessary 2-3 times weekly.

9.5 Behavioural Problems

Behavioural problems are often rooted in suboptimal husbandry or inappropriate housing; housing animals individually rather than in social groups. Behavioural problems to be aware of include:

- Pacing – pacing may be recognised by well worn tracks and paths in an animals exhibit. As white fronted brown lemurs are an arboreal species, it is beneficial for keepers to spent time outside of feeding times observing animals. This should be done preferably when animals are unaware of keepers' presence.
- Over grooming and mutilation - Primates often over groom themselves and each other. This can be caused by boredom or stress.
- Hyper aggression – this may be directed at conspecifics or keepers
- Abnormal maternal behaviour - this includes over-grooming, as well as rejection of young.
- Feeding disorders

(Wolfensohn and Honess 2005)

The most success way to treat behavioural problems is by identifying the trigger or cause of the problem. Band-Aid solutions (such as placing physical barriers in pacing tracks) do little to address the real issue and will not improve an animal's welfare.

9.6 Signs of stress

All lemur species are susceptible to stress in captivity. This may be caused by a number of factors such as catch-ups for veterinary procedures, conspecifics interactions (aggression), unpredictability in their environment, boredom and sub-standard husbandry conditions.

Signs of stress may include:

- Fur plucking or over grooming
- Vocalizations
- Diarrhoea and loose faeces
- Increased or decreased activity levels
- Stereotypic pacing
- Increased or decreased appetite

(Wolfensohn and Honess 2005)

9.7 Behavioural enrichment

Enrichment for lemur species may include a variety of strategies:

- Auditory – provision on novel sounds such as music, bells or prerecorded sounds. Calls of other lemurs species may be used however care should be taken to properly assess the reaction and effect this has on the lemur.
- Olfactory – novel scents such as essential oils, perfumes and deodorants, herbs, spices and flowers may stimulate exploratory and investigative response in lemurs.
- Novel objects – boxes, mirrors, balls and plastic containers.
- Social – housing with conspecifics to provide social interactions. Interaction with keepers may also provide a form of social enrichment, however should not be a replacement for housing animals in groups.
- Training and conditioning – crate conditioning, stationing and scale training provide a cognitive challenge for lemurs.
- Environmental – changing ropes and climbing apparatus to provide new pathways and routes throughout the exhibit. Changing position of feeders and nest boxes. Addition of new enclosure furniture.
- Food based - provision of novel food items such as season fruits, flowers and browse. Human foods such as diet jelly and cordial ice blocks, peanut butter and jam may be offered in small quantities as they are high in calories and low in nutritional content.



Figure 3.1 A male White fronted brown lemur investigating a hanging puzzle feeder. This device encourages natural behaviours such as puzzle solving and exploring. Photo taken at Taronga Western Plains Zoo, January, 2009.

9.8 Introductions and removals

Introductions of new animals are an inherently stressful and potentially dangerous occasion for both new lemurs and existing troupes. Introductions should be carried out in a controlled manner and be carefully observed and observations recorded by keepers.

If a single animal is to be introduced to a form a pair with an extant animal, the two should be introduced slowly. The pair may be held in adjoining cages with fence line contact only and behaviour monitored and gauged for compatibility. Pending behaviour of both animals short periods of contact may be allowed, building up to extended times together and eventual permanent pairing. It can be beneficial to introduce animals into a third enclosure where neither has an establish territory. Food can also play an important part in introductions, as feeding my serve as a distraction and positive reinforcement.

A solitary animal joining an existing troupe will benefit by being introduced to one or two animals first, so it may for bonds and alliances with already established animals. This may be done as described above for pairs. Once allegiances are built animals may be released as a group back into the troupe. This will afford the new comer some protection from an established troupe.

Post introduction animals should be carefully monitored for signs of stress and aggression (both from and to existing troupe members). A new animal will need to establish itself in the extant hierarchy and some mild aggressive behaviour will probably be observed. Keepers must be able to use their discretion about when to intervene as it is important to let natural, mild aggression and social interactions to occur for the long-term acceptance of the new comer to the troupe.

For guidelines regarding timing of transport and appropriate transport crates, please refer to Section 7.

9.9 Interspecific compatibility

White fronted brown lemur territory may overlap with other species in the wild, as there has been reports of hybridization as discussed further in section 10.5. However in captivity care should be taken in mixed exhibits. White fronted brown lemurs are considerably smaller lemurs than the other lemur species commonly held in Australasian Zoos (*Varecia variegata*, *Lemur catta*) and as such may find it difficult to compete in a shared space with these animals.

