

Koala Phascolarctos cinereus

Captive Husbandry Guidelines

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Status :

M&MSG - Lower Risk (near threatened) (Maxwell *et al.*, 1996).

IUCN – Near threatened.

ASMP Category: 3(2)

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Table of Contents

1. Introduction	1
2. Taxonomy	1
2.1 Nomenclature	1
2.2 Subspecies and Descriptions	1
2.3 Other Common Names	2
3. Natural History	2
3.1 Morphometrics	2
3.2 General Description	2
3.3 Distribution	3
3.4 Habitat	4
3.5 Wild Diet	4
3.6 Longevity	6
3.6.1 Wild	6
3.6.2 Captivity	6
3.6.3. Determination of Age	6
4. Housing Requirements	8
4.1 Exhibit Design	8
4.2 Holding Area Design	10
4.3 Position of Enclosures	10
4.4 Weather Protection/Heating	10
4.5 Substrate	10
4.6 Enclosure Furnishings	11
4.7 Interspecific Compatibility	25
5. Handling and Transport	11
5.1 Timing of Capture and Handling	12
5.2 Catching Bags	12
5.3 Capture and Restraint Techniques	12
5.4 Weighing and Examination	14
5.5 Release	14
5.6 Transport	14
5.6.1 Box Design	14
5.6.2 Furnishings	14
5.6.3 Water and Food	14
5.6.4 Animals Per Box	15
5.6.5 Timing of Transportation	15
5.6.6 Release from Box	15
5.7 Koala Handling and Photographing	15
5.7.1 Signs of Stress	15
5.7.2 Minimising Stress During Handling	15
6. General Husbandry	16
6.1 Hygiene and Cleaning	16
6.2 Record Keeping	16

6.3 Identification.....	16
6.3.1 Ear Tags.....	16
6.3.2 Passive Integrated Transponder Tags.....	16
6.3.3 Facial Features.....	16
7. Health Requirements.....	17
7.1 Daily Health Checks.....	17
7.2 Detailed Physical Examination.....	18
7.3 Major Diseases.....	19
7.3.1 Chlamydia.....	19
7.3.1.1 Infection.....	19
7.3.1.2 Clinical Signs.....	20
7.3.1.3 Precautions.....	20
7.3.1.4 Treatment.....	21
7.3.2 Other Diseases.....	21
7.4 Stress.....	21
7.5 Changes in Body Weight.....	21
7.6 Quarantine Requirements.....	22
7.6.1 Imported Animals.....	22
7.6.2 Accession Koalas.....	22
7.6.3 Quarantine Facilities.....	23
7.6.4 Clean up after Positive Chlamydia Results.....	23
8. Behaviour.....	23
8.1 Daily Activity Cycle.....	24
8.2 Aggression.....	24
8.3 Animal Introductions.....	25
8.4 Behavioural Enrichment.....	25
9. Captive Dietary Requirements.....	26
9.1 Species of Eucalypts Preferred.....	26
9.2 Choice of Eucalypt Branches to Be Cut.....	26
9.3 Storage of Leaves.....	27
9.4 Feeding of Leaves.....	27
9.5 Eucalypt Plantations.....	28
9.6 Artificial Diets.....	29
9.8. Supplementary Milk Diets for Aged and Sick Koalas.....	29
9.7 Vitamin and Mineral Supplement.....	29
10. Breeding.....	29
10.1 Breeding System.....	30
10.2 Age at First Breeding.....	30
10.2.1 Males.....	30
10.2.2 Females.....	30
10.3 Ability to Breed Every Year.....	30
10.4 Timing of Breeding.....	30
10.5 Ability to Breed More Than Once Per Year.....	30
10.6 Oestrous Cycle.....	31
10.7 Breeding Strategy.....	31
10.8 Reproductive Behaviour.....	31

10.9 Breeding Methods	31
10.9.1 Selective Breeding Method	32
10.9.2 Harem Breeding Method	32
10.9.3 Random Breeding Method	32
10.9.4 Breeding Group Sex Ratio.....	32
10.9.5 Aggression.....	32
10.10 Mating Site	32
10.11 Gestation Period	33
10.12 Number of Young Born.....	33
10.13 Number of Young Surviving.....	33
10.14 Pouch Checking.....	33
10.15 Growth and Development.....	33
10.16 Weaning Weight and Age.....	34
10.17 Age at Dispersal	35
11. Artificial Rearing of Koalas.....	35
11.1 Initial Strategy	35
11.2 Housing.....	35
11.3 Health and Hygiene	36
11.4 Temperature Requirements.....	36
11.5 Diet	37
11.6 Feeding Routine.....	37
11.7 Weighing	39
11.8 Weaning.....	39
11.9 Rehabilitation Procedures.....	39
11.10 Legalities of Hand Rearing Koalas.....	39
12. Acknowledgments	39
13. References	40
14.0 Bibliography	45
Appendix 1. Draft 2. ARAZPA Monotreme and Marsupial Taxon Advisory Group Recommendation on Subspeciation in Koalas	50
Appendix 2. NSW EAPA Standards for Exhibiting Koalas in New South Wales	52
Appendix 3. Queensland Wildlife Parks Association Guidelines	60
Appendix 3a. Koala monthly weighing record.....	68
Appendix 3b. Koala handling time records	68
Appendix 4. Review of Environment Australia's Conditions for the Overseas Transfer of Koalas	70
Appendix 5. The Management of Eucalyptus plantations for Koala Fodder.....	85

1. Introduction

The koala *Phascolarctos cinereus* (meaning ash coloured pouched bear) and the large kangaroos are probably Australia's most popular mammals. The empathy created by the koala appears to be due to it being one of the few mammals that has a face rather than a muzzle, a trait it shares with humans (Lee & Martin, 1988).

The koala is nocturnal to crepuscular and is one of the largest arboreal mammals (4.1-14.9kg), resting in trees without building nests (Strahan, 1995). The koala's feet and hands are well developed and possess long, pointed claws, which are of great benefit in climbing branches and tree trunks. The fur is thick, short, fine and densely matted and has some of the best insulating properties found in marsupials, verging on those of some arctic mammals (Cronin, 1987). Its colour differs between different locations, ranging from light to dark grey on the back, although sometimes showing touches of brown and white or yellowish fur on the underbelly.

Due to their popularity, koalas are a good educational tool for increasing public awareness of conservation for both children and adults (Finnie, 1990). Koalas in zoos can be ambassadors for conservation, particularly as the major factors affecting the long term survival of wild koalas, and many other species, is the availability of suitable habitat. The koala can be used as a tool to provide the visitor with information of habitat conservation by providing stimulating graphics and keeper talks (Finnie, 1990).

Research within zoos can contribute to conservation of the koala through an increased understanding of animal behaviour, reproduction, physiology, nutrition and disease.

2. Taxonomy

2.1 Nomenclature

Class	Mammalia
Subclass	Marsupialia
Order	Diprotodontia
Suborder	Vombatiformes
Family	Phascolarctidae
Genus Species	<i>Phascolarctos cinereus</i>

2.2 Subspecies and Descriptions

The koala was first described by Goldfuss in 1817. It is the only member of the Family Phascolarctidae. Previously there has been considered to be three subspecies of koalas. The nominate subspecies *P. c. cinereus* that has a range extending from the north to southern New South Wales (type specimen from unknown location in NSW). The northern subspecies *P. c. adustus* (Thomas, 1923) is found in Queensland, with the type specimen coming from O'Bil Bil near Mundubbera. The third subspecies *P. c. victor* (Troughton, 1935) is found in Victoria with the type locality being Booral (Strahan, 1995). Confusion exists over the relationship between the three subspecies. Their ranges are presently defined by state borders, but variation may be due to a cline or continuum. The described subspecies were named by scientists with access to only a few specimens and with no idea of the extent of individual variation in any one area (Cronin, 1987). It has also been suggested that koalas do not cling to state boundaries,

and that it is clear that these subspecies create artificial boundaries in a north-south trend or cline (Lee & Martin, 1988). More recent genetic research by Houlden *et al.* (1999) found limited genetic distinction between geographically distant populations suggesting a tentative support for koalas to be considered a single evolutionary significant unit. As a result, all populations should be referred to under the scientific name of *Phascolarctos cinereus* with no recognised subspecies (Lee & Martin, 1988), however there are two captive management units that have been developed, a northern and southern, which reflect the clinal variation in koalas (Appendix 1).