9.10 Intraspecific compatibility

White fronted brown lemurs are a social species and in the wild will be found in social groups of 4 - 17 individuals. Like all lemurs and most primate species, it is important for these animals to be housed socially to support their psychological wellbeing and development.

9.11 Suitability to captivity

White fronted brown lemurs may be kept successfully in captivity as long as basic husbandry requirements of the species are met. It is imperative that these lemurs be housed in social groups rather than in solitary situations. Enclosures must address behaviour needs and allow arboreal travel and habituation. Environmental enrichment should be a cornerstone of husbandry for this species to address its need for cognitive stimulation and challenge.

10 Breeding

10.1 Mating System

The mating system of white fronted brown lemurs is yet to be described. However preliminary studies suggest it is polygynous like Red Ruffed lemurs (*Varencia variegata rubra*). Polygynous describes a mating pattern in which a male mates with more than one female in a single breeding season (Gould and Sauter 2006).

Unlike other members in the genus no subspecies of brown lemur display female dominance and as such it is not known how active participation females have in mate selection.

10.2 Ease of Breeding

White fronted brown lemurs have been bred in captivity with success. There is currently an active breeding program for this species in North American Zoos; however this species is being phased out in Australia (delete by attrition). Taronga Western Plains Zoo, Dubbo is the only Australasian Zoo to now hold this species (a non breeding group).

Infant mortality has not been reported in white fronted brown lemurs; however it has been recorded as high as 65% in the closely related Red ruffed lemur (*Varencia variegata rubra*).

(Animal Diversity Web, *Eulemur fulvus* 2009)

10.3 Reproductive Condition

10.3.1 Females

Before being able to breed females must reach sexual maturity (around 18months of ages).

Female white fronted brown lemurs need to maintain a minimum body weight (or levels of body fat) in order to either begin or resume ovulatory cycling. This body condition may be affected by a number of outside factors including environmental stress or poor immunological function (Wolfensohn and Honess 2005).

Hierarchy within lemur troupes also plays a very important role in determining a female's ability to breed. Dominant females will often prevent subordinate animals from breeding. Males

10.3.2 Males

Before being able to breed males must reach sexual maturity (around 18months of ages).

Male white fronted brown lemurs must not only be in good physical health to successfully breed; their social ranking within the troupe plays a large part too. A male's success in breeding over his lifetime hinges closely on his ability to establish a high ranking within his troupe. Like females, dominant males may inhibit lower ranking males from breeding (Wolfensohn and Honess 2005).

10.4 Techniques Used to Control Breeding

Asa and Porton (2005) note contraception plays a vital role in controlling captive populations of all captive primate species. As space is a limiting factor in a captive breeding population the control of fertility allows group numbers to be managed. If facilities allow troupe separation, lemurs may be housed in single sex groups to prevent breeding. However, where no backup facility exists, contraception may be the answer.

Contraception may occur of either the male or the female lemur. Male contraception may include injections of Protein hormones such as Deslorelin, vasectamisation or castration (non-reversible) (Asa and Porton, 2005).

Female lemurs present more contraceptive options.

Progestin Implants; Depo-Provera

Progestin Oral; Progestin-only tablets

Protein hormones; Deslorelin (though note that Deslorelin will prompt oestrous about a week after injection before providing sterility)

Immunocontraception ; a vaccine causing impermanent sterility

Tubal ligation

The decision of which contraceptive method to employ should take into account potential future plans for the individual animal. For example; a genetically important animal might be contracepted using Deslorelin injections rather than permanent surgical means so it may breed in the future.

10.5 Occurrence of Hybrids

All subspecies of brown lemur can interbreed, but geographical isolation of subspecies in the wild prevents interbreeding.

Though hybrids have not been reported for this particular subspecies of brown lemurs, there have been reports of the following crosses;

Brown lemurs x Mongoose lemurs (*Eulemur mongoz*)

Brown lemurs x Black lemurs (*Eulemur macaco*)

Brown lemurs x Red fronted brown lemurs (*Eulemur rufus*) (Mittermeier et al, 2009).

10.6 Timing of Breeding

White fronted brown lemurs are annual breeders and in the wild matings takes place in the dry season between May and July. Females have an oestrous cycle of about a month and pregnancy lasts for 13-14 weeks. This is timed that the young are born in the wet season - when food is plentiful in the forest.