The closest extant relatives of the koala are the wombats, which share the same Suborder Vombatiformes.

2.3 Other Common Names

Koala bear or Native bear. Despite them not being at all related to bears.

3. Natural History

3.1 Morphometrics

Adult koalas can weigh between 4.1 and 14.9 kilos depending on sex and latitude (Strahan 1995).

Queensland Average Weights

Males 6.5kg (range 4.2-9.1kg)

Females 5.1kg (range 4.1-7.3kg)

Victoria Average Weights

Males 12.0kg (range 9.5 – 14.9kg)

Females 8.5kg (range 7.0 - 11.0kg)

Sexual size difference is evident with males being approximately 50% larger than females (Lee & Martin, 1988). It is suggested that this sexual dimorphism is associated with the polygynous mating system and a male dominance hierarchy (Tyndale-Biscoe & Renfree, 1987).

3.2 General Description

The koala has small eyes in comparison to the size of the head, with the slits of the pupils being vertical rather than horizontal as in other marsupials. The fur of the koala is thick and woolly and thicker and longer on the back than on the belly. Both the inside and outside of the ears are heavily furred (Lee & Martin, 1988). Koalas have a shorter coat the further north within their distribution they progress, due to the increase in average temperatures. The colour and pattern of the coat varies considerably between individuals and with age (Lee & Martin, 1988). The male Victorian koala is 70% and the females 90% larger than their Queensland counterparts (Cronin, 1987). The Victorian race also has a heavier, shaggier coat with more fur in the ears and around the face while the Queensland koala is somewhat smaller in size and sleeker in coat.

The koala has a number of features, some of which it shares with the wombats, that distinguish it from the other diprotodont marsupials. These include a backward

opening pouch with two teats, cheek pouches, a vestigial tail, the absence of the first two premolars, and the presence of selenodont molars. In contrast to the wombats, the koala has three incisors on either side of the upper jaw and the teeth have roots. The manus (hand) is forcipate with digits I and II opposed to the remaining 3 digits, with each digit terminating in a strongly curved claw (Lee & Carrick, 1989).

The females have a pouch which contains two teats and opens centrally and downwards when not occupied, and backwards when there is a large pouch young present. Males have a prominent sternal gland which normally stains the fur around this area orange to dark brown. Male koalas can be distinguished from females by the shape of the head (Fig. 1). The head of adult males is relatively larger than that of females, and appears broader and squared off in profile. Males also have a broad rather than pointed chin, relatively small ears and a large pendulous scrotum.

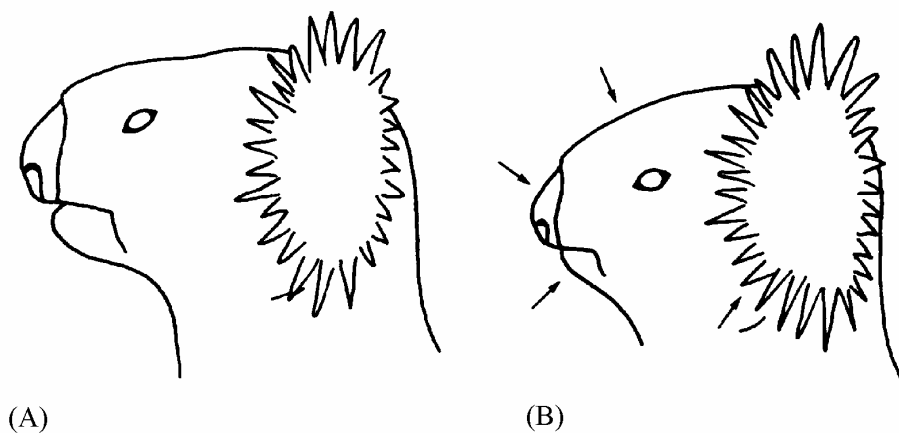


Figure 1. Profiles of the head of male and female koalas (a) a male koala, (b) a female koala, illustrating the distinctive 'Roman' nose of the male and the straighter nose of the female (Lee & Martin, 1988).

3.3 Distribution

The koala is found on the east coast of Australia from Queensland to Victoria (Fig. 2). Scattered populations can be found from the extreme east coast of Victoria to the extreme west. In the 1870's and 1880's koalas were released on Phillip Island in Westernport Bay and on French Island, and later on other islands (Cronin, 1987). The heaviest concentrations occur in Gippsland, and a broad area east and west of Melbourne. In New South Wales the koala is not doing so well and are classified as vulnerable. They have been shot out of the New England Tableland and most of the state south of Sydney. The vast majority of the New South Wales koalas occur east of the Great Dividing Range from Sydney to the Queensland border, with further populations scattered in an arc from Sydney to Dubbo. The southeast corner of Queensland is the stronghold of the Queensland race. Scattered populations occur all along the coast up to Townsville and sections of the Atherton Tableland with a small population at Ravenshoe being the furthest most location recorded to date (Cronin, 1987).

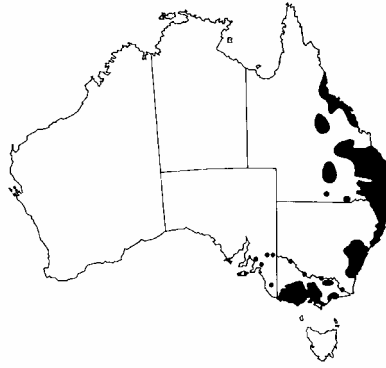


Figure 2. Present day distribution of the koala (Cronin, 1987).

3.4 Habitat

Throughout the koalas distribution, it is found in various habitats that range from open forests to woodlands and from the tropics to cool-temperate regions. Within its range it is limited to areas where there are acceptable food trees. As forests and woodlands are cleared, koalas are forced into smaller and smaller areas, leaving them susceptible to starvation through the continued deprivation of food. (Lee & Martin, 1988).

In recent years continued clearing of large tracts of eucalypt forest and the consequent restriction of population to small patches of discontinuous and possibly sub optimal habitat leave the long term future of the species in some doubt. It seems clear that the survival of many populations will depend upon appropriate forestry management. In residential areas protection from roads is required in order to minimise the numbers injured or killed by vehicles.

3.5 Wild Diet

Koalas feed predominantly on the foliage of eucalypts, with some non-eucalypts also contributing to the diet (Table 1). Koalas are occasionally found sitting in, and even feeding on, trees of genera other than *Eucalyptus* including *Pinus*, *Leptospermum*, *Melaleuca*, *Allocasuarina* and *Callitris glauca* (Hindell & Lee, 1991; Gifford, pers. comm). There are marked local and seasonal preferences exhibited in the diet of koalas (Lee & Martin, 1988).

As eucalypt leaves have a high water content (approx 60-80%), koalas normally don't need to drink, but obtain sufficient water from their food. Eucalypt leaves have a high fibre and low protein content. They contain strong-smelling oils, phenolic compounds and sometimes cyanide precursors which make them unpalatable or even poisonous to most mammals. To cope with this diet, the koala has numerous adaptations, most notably an enlarged caecum, proportionally longer than in any other mammal, in which microbial fermentation takes place. Oils and phenolic compounds are detoxified in the liver and leaves containing cyanide precursors are probably avoided. There is no evidence for the widespread belief that eucalyptus oils intoxicate koalas, rendering them lethargic. The koala is delicately balanced between the minimum size enabling its liver to cope with a nutritionally poor diet of leaves and the maximum size it can attain and still have enough mobility in trees to actually gather the leaves, hence their slow movements (Lee & Martin, 1988).

Table 1. Species of eucalypts eaten by koalas throughout their distribution. Derived from Taronga Zoo, Lone Pine Sanctuary, Currumbin Sanctuary, Melbourne Zoo and Healesville Sanctuary.

Scientific name	Common name	Qld	NSW	Vic
<i>E. amplifolia</i>	Cabbage Gum		*	
<i>E. acmenoides</i>	White Mahogany		*	
<i>E. botryoides</i>	Southern Mahogany		*	*
<i>E. camaldulensis</i>	River Red Gum	*	*	*
<i>E. canaliculata</i>	Large-fruited Grey Gum		*	
<i>E. creba</i>	Narrow-leafed Red Ironbark	*	*	
<i>E. cypellocarpa</i>	Mountain Grey Gum			*
<i>E. drepanophylla</i>	Queensland Grey Ironbark	*		
<i>E. dumii</i>	Dunn's White Gum	*		
<i>E. exserta</i>	Queensland Peppermint	*		
<i>E. eximia</i>	Yellow Bloodwood		*	
<i>E. eugenoides</i>	Thin-leaved Stringybark		*	
<i>E. globulus</i>	Tasmanian Blue Gum		*	*
<i>E. globoidea</i>	White Stringybark		*	
<i>E. goniocalyx</i>	Long-leafed Box			*
<i>E. grandis</i>	Flooded Gum	*		*
<i>E. gummifera</i>	Red Bloodwood		*	
<i>E. haemostoma</i>	Scribbly Gum		*	
<i>E. henryi</i>	Large-leafed Spotted Gum	*		
<i>E. macrorhyncha</i>	Red Stringy bark			*
<i>E. maculata</i>	Spotted Gum	*	*	
<i>E. maidenii</i>	Maidens Gum		*	
<i>E. major</i>	Grey Gum	*		
<i>E. mannifera</i>	Mottled Gum		*	
<i>E. melliodora</i>	Yellow Box	*		*
<i>E. microcorys</i>	Tallowwood	*	*	
<i>E. moluccana</i>	Grey Topped or Grey Box	*	*	
<i>E. nicholii</i>	Narrow-leafed Peppermint	*	*	*
<i>E. obliqua</i>	Messmate		*	*
<i>E. oblonga</i>	Narrow-leafed Stringybark		*	
<i>E. ochrophloia</i>	Yapunyah	*		
<i>E. ovata</i>	Swamp Gum			*
<i>E. paniculata</i>	Grey Ironbark		*	
<i>E. parramattensis</i>	Drooping Red Gum		*	
<i>E. pellita</i>	Large-fruited Red Mahogany	*		
<i>E. pilularis</i>	Blackbutt	*	*	
<i>E. piperita</i>	Sydney Peppermint		*	
<i>E. populnea</i>	Poplar Box	*		
<i>E. propinqua</i>	Small-fruited Grey Gum	*	*	
<i>E. punctata</i>	Grey Gum	*	*	*
<i>E. radiata</i>	Narrow-leafed Peppermint			*
<i>E. resinifera</i>	Red Stringybark	*	*	
<i>E. robusta</i>	Small Mahogany	*	*	*
<i>E. rossii</i>	Scribbly Gum		*	
<i>E. rubida</i>	Candle Bark			*
<i>E. saligna</i>	Sydney Blue Gum	*	*	*
<i>E. scoparia</i>	Wallangarra White Gum		*	
<i>E. seeana</i>	Narrow-leafed Grey Gum	*		
<i>E. sideroxylon</i>	Red Ironbark	*	*	
<i>E. signata</i>	Scribbly Gum	*		
<i>E. tereticornis</i>	Forest Red Gum	*	*	*
<i>E. viminalis</i>	Manna Gum	*	*	*
<i>L. conferta</i>	Brush Box	*		

The koala is also remarkable as its digestive tract exhibits enormous development of the hindgut, including the caecum and in the proximal colon. The caecum is used as a fermentation chamber and with the aid of bacteria breaks down the cellulose. Apart from the enormous size of the hindgut the stomach of the koala also contains a cardio-gastric gland, similar to the wombat, although in the koala it is branched and more complex (Hume, 1982).

At the commencement of weaning, the joey eats semi-liquid faeces (a type of diarrhoea) taken from the rectum of the mother. This substance is called pap and contains viable gut flora and bacteria from the mothers' caecum (Osawa *et al.* 1993). Apart from its nutritional value, this is believed to facilitate inoculation of the alimentary tract of the young animal with symbiotic bacteria enabling it to digest eucalyptus leaves (Lee & Martin, 1988; Osawa *et al.* 1993).

3.6 Longevity

3.6.1 Wild

There are few records of longevity in the wild, although an average age appears to be approximately 12 years. A female tagged on French Island was still breeding at ten years of age and a male at Walkerville, Victoria was estimated to have died at 16 years of age (Lee & Martin, 1988).

In the past, the major causes of mortality appear to have been predation by Aborigines and dingoes and hunting by Europeans for their pelt. Other known natural predator include goannas and the powerful owl (*Ninox strenua*), which takes young weighing less than one kilogram. Bush fires and droughts may also kill koalas. Koalas have no means of escaping fires which sweep through the crowns of eucalypts, and the few that survive these fires have little hope of avoiding starvation before the trees produce epicormic growth. In the early 1980's, a severe drought in central Queensland caused browning and loss of leaves from eucalypts, and resulted in substantial mortality among koalas (Gordon *et al.* 1988).

Other factors that influence longevity include disease, particularly that caused by the bacterium *Chlamydia*, and the rate of wear of the teeth which ultimately results in an inability to masticate sufficient food to meet the animal's nutritional needs.

3.6.2 Captivity

The average longevity in captivity is around 12-14 years for females and 10-12 for males, although a female in San Diego Zoo lived to 18 years and a female at Lone Pine is alive that is 21 years of age. The oldest male at Lone Pine has had is 13 years. In captivity the major causes of death are generally diseases (such as Chlamydia) and tooth wear (Lee & Martin, 1988).

3.6.3. Determination of Age

A method for determining the approximate age of koalas is with the use of tooth wear (Gordon, 1991). This technique provides a useful indication of the relative age of a koala, although there is high variation in the rate of tooth wear between individuals which increases as age increases. As tooth wear is heaviest on the anterior cheek teeth and because of its accessibility, the right upper premolar (P⁴) is selected to determine the Tooth Wear Class and approximate age. A description and figure of the tooth wear classes can be found in Table 2 and Figure 3 respectively.

Table 2. Tooth wear stages and criteria used in age assessment of koalas (Gordon, 1991). The letters in parentheses correspond to the same letters in Figure 3.

Tooth Class	Wear	Mean Age (years)	Age Range (Years)	Tooth Wear Stage
1		1.2	1-2	No dentine exposed on P ⁴ (a)
2		2.0	1-4	P ⁴ spots of wear (b)
3		2.7	2-4	P ⁴ one line of wear (c)
4		4.3	3-6	P ⁴ two lines of wear (d)
5		5.5	3-8	P ⁴ circle of wear (e)
6		7.3	5-10	P ⁴ flat, M ¹ not flat (f-h)
7		9.0	9	M ¹ flat, M ² not flat (g-i)

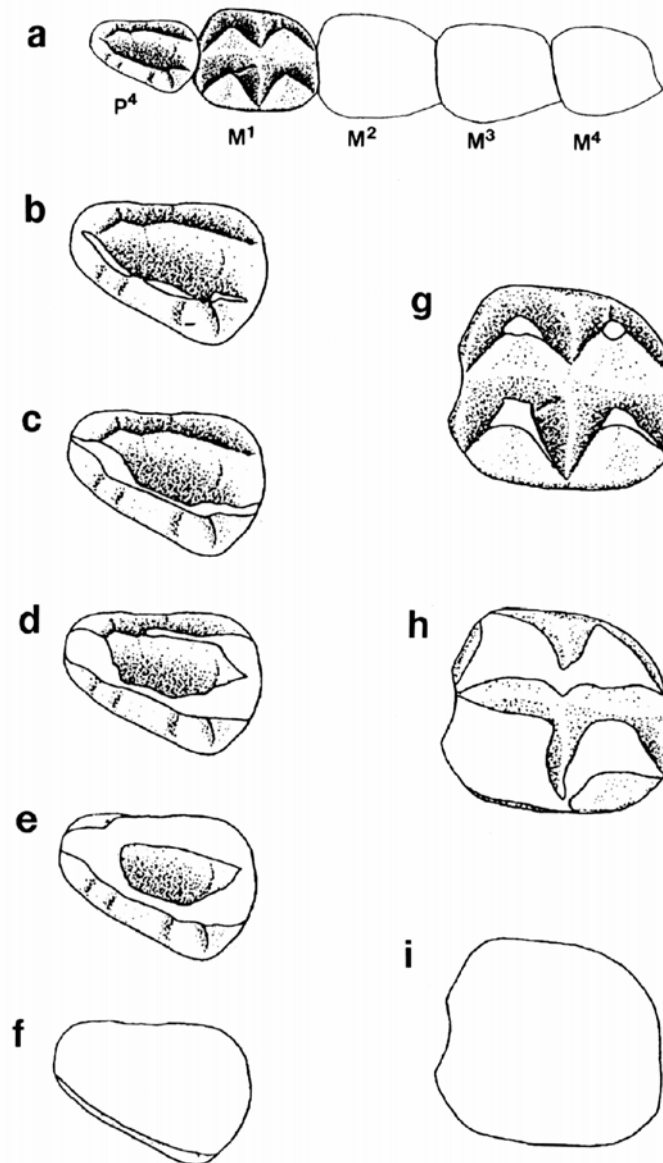


Figure 3. Classes of tooth wear on the upper right premolar (P⁴) from the right upper jaw of Koalas (Gordon, 1991).