10.7 Age at First Breeding and Last Breeding

White fronted brown lemurs reach sexual maturity at approximately 18 months. Females give birth to their first young at 2 years of age. This species is currently not being managed as a breeding population in Australia. It is unknown how old this particular species is when it is last able to breed, however it is likely to be able to breed until mid to late 20's like Red ruffed lemurs (*Varencia variegata rubra*).

10.8 Ability to Breed Every Year

Breeding can occur every year in this species.

10.9 Ability to Breed More than Once Per Year

Only one infant is born to each mother in each year. Single births are most common; however twin births have been reported (Gould and Sauther 2006)..

10.10 Nesting, Hollow or Other Requirements

White fronted brown lemurs will give birth to young who will then cling to the abdomen. This species does not plant or stash its babies.

It is important to provide shelter for expectant mothers and a number of nesting boxes with bedding should be offered so that she may choose a birthing location. Providing a number of nesting boxes will assist in reducing competition or monopoly of boxes from troupe mates (Gould and Sauther 2006).

10.11 Breeding Diet

The standard diet described in Section 6.2 is suitable for breeding white fronted brown lemurs. Care should be taken to monitor feed consumption during gestation. Lactating females may require an increase in diet. Once young are experimenting with solid food, diet items should be presented in such a way to encourage them. For example providing small, chopped pieces of fruits and vegetables.

10.12 Oestrous Cycle and Gestation Period

Oestrous cycles are approximately every 28 days. The gestation period for white fronted brown lemurs is 120 days (Gould and Sauther 2006).

10.13 Litter Size

Single births are most common; however twin births have been reported.

10.14 Age at Weaning

Young lemurs are usually weaned at approximately 4 – 6 months of age.

10.15 Age of Removal from Parents

Young are fully independent at 1 year of age.

Preliminary studies have suggested that White Fronted Brown lemurs are similar to the Red fronted lemur which is characterized by female philopatry (females remain with their natal troupe) and male dispersal. This suggests that female young will remain with their family for life whilst male young may disperse to new troupes (Gould and Sauther 2006).

10.16 Growth and Development

Lemurs, like all primates have relatively slow rates of growth and development than other mammals. Neonates rely heavily on their mothers for food and transportation. Compared to other mammals of similar size there is a long period between reaching the juvenile stage and sexual maturity.

For the first 21 days after birth neonate lemurs cling to their mothers' abdomen; the only exception being when they will move to nurse. After this initial period, young will ride on their mother's back. First steps will be taken at around 4-6 weeks of age, around the same time as solid food is being investigated. Young are fully independent at 12 months and sexually mature at 18 months (Gould and Sauther 2006).

11 Artificial Rearing of Mammals

11.1 Housing

Warmth is one of the most important considerations for neonatal lemurs as naturally the young rely on their mother's body heat to keep them warm. Therefore basic requirements for neonate lemurs are a regulated heat source, a thermometer to monitor temperature and a secure and easy to clean enclosure (Williams, 2002).

Only one infant should be housed per incubator/ humidicrib unless it can be partitioned into multiple areas; this will prevent infants from suckling on each other (Williams, 2002).

A surrogate mother by means of soft toy, bundled towel etc should be provided for neonates that would ordinarily cling to their mother (Williams, 2002).

Infants may be introduced to branches, ropes and boxes once they are old enough to move to a larger enclosure and should be encouraged to swing, jump, leap and engage in natural physical behaviours (Williams, 2002).

11.2 Temperature Requirements

Incubators are ideal for very young animals. Humidity should be set at 50-65% and surrounding air temperatures between 35.5-36.7c for neonates. This may be adjusted to maintain body temperature between 35.5-36.7c. As the infant ages, and its ability to thermoregulate develops, temperatures may be incrementally decreased (Williams, 2002).

Lemurs a month or more in age may be maintained with a heat lamp, hot water bed or warm water circulating blanket (Williams, 2002).

Important: standard heating pads may generate enough heat to burn an infant and as such are *NOT* recommended (Williams, 2002).

11.3 Diet and Feeding Routine

Eulemur species produce milk that is dilute, low in energy, fat and protein. Parent raised lemur will nurse 'on-demand'. Human baby milk preparations may be used as a substitute to raise neonate lemurs, however care should be taken to choose a variety low in iron (see chapter in this manual on haemotomachrosis) (Williams, 2002).

Prepared formula will quickly build unacceptable bacterial levels and so should be made up only as required. Portions may be refrigerated and stored for 24 hours, but after this time a fresh batch should be made up (Williams, 2002).