4. Housing Requirements

4.1 Exhibit Design

In holding koalas there are a number of general principles that should be followed in order to satisfy minimum conditions for the keeping of animals in captivity. Further details of the standards for exhibiting koalas in New South Wales (Anon, 1997) and Queensland (Anon, 1994) can be found in Appendices 2 and 3 respectively. Conditions include:

- 1) Enclosures shall be constructed of such materials and maintained to ensure all animals are at all times held securely and safely.
- 2) Enclosures can be open, semi-enclosed or totally enclosed design.
- 3) Sufficient shelter must be provided to allow protection from wind, rain, and extremes in temperature and allow sufficient access to shade during the hot periods of the day.
- 4) The size and shape of enclosures shall provide freedom of movement both vertically and horizontally.
- 5) The enclosures shall be well drained and have either a readily cleanable substrate or be of a material which can be replaced to avoid the accumulation of faeces and urine.
- 6) There must be at least two forks per koala not less than 1.8m above the ground and not closer than 0.9m to the next fork.
- 7) All supports and branches shall provide sufficient traction for koalas to climb easily and safely.

Various enclosure designs have been used by institutions to display koalas. These range from a comparatively simple design with a circular or oval wall at least 1.2m high, with a floor that is grassed or made of concrete. Rough barked tree (eg. *E. obliqua*) support should be greater than 3m with 1-2 natural forks for the koalas to sit in an arc spaced 3m approximately apart which encourages the koalas to jump from tree to tree. These can however be joined by lateral branches to facilitate movement from tree to tree without coming to the ground. Areas of enclosures typically range from 30m² to 100m².

At Healesville Sanctuary (Fig. 4) the display area is approximately 50 x 50m and is a large planted exhibit. The koalas are viewed from a large raised wooden walkway, 2m off the ground to bring the viewer closer to the canopy. A small gallery located at the centre point of the walkway contains an interpretive display and serves as a shelter area for the public during adverse weather. A 1.5m sheet metal fence surrounds the display and branches of trees are trimmed from its vicinity to prevent the animals from escaping. The display is furnished with large branching stringy bark perches, each at least 6m high. These are inserted into the ground by trimming the base to fit into terracotta pipes buried in the soil. These perches are replaced approximately every 12 months as they lose their bark and become slippery. The exhibit has 11 perches, each with soil moulded slightly around it to aid in drainage. The rest of the exhibit is grassed and planted with a variety of unpalatable trees and shrubs. The exhibit is watered with the use of a permanent ground sprinkler system, set on a timer, which waters the whole exhibit. Water is also sprayed from a removable bayonet system elevated off the ground on 2m poles that helps keep the foliage fresh on hot windy days.

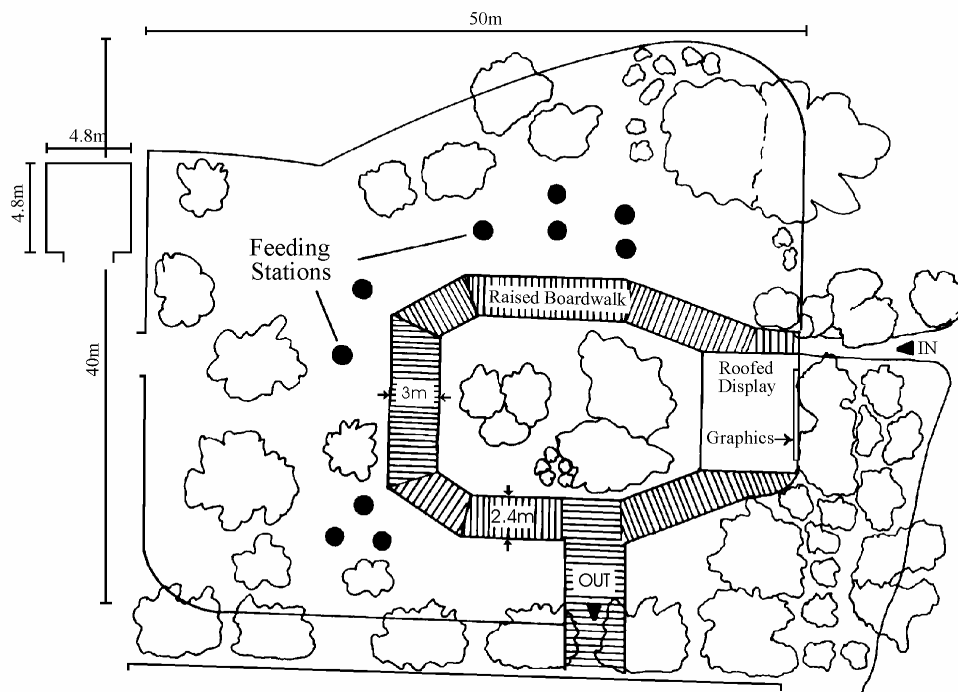
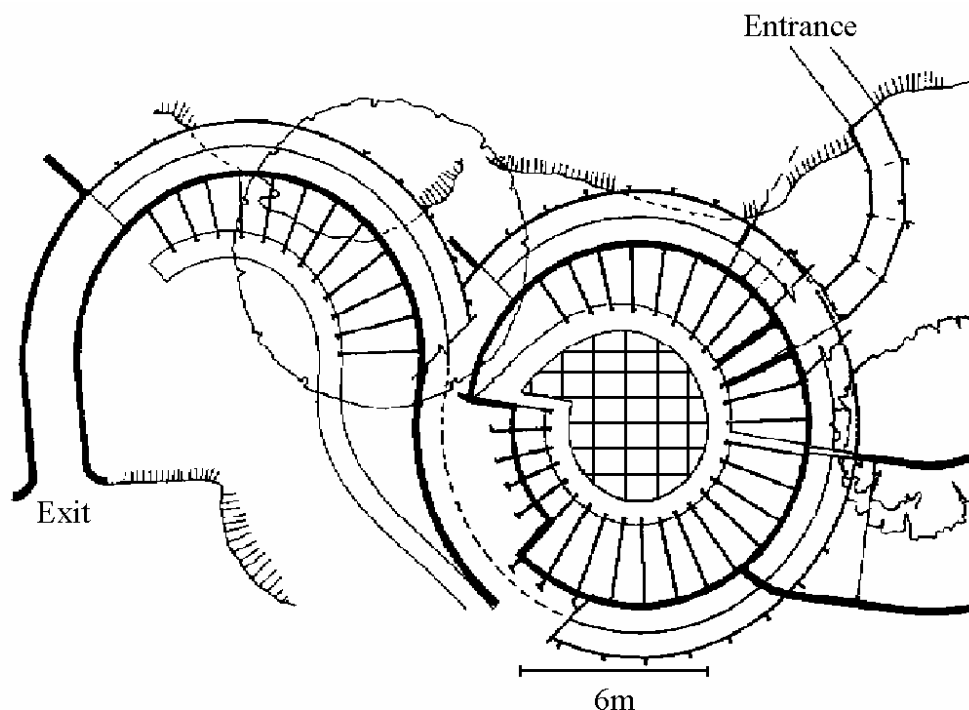


Figure 4. Design of koala display at Healesville Sanctuary (Drake *et al.*, 1991).

The design of the koala exhibit used at Taronga Zoo is a complex helical structure with the public pathway following a loop around the koalas and spiralling up to the canopy of the trees (Fig. 5).

Plan View



Side View

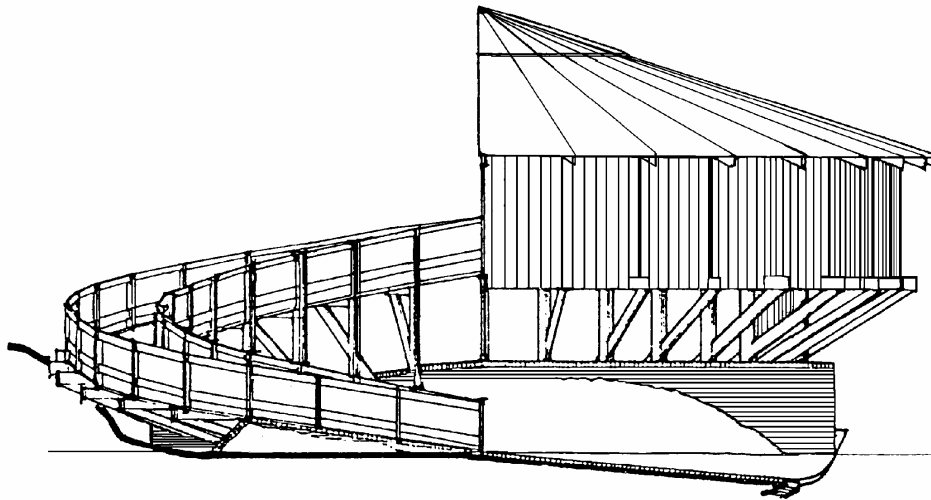


Figure 5. Design of the koala display at Taronga Zoo. The cross hatching in the plan view represents the exhibit area.

4.2 Holding Area Design

Holding areas for koalas need only be of a simple design. They are totally roofed and can be constructed of chain or welded mesh of a size to ensure that koalas are not able to get any part of their body stuck. An area of at least 2 x 2 x 2m with several forks and cross branches is adequate for 1-2 koalas. A cement floor, well drained to a good size sump with a grate is the easiest way to maintain off exhibit koalas on a long-term basis, as there is not the need to replace dolerite substrates regularly. The floor is swept, hosed and scrubbed daily to remove any algal growth and ensure a safe and hygienic floor.

4.3 Position of Enclosures

The position of an exhibit is important particularly in regard to aspect, because the koalas need to be provided with sufficient shelter from wind, rain, extreme heat and provide the opportunity of warming themselves during cold weather. Shelter can be provided in the form of partial or total overhead coverage, by carefully placing the branches of eucalypts and by planting shady trees within the enclosure.

4.4 Weather Protection/Heating

The trees in the exhibit can be placed in a compact arrangement to help insulate the animals against the cold (Drake, 1982). No heating is required for koalas unless they are held at temperatures are constantly low (0°C or less), where they may need to be held indoors with a source of heating.

4.5 Substrate

The base of the enclosure can be made of any number of materials from a smooth surfaced concrete to various types of soil such as dolerite. Dolerite is easily raked and drains well, leaving a dry, compacted and attractive surface. In display exhibits it is

better to use soil as it is more aesthetically pleasing while off exhibit holding enclosures are easily maintained with smooth finished concrete. The base of the enclosure must drain readily to ensure that in the event of rain, the koalas are able to move between trees without having to wade through water.

4.6 Enclosure Furnishings

In an exhibit one trunk should be supplied for each koala that contains 2-3 forks that are no less than 1.8m from the ground. This should also contain a leaf pot for each individual as this will allow plenty of room to move and reduce the incidence of aggressive encounters, particularly during the breeding season. The tree trunk should be very sturdy with a base diameter of approximately 20-30cm with rough bark (eg iron bark species) to assist in the climbing mobility of the koalas. Cross branches can also be supplied to link each of the tree trunks, assist the females to escape from male aggressive behaviour. These may not be required if the trees are placed reasonably closely together with limbs from adjacent trees that come within 1-2m of each other as the koalas will be able to jump from one tree to another. If the koalas are unable to jump from one tree to another they will readily come to the ground to go from tree to tree. Using only vertical branches is particularly advisable for display animals, as it is aesthetically better than branches tied horizontally between vertical trunks.

Ideally a garden and other trees should also surround the exhibit to provide additional shade from the sun, shelter from the wind and rain, and reduce the appearance of the enclosure looking like a round pit. Shade trees should be watered regularly and may need the protection of metal guards to prevent the koalas climbing them. Although the metal guards can be painted brown so they are more aesthetically pleasing, they can look unsightly. As the tree grows the metal will need to be checked so that the tree doesn't grow over it and buckle the sheet of metal. Depending on the size and position of the shade trees it may be adequate to let the koalas climb in them if they wish, particularly as this may voluntarily bring them closer to the public. Care should be taken so that the trees surrounding the exhibit do not allow the animals to escape because they will make use of any overhanging limbs, and even fern fronds if given the opportunity. As a general rule, a 1.8m gap should stop any koalas from escaping.

Generally koala branches are long lasting, however they will need to be replaced when the surfaces of the trunk begin to wear smooth, which is usually every 12 months. Depending on the size and accessibility of the trunks and exhibit a crane may be required to lift out and then place new trunks which may be 6+ metres high and 40-60+ centimetres in diameter.

In off-exhibit holding facilities three vertical branches 2-3m in height can be erected with cross branches between them so they make a triangle is adequate for 1-2 koalas. In holding enclosures the vertical branches and cross branches generally requires very little maintenance and is seldom renewed. When new branches are required they can be replaced more readily and merely lifted and tied into position. Forks of branches should be 5-10cm in diameter each with an attachment for a leaf pot if required.

5. Handling and Transport

5.1 Timing of Capture and Handling

Animals should be observed daily and physically checked monthly or more regularly in the case of sick or injured animals. The best time to capture animals for examination is in the morning when the temperature is cooler. This is particularly important during warmer weather. In exhibits with tall trees it may be more convenient to capture the animals when they are fed in the afternoon as they will often come down from the higher branches to feed. This is not recommended in hot weather as the koalas are unlikely to come down to feed in the heat anyway.

5.2 Catching Bags

These should be made of thick cotton or good quality hessian. The opening of the bag should be wide with a diameter of approximately 45-60cm and have a depth of approximately 60-90cm.

5.3 Capture and Restraint Techniques

Koalas can generally be coaxed down a branch with the use of a long rod or broom. The rods are usually 3-4 metres long with hessian sack or rag attached to the end. The rustling of large plastic bags also works very well. The sack or rag is waved just above the head of the koala which should begin to descend the tree. The bag is kept slightly above the head of the koala as it descends. When the koala is within reach unconditioned animals can generally be coaxed down further by placing your hand firmly on its head and pushing it gradually down the branch and into a catching bag. Koalas can also be removed from a tree by putting the catching bag over the animal's head (which helps to calm the animal) and then push edge of the bag over the back toward the rump, and finally unhook the feet (Fig. 6).

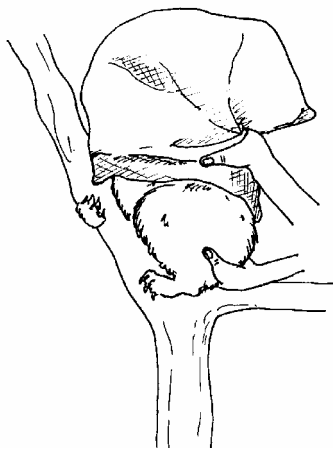


Figure 6. Restraint of a koala using a catching bag. Drawing by B. Macreadie.

An alternative to catching a koala in a catching bag is to lift it off the tree by holding its wrists firmly from behind. In this way it may be safely carried facing away, at arms length, or effectively restrained by pressing it to the floor or table for closer examination. An alternative way of carrying a koala is to grasp the fur of the neck with one hand and the fur of the rump with the other (Fig. 7).



Figure 7. Restraint technique for a koala. Drawing by B. Macreadie.

Another method of removing a koala from a tree is to use a noose which is slung around the neck on one side and under the armpit on the other side. The noose is tightened and the animal pulled from the tree. This is not the preferred method as it is very stressful for the koala and when trying to position the noose the koala may climb up the tree and out of reach.