Milk formula should be warmed by decanting milk into the feeding bottle and then gently warming it in a mug of hot water. Microwaving is not advisable as this can cause uneven temperatures and 'hot spots' in the milk. The temperature of the milk may be tested on the inside of the keepers' wrist, or on the lips. It should be a comfortable 'body armth' temperature (Williams, 2002).

FIRST 24 HOURS:

Neonates should be offered electrolyte solution from a bottle.

SECOND 24 HOURS

Offer 3/4 electrolyte solution, 1/4 milk solution from a bottle

THIRD 24 HOURS

Offer 1/2 electrolyte solution, 1/2 milk solution from a bottle

FOURTH 24 HOURS

Offer 1/4 electrolyte solution, 3/4 milk solution from a bottle

Newborns need to be fed every two hours around the clock for the first week of life. A good rule of thumb is to offer the infant 25% of it's bodyweight in formula split over the course of 24 hours (Williams, 2002). For example:

A newborn 100g lemur would require 25ml of formula in 24 hours.

On 12 feeds a day (i.e. feed every 2 hours) this would equate to 2.08ml per feed.

As the infant grows, milk quantities should be increased using the 25% ratio. Growth targets for eulemur species are 5-7grams per day after the first week.



Figure 3.2 Photo showing appropriate bottle feeding method for a neonate lemur. Although this photo shows a Ring tailed lemur (*Lemur catta*) the same method is appropriate for White fronted brown lemurs. Photo taken from <<http://www.zooborns.com/zooborns/2009/04/a-labor-of-lemur-love.html>>

11.4 Specific Requirements

As mother lemurs would ordinarily stimulate defecation and urination of the infant, it falls to the keeper to do this (Williams, 2002). A cotton ball, commercially available baby-wipe or moistened tissue may be rubbed gently over the anal-genital area of the infant to stimulate passing waste. Care should be taken not to over do toileting as the sensitive skin of this area can quickly become red and chaffed.

11.5 Data Recording

Good data collection is vital to the success of any hand raised lemur. Infants should be weighed daily, at the same time, before feeding. This should be recorded and can be checked against ideal growth rate charts. Defecation, urination, milk consumed and behavioural notes should be recorded (Williams, 2002).

Recorded data is important not only for keeping a track on the development of the infant, but also as a record accessible by others in the future undertaking the hand rearing of lemur species.

11.6 Identification Methods

Where multiple neonates are housed together, identification of individuals can be through natural differences in coat coloration or markings. If no significant differences are

evident individuals may be distinguished by shaving a small patch of fur from the tail or other nominated body part.

11.7 Hygiene

Neonates who do not receive their initial milk from their mother miss out on colostrums and antibodies which would usually bolster their immune system. Great care should be taken to ensure neonates are not exposed to harmful pathogens. Personal hygiene of the keeper and good husbandry will serve well. Hands should be washed before handling neonates, lab coats or scrub tops and gloves should be used when feeding or toileting (Williams, 2002).

All utensils and bottles, including suckling teats should be carefully cleaned and sterilized after each use. Milton antibacterial solutions may be used to soak items in between feeds, making sure to rinse them thoroughly before use (Williams, 2002).

11.8 Behavioural Considerations

Lemurs as social animals require social stimulation by way of grooming, playing and bonding interactions. Solitary housed infants being hand raised will require considerable time from their keeper to engage them in social interactions. Post-feed time is an opportune time to encourage play behaviours (Williams, 2002).

Lemurs of 1.5-2 months of age will begin to display leaping, jumping and climbing behaviours and should be encouraged to develop physical coordination.

11.9 Use of Foster Species

Due to the complex social systems of all primate species the use of foster species for rearing eulemur species is not recommended.

11.10 Weaning

From 4 weeks of age infants should be introduced to solid foods such as specifically manufacture primate kibble and fruits and vegetables. Primate kibble may be made more palatable by softening it in fruit juice, milk formula or mashed banana first (Williams, 2002). Care should be taken to ensure choking does not present a hazard when first introducing solid foods and young should be supervised initially when experimenting with solids.

Acknowledgements

Thank you to

- Jen Conaghan, Division 3 Supervisor at Taronga Western Plains Zoo for help and advise in compiling this husbandry manual
- Paul Metcalfe, Life Sciences Manager and Ian Anderson, Senior Keeper at Taronga Western Plains Zoo for their support with my writings
- the Veterinary team at Taronga Western Plains Zoo for assistance with information on the health requirements of lemurs
- Dawn Williams for proof reading the draft copy
- Graeme Phipps, TAFE NSW.