Although koalas appear to be docile and cute, they can be both agile and aggressive if disturbed. Their teeth and claws are very strong and sharp, and when handled, they will tend to grab at anything within their reach. Care needs to be taken to avoid being scratched or bitten.

Koalas are best restrained for examination by placing them in a hessian sack and firmly holding them on the ground. This usually requires one person to hold the forearms, another to hold the hind legs and the third to do the examination. Cover the head (unless examining the face) and bring out of the bag only the parts required for examination at any one time, eg. ear for ear tag identification, leg, or arm for examination. When done this way the animal is more easily restrained and the claws are kept under control from scratching. Be careful that you know where the mouth is while in the sac as if given the chance they will bite hard through the sac.

Young can be examined by holding the mother on the ground or on a bench while in a hessian sack exposing the lower half the mother for examination (therefore the head and upper arms are held firmly in the sack). While one person is keeping the forearms under control, a second is holding the legs down, allowing a third person to open the pouch to check for pouch young. If required, measurements can be taken of the pouch young to estimate its age and to chart its growth.

If an animal has been hand-raised and is accustomed to handling they can generally be carried on the body with the arms gripping your shirt and the rump supported so that the koala doesn't need to hold as strongly to your clothing. It is often advisable to wear a jumper when carrying a koala in this way as their claws will easily go through a shirt, particularly if the koala becomes frightened. Young animals can be easily held by giving them a large stuffed toy or teddy to hold onto.

5.4 Weighing and Examination

During an examination, the animal should be weighed by placing them in a hessian sack and weighing them with either hanging spring scales, usually 5kg, 10kg or 20kg, or preferably on electronic scales as they are more accurate. If using spring scales use the same set every time to reduce the differences between scales. The stomach should be checked to make sure it isn't too hard which may indicate a build up of gas, and the skin should be pinched to test for dehydration. The pouch should be examined to check for any pouch young and the body checked for any wounds. Although the nails of koalas are generally quite long they usually do not require trimming as they must be sharp to climb trees efficiently.

5.5 Release

Release from a hessian sack is best effected with the opening of the sac facing the base of the tree trunk 1-3m away. When the koala leaves the sac it should run straight to the tree, although it may choose another trunk.

Animals being held are best released by standing next to the tree you wish them to go to, ideally at a fork, and moving the koalas arm closest to the tree from your shirt or jumper to the tree. Then move the other arm across to the tree while at the same time lifting the bottom over to the tree. Often the koala will begin moving itself onto the branch by leaning over to the branch and reaching out either before or after the first arm has been moved across. If this occurs keep supporting the bottom and carefully lift the koala over to the branch or fork.

5.6 Transport

The conditions for the transport of koalas have been formulated to maximise the welfare of koalas involved in overseas transactions. The conditions set by Environment Australia provide the framework for the transport of koalas. A full list of the conditions for the overseas transfer of koalas can be obtained from the Environment Australia Conditions for the overseas Transfer of Koalas (See Appendix 4).

5.6.1 Box Design

Each koala should be transported in a solid framed cage with inside measurements of 1000mm (length) by 820mm (breadth) by 1040mm (height). The cages must have removable, leak proof metal drop trays fitted at the base. Sides and top must be of stout wire mesh and fitted with light hessian or shade cloth covers.

5.6.2 Furnishings

At least 1-2 fork branches are required so the koala is able to sit during its transportation. These need to be securely fixed to the box to prevent them becoming dislodged during handling and shipment.

5.6.3 Water and Food

Although koalas generally don't drink, a stable dish of water should be placed in the box. Three or four shortened branches of tips should also be placed in a modified shortened leaf pot that is filled with water. Depending on the length of the flight, the leaves may need to be changed at least once during the flight.

5.6.4 Animals Per Box

One koala per box. Females are not permitted to be transported if they are carrying young.

5.6.5 Timing of Transportation

Overnight is preferable as it is cooler.

5.6.6 Release from Box

When releasing the koala from the box, the box should be placed in the exhibit next to the base of a tree. The door to the box should be completely opened or removed and the animal allowed to leave the box when it feels ready, therefore giving the koala the opportunity to explore its surroundings and climb a tree at its leisure. When the animal is up a tree the box can be removed from the enclosure. Alternately the animal can be lifted out of the box by an experienced handler and placed onto a tree or next to a tree and then allowed to climb the tree.

5.7 Koala Handling and Photographing

It is imperative that koalas are chosen based on their temperament and is conditioned from weaning for handling. It is also important that constant attention is paid to the koalas, particularly if being held by the visitor, to assess the level of stress in each animal. In New South Wales and Victoria koalas are not permitted to be placed on visitors so that they can hold them, while in Queensland they are permitted to be held by the public, although strict guidelines have been set by the QWPA (Appendix 3).

5.7.1 Signs of Stress (derived from Booth, 1989).

Although it is not recommended that koalas are used for handling or photography, the signs of stress when undertaking this should be monitored at all times. These include:

- 1) Will not sit in branch, keeps coming to the ground and walking around.
- 2) Completely flaccid and tractable.
- 3) Often urinating and defecating.
- 4) Continuous ear flicking.
- 5) Signs of anxiety in the koala include hiccups, a low whining vocalisation, and a typical alarm posture (wide eyes, ears forward, spine very vertical).

5.7.2 Minimising Stress During Handling (derived from Booth, 1989).

Stress can be minimised during handling or photographic sessions by:

- 1) Only use koalas with suitable temperaments.
- 2) Captive bred koalas are obviously the best. Even better if hand raised.
- 3) There is no difference in males and females with respect to temperament.
- 4) Responsible and experienced supervisors that will respond to the koalas needs even when it is busy.
- 5) Minimal restraint gives best cooperation.
- 6) Close monitoring of individual koalas' time spent in photo sessions.
- 7) Reposition tourist, not koala, for photo.
- 8) Monitoring of body weight of koalas and giving individuals "holidays" whenever a drop or insufficient gain is noted.

6. General Husbandry

6.1 Hygiene and Cleaning

All enclosures should be cleaned daily. Soil substrates should be raked daily and concrete substrates should be hosed daily to remove all faecal matter. All faecal material should be removed from the tree trunks as necessary. All feed pots should be emptied and refilled daily to keep the water fresh. Drinking water dishes should be cleaned and refilled daily. When a koala permanently leaves an enclosure with a concrete floor, the floor should be thoroughly disinfected and scrubbed in preparation for the next arrival.

6.2 Record Keeping

Accurate records should be kept for all individuals to assist in the documentation of previous illness's and breeding events. To assist in record keeping, all koalas should be individually identifiable. There should be comprehensive record-keeping, including details of veterinary examinations and treatments, movements of koalas between enclosures, weighing, aggressive encounters, breeding details such as matings, pouch examinations, observation of pouch young and pap feeding. Acquisitions and disposal of koalas should also be added (Meikle, 1990). Following the death of a koala post mortem reports are required.

When new establishments seek to exhibit koalas they may be required to maintain additional records on diet to provide an index of appetite and feed preference. This precaution may be necessary because of local and seasonal differences in digestibility and palatability of leaves. Because of the changes to the palatability of leaves, new exhibitors may be required to demonstrate access to adequate fresh supplies of leaves from at least three species of koala food trees in their local region that are considered most favoured.

6.3 Identification

Each animal should be individually identified with a separate record card for each specimen. There are several methods used to identify koalas for maintaining records.

6.3.1 Ear Tags

These are probably the most used form of identification in koalas. Large coloured eartags are generally effective in determining individuals without catching them, although these are often hidden by the fur on the ears particularly in the Victorian koalas.

6.3.2 Passive Integrated Transponder Tags

These can be implanted between the shoulder blades.

6.3.3 Facial Features

Generally koalas have quite distinctive faces which can be readily distinguished from each other with practice. Potentially a photo could be taken of their faces and kept for record.

7. Health Requirements

7.1 Daily Health Checks

Animals should be observed daily for any signs of injury or illness. The most appropriate time to do this is generally each morning when the enclosure is being cleaned and in the afternoon when the branches are replaced, which is often in conjunction with a koala talk and when the koalas are often more active. During these times, each animal within the enclosure should be checked for evidence of:

- Coat should be checked to make sure it is in good condition.
- Discharges from the nose, eyes or cloaca should be noted.
- Wrinkles on the nose, suggesting dehydration should be examined.
- Dirt around the mouth suggesting dirt eating.
- Appetite should be good.
- Demeanour changes.
- Climbing ability using of all four limbs.
- Wetness of the cloaca and rump.
- Injuries.
- Presence and development of pouch young.