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Glossary

Arboreal	inhabiting or frequenting trees
Cathemeral	active for brief periods throughout the day and night
Conspecifics	another individual of the same species
Delete by attrition	phase out of collection through natural death
Ectoparasites	any external parasitic organism
Endoparasites	any internal external parasitic organism
Ethogram	record of individual or discreet behaviours displayed by an animal or group of animals.
Hemosiderosis	a form of iron overload disorder resulting in the accumulation of hemosiderin
Intradermal	areas between the layers of the skin
Matriarchal	pertaining to a matriarch; governed by a matriarch
Neonate	a baby from birth to four weeks
Nonhuman primate	Any primate other than <i>Homo sapiens</i>
Olfactory communication	refers to scent marking or scents left by animals to communicate with others (e.g. oestrous signals)
Opposable	capable of being placed opposite to something; "the thumb is opposable to the forefinger"
Phylogenetic	relating to the evolutionary development of organisms
Polygynous	having more than one female partner at a time
Stereotypic	repetitive, usually undesirable behaviours (e.g. pacing)
Tannin	astringent, bitter plant polyphenols that either bind and precipitate or shrink proteins.

Tapetum	An area in the pigmented layer of the choroid coat of the eye in many animals, which has an iridescent or metallic luster and helps to make the eye visible in the dark.
Taxon	animal or plant group
Zoonotic	any infectious disease that can be transmitted from non-human animals to humans or from humans to non-human animals

Appendix

Appendix 1.1 Lemur Cake Recipe

Lemur Cake Recipe

Ingredients

3 ½ Boxes	High Protein Baby Cereal
1 1/3 Cups	Wheat germ
1 1/3 Cups	Sustagen
½ Tablespoon	Vegemite
¾ Tablespoon	Pentavite
4 Tablespoons	Honey
4 Tablespoons	Glucodin
100mls	Warm Water

Method

Mix all dry ingredients (baby cereal, wheat germ, Sustagen & Glucodin) into a bucket.

Mix wet ingredients (vegemite, Pentavite, honey) into water in a separate bowl.

When wet ingredients are well mixed, add to bucket of dry ingredients.

Mix well – Add additional water to get a firm wet consistency.

Roll mix into roughly golf size balls.

Mark bags with contents and date of production.

Put balls into bags and tie up.

***Extra additions to this recipe include mixed dried fruit or using fruit flavoured tea instead of water.

Ball Sizes

Roughly the size of golf balls

To ensure freshness mark each bag with contents and date of production (e.g. Lemur Cakes 01/01/08).

Appendix 1.12 Supplier contact information for commonly used dietary items

Product name	Producer name	Producer contact details	Available in domestic supermarket / chemist?
High protein baby cereal:	Heinz	1800 037 058	Supermarket
Wheat germ:	Furney's Stock Feeds	(02) 6882 2011	Supermarket
Sustagen:	Nestle	1800 671 628	Supermarket
Vegemite:	Kraft	1800 033 275	Supermarket
Pentavite:	Bayer	1800 033 111	Chemist
Honey:	Capilano	(07) 3712 8282	Supermarket
Glucodin:	chemistcare.com.au	(07) 3204 5977	Supermarket
Peanuts:	Peanut Company Australia	(07) 4162 6311	Supermarket
Coconut (desiccated):	Great Aussie Food	(03) 9899 6405	Supermarket
Natural Muesli:	The Muesli Company Online	(03) 9469 3177	Supermarket

Supermarkets:

Coles Supermarket

Centro Dubbo, 177
Macquarie St (Cnr Bultjie St),
Dubbo NSW 2830
(02) 6882 6250*

Woolworths

Macquarie St, Dubbo NSW
2830
(02) 6882 1633*

Chemists:

Orana Mall Pharmacy

Orana Mall, Dubbo NSW
2830 (02) 6882 7677*

O'Donnells Pharmacy

65 Wingewarra St, Dubbo
NSW 2830
(02) 6882 4544*

Appendix 1.2 Wonderclean MSDS



wonderclean msds.pdf

Appendix 1.3 Bleach MSDS



MSDS_All_Clor_Bleach.pdf

Appendix 1.4 F10 MSDS



F10SC_MSDS_Dec_2003.pdf

Appendix 1.5 Supplier contact details for Kramar

The KraMar Pet Company Pty. Ltd.
144 Hartley Road, Smeaton Grange NSW 2567
Tel: 02 4648 8500 Fax: 02 4648 8599
Postal: Locked Bag 5000, Narellan NSW 2567
Email: customerservice@kramar.com.au