Koalas can be prone to infestations of large numbers of ticks, particularly around their ears. Ticks cause irritation and mild to severe anaemia which can be life threatening and should be removed whenever animals are in reach (Speilman pers. comm.).

During the summer months koalas should be checked for signs of heat stress which include lethargy, and the presence of loose, very dry skin on the nose (Drake, 1982). Heat stress tends to occur at temperatures of approximately 30°C or higher, so they need to be checked regularly when these high temperatures for signs of stress. Heat stress can be reduced in hot weather by placing a sprinkler where it will spray the trees of approximately one-third of the enclosure (Drake, 1982). The sprinklers can be left on day or night if required. During winter, the main concerns include the provision of adequate shelter from the wind and rain. This can be aided by placing gum trees in a compact arrangement to help insulate the animals against the cold (Drake, 1982).

The faeces should be checked for the numbers of pellets dropped (normally between 100-150), particularly in the case of sick animals and animals that are solitary (as it is difficult to know how many each individual has produced if there are a number of animals in an enclosure). The consistency of the faeces should also be noted to see if there is any diarrhoea or soft faeces. Although the presence of runny faeces can indicate potential problems, very high quality leaves also cause it, particularly after a period when the leaf quality has not been optimal.

It is important for consistency that the same keepers regularly inspect and weigh the koalas as they are more able to determine the subtle changes in the health of individuals. This includes behavioural changes, which may indicate the presence of a health-related problem.

At Currumbin Sanctuary, koalas over 12 months of age are given an annual veterinary examination for disease screening of the collection and to ensure optimal health. This detailed examination involves both a visual assessment and a detailed physical

examination including blood sampling for *Chlamydia*, *Cryptococcus*, haematology and biochemistry.

7.2 Detailed Physical Examination

Very placid animals that are used to handling and human intervention may be examined conscious. For short, non invasive procedures where no analgesia is required (e.g. radiographic positioning), Diazepam at 0.5-1 mg/kg IM or 0.5 mg/kg IV can be employed. In most cases gaseous anaesthesia via mask induction and maintenance with Isoflourane and oxygen is used. The animal is induced on 4-5% and maintained on 1.5-2% Isoflourane.

The physical examination may include the following:

- General Body Condition Assessment
 - ⇒ Body Condition - is best assessed by muscle palpation in the area over the scapula spine and temporal fossa. A standardised condition score (1-10) based on muscle mass in this region is used. When present subcutaneous fat deposits are relatively small so that a koalas ribs will always feel prominent irrespective of whether the animal is robust or emaciated.
- Temperature- Rectal temperature can be taken through the cloaca (35.5-36.5°C).
- Weight - is recorded and compared to the previous weights recorded
- Pulse Rate - Taken over the femoral artery (65-90 per minute)
- Respiratory Rate - Normally 10-15 per minute but panting (rapid, shallow breathing with the mouth closed) is normal in stressed or excited animals.
- Lymph Nodes - The inguinal, axillary and facial are palpable in normal koalas.
- Fur - Check for alopecia, ectoparasites, fungal infections, trauma or evidence of fighting.
- Limbs - check paws and claws. Particularly treat nail infections seriously.
- Eyes.
 - ⇒ Should be clear, bright and alert.
 - ⇒ Normal bilateral pupillary light response.
 - ⇒ Normal corneal reflex.
 - ⇒ Discharge if any.
- Nose and nostrils - should be clean. If discharges are present then swab for *Chlamydia* and *Cryptococcus* and other pathogens.
- Ears.
 - ⇒ Check pinnae for signs of fighting.
 - ⇒ Confirm identity via ear tag
 - ⇒ Use otoscope to check external ear down to external acoustic meatus
- Mouth.
 - ⇒ Check lips, check pouches.
 - ⇒ Check for any abnormal swellings.
 - ⇒ Mucous membrane colour.
- Abdominal Palpation - to assess gut fill.
- Abdominal Auscultation should reveal occasional peristaltic sounds
- Thoracic Auscultation of ventral and ventrolateral aspects of thorax usually yields clearest sounds.

- Tooth Wear - Very important to check wear because in an old koala it may be the primary cause of debility. Concentrate examination on the upper premolar and first molar. Various classes of tooth wear have been categorised.
- Cloaca.
 - ⇒ Should be clean.
 - ⇒ Check for presence of cystitis which may be associated with stained, wet, matted fur around the cloaca.
 - ⇒ Check for faeces around the cloaca. This may indicate diarrhoea or improper perches are present.
- Faecal Sample Collection - Olive to khaki and tapered slightly at each end. The average koala will pass 100 - 150 pellets a day. If joined together by strands of undigested fibre then check teeth wear. A qualitative faecal flotation test is performed.
- Pouch check.
 - ⇒ Condition of the pouch
 - ⇒ Check whether lactation is occurring
 - ⇒ If pouch young present, estimate age & correlate with breeding records, sex and condition.
- Males.
 - ⇒ check two testicles - size, shape and consistency.
 - ⇒ extrude penis and check.
 - ⇒ check the size and activity of the sternal gland.
 - ⇒ check with the keeper on whether showing mating behaviour eg calling, presence of erection.
- Blood sampling - can be taken from quiet conscious animal with arm extended from a hessian sack. Cephalic vein used for collection or placement of indwelling catheters. The femoral vein is an alternative for blood sampling not catheterisation.
- Urine Sampling - May occasionally be red due to possible by product of Eucalypt leaf digestion. Should not be confused with haematuria

7.3 Major Diseases

7.3.1 Chlamydia

Chlamydia is a genus of bacteria that is responsible for reproductive diseases in a range of mammals (Handasyde *et al.*, 1988). Two agents have now been classified *C. pecorum* and *C. pneumoniae* with both species causing an ocular and urogenital disease (Glassick *et al.* 1997). *C. pecorum* appears to be more prevalent and more virulent than *C. pneumoniae*, and combined infections suggest that cross-immunity does not occur (Booth & Blanshard 1999). These bacteria have been isolated from ovarian diverticula, ovaries, uterine tubes, uteri, median and lateral vaginae, urinary bladder, renal pelvis, penile urethra, urogenital canal, nasal septum and rectum (Brown & Woolcock, 1988). They have also been implicated in a number of signs of disease including infertility, rhinitis, pneumonia, urinary cystitis, nephritis, cystic ovary, conjunctivitis and keratoconjunctivitis. These are often associated with the "wet bottom" or "dirty tail" syndrome. (Brown & Woolcock, 1988).

7.3.1.1 Infection

Koalas are often infested with a fur mite (*Koalachirus perkinsi*) which could act as a source of infection and play a role in the transmission of *Chlamydia* (Brown & Woolcock, 1988). As koalas harbour *Chlamydia* in the upper respiratory tract and the

lower intestinal tract, transmission may also occur by aerosol spread or faecal contamination. As pouch young undergo coprophagia at commencement of weaning, transmission via this route is possible (Brown & Woolcock, 1988). The most common route of transmission is venereally, as *Chlamydia* is found in the penile urethra as well as the urogenital canal of the female. It is possible that *Chlamydia* is present in all koalas, so that it is difficult to prove transmission (Booth, 1991).

7.3.1.2 Clinical Signs

Chlamydiosis in koalas can be present in three main syndromes (Booth & Blanshard 1999).

- 1) Keratoconjunctivitis – In chronic cases it is seen as a purulent discharge from both eyes. In severe cases there can be inflammation of the conjunctiva (delicate membranes that line the inside of the eyelids and covers the front of the eye) with keratitis (inflammation of the cornea) and occasionally inflammation of the entire tissues of the eye (panophthalmitis). Koalas affected by this syndrome often fall prey to dogs due to vision impairment.
- 2) Urogenital Tract Disease – This syndrome generally results in a severe inflammation of the urinary bladder (cystitis), and sometimes can include the urinary tract. This can be seen by a constant urine dribbling and generally results in a red brown stain on the fur of the rump (hence the name dirty tail or wet bottom). Koalas with this condition often become weak, lose their appetite and may die from malnutrition.
- 3) Reproductive tract disease – In females one or both of the ovarian bursae (a bursa is a small sac filled with fluid) may distend with inflammatory exudate due to the inflammation of the drainage point. Although the ovaries themselves are not cystic, this causes effective infertility. This syndrome is usually associated with a chronic low grade cystitis (an inflammation of the urinary bladder).

7.3.1.3 Precautions

Chlamydia are infectious organisms for koalas and strict quarantine procedures need to be enforced where captive colonies of koalas are concerned. Outbreaks of conjunctivitis, rhinitis or cystitis in captive koalas can spread quickly, and koalas in contact with infected animals are at risk (Brown & Woolcock, 1988). Lack of information concerning the source of infection, the mode of transmission and the possible vectors of *Chlamydia* in koalas compound any attempt to manage chlamydial diseases in both captive and wild populations. Strict quarantine procedures adopted in many captive colonies have been effective in controlling the spread of disease within these colonies (Brown & Woolcock, 1988). Any animals new to the collection should be tested for *Chlamydia* and if positive should be kept isolated from "chlamydia free" koalas.

There are a number of ways to test for *Chlamydia* (Booth & Blanshard, 1999). These include:

- 1) The presence of advanced cysts (detected by palpation) in the anterolateral region of the epipubic bones.
- 2) Radiography with negative contrast (pneumoperitoneum) or ultrasonography that may detect reproductive tract anomalies.
- 3) Cell culture.
- 4) Analysis of conjunctival or urogenital swabs to detect chlamydial DNA by polymerase chain reaction.

- 5) Antibody enzyme-linked immunoabsorbent assay (ELISA) with rabbit anti-koala immunoglobulin G (IgG) conjugated to horseradish peroxidase.
- 6) Antigen ELISA. Clearview (Unipath Ltd.) is the most sensitive.
- 7) Antigen detection through direct immunofluorescence. Chlamydia-Cel Vet IF Test (Cellabs Diagnostics) and Imagine Chlamydia Test Kit (Boots-Celltech Diagnostics). These are generally less sensitive than the ELISA kits.
- 8) Histopathology using Giemsa or Macchiavello stains. These can be improved using immunologic stains.

7.3.1.4 Treatment

Early diagnosis and initiation of therapy are important in the success of treatment. Chronic cases often don't respond well to treatment and recurrence of clinical signs after treatment is common (Booth & Blanshard, 1999). A number of antimicrobials have been used to treat conjunctivitis and/or cystitis in koalas. Treatment with fluoroquinolones and tetracyclines supplementary feeding to minimise weight loss associated with anorexia have been successful.

At present there is no confirmed successful treatment for chlamydial disease in koalas. In captivity a number of animals which tested positive to *Chlamydia* have not shown signs of the disease. It appears that the level of stress may be critical in the establishment of disease in koalas. Therefore stress should be minimised in order to reduce the potential for the disease to occur.

7.3.2 Other Diseases

Other diseases found in koalas include septicemia, tubulointerstitial nephrosis, neoplasia, cystic ovaries, cystic uterine tubes, pulmonary diseases, nephritis and cystitis, ophthalmia and conjunctivitis, gastritis, enteritis, osteitis, osteosarcoma, dermoid cysts, rhinitis, pneumonia, necrobacillosis of the jaw; salmonellosis and cryptococcosis (Brown & Woolcock, 1988; Finnie, 1988a; Booth & Blanshard, 1999).

7.4 Stress

It has been suggested that stress may be immunosuppressive and increase the risk of infections and the likelihood of overt disease such as chlamydia. Stresses including handling, disruption of feeding times, disruption of sleeping times, overcrowding, separation of the sexes, controlled mating and controlled weaning.

Sick or injured animals are notoriously difficult to treat (Finnie, 1988a). Treatment of a seriously ill koala is difficult because the animal generally does not eat, no matter how good the treatment, causing death from malnutrition. In an attempt to overcome this, stress should be kept to a minimum and it may be necessary to hand feed or use multi vitamin B therapy to stimulate the appetite.

7.5 Changes in Body Weight

Trends in body weight of koalas give a good general indication of the animals state of health, provided age, sex and geographical location are taken into account. Animals in captivity should be weighed at least monthly to gain an indication of trends in body weight. This may range from monthly for healthy animals to several times a week for sick or injured animals. Fluctuations of up to 400g (in Victorian animals) may result from variable gut fill. However if a consistent decline in weight occurs, a vet should be

consulted, and supplementary feeding may be required (eg. daily doses of Prosobee, Portagen or Triglyde) (Handasyde *et al.*, 1988).

7.6 Quarantine Requirements

The quarantine protocol for koalas is primarily aimed at preventing the introduction of chlamydia. Secondly it is good protocol to follow to prevent the introduction of other diseases to the collection. Thirdly it establishes comprehensive baseline parameters for each individual animal.

7.6.1 Imported Animals

Before entering stock facilities, all imported koalas should have the following checks (in priority order):

1. Thorough clinical examination including a full clinical history if available. The following should be noted - weight, ID, age, pouch check, physical abnormalities, teeth condition.
2. Clearview chlamydia antigen test from a conjunctival swab.
3. Blood samples taken for body function (blood cell count and biochemistry) and chlamydia antibody serology (EDTA ½ ml minimum, 2 x Serum gel tube 2 ml minimum).
4. Blood sample taken for cryptococcus antigen serology (Serum gel tube 2 ml minimum).
5. Faecal flotation.
6. Blood sample taken for lead levels (Lithium Heparin 2 ml minimum).
7. Cryptococcus interdental swab.
8. Check for Trovan ID and implant one if not present.
9. Ear tag.

All animals should be held in off-limits quarantine until all serology results are returned negative, and should be monitored daily by keepers. All animals should be checked and cleared by a veterinarian prior to introduction to stock facilities. All imports should be considered infective until proven otherwise. All handling of animals and their used feed is to be carried out by one person. Used feed is to be taken directly to the compactor and when carried on a trolley or electric cart be wrapped in plastic. Gloves, coat and rubber boots should be worn while handling quarantined koalas and their feed. These items of protective clothing are to remain at the off limits quarantine area. A footbath of disinfectant renewed at intervals of 24 hours may be used instead of rubber boots. Keepers hands and forearms should be scrubbed with hibitane or iodine scrub after boots, gloves and coat have been removed in that order.

7.6.2 Accession Koalas

Accession koalas are to be quarantined from all stock animals and should be assumed to be infective until proven otherwise. Animals should be relocated as soon as practical after response to treatment. Accession koalas are only to be handled by the veterinary staff and these staff should handle no stock koalas. Where it is necessary for a member of staff to handle more than one class of animal, the order of treatment should be:

- Stock.
- Imports.
- Accession animals.
- Trauma cases.
- Medical cases.

- Chlamydia cases.

Staff handling these animals should wear disposable gloves and protective clothing. Gloves should be changed after each treatment and handlers must scrub hands and forearms with hibitane or iodine scrub after treatments are completed. Non-disposable protective clothing will be soaked in Avisafe prior to washing. Soles of boots should be sprayed with Avisafe. Releasable koalas cannot be introduced to stock. Any koala that dies must be autopsied and a written post mortem reported forwarded to the relevant authority within 30 days.

Accession koalas should be subjected to the following:

- Full clinical examination under anaesthesia, including radiographs if indicated.
- Full haematology and biochemistry.
- Serology for chlamydia and cryptococcus.
- Samples required for diagnosis of the condition/s.
- Blood lead levels.
- Ear tagging.
- Gum palatability records.

7.6.3 Quarantine Facilities

Cages are to be cleaned with Avisafe at least once weekly and should be spelled for as long as possible between animals. Where an animal is found to be a chlamydia carrier, the facility should be cleaned thoroughly with Avisafe and aired / sunned for at least seven days. All in contact animals should be quarantined for a further 30 days and re-tested.

7.6.4 Clean up after Positive Chlamydia Results

Koala forks which were in use by koalas with only antibody response to Chlamydia and with negative swabs, can be disinfected by thoroughly drenching with Microcide at anti-viral concentration (20 mls per litre). Contaminated forks from positive swab enclosures are to be removed either by taking to the dump or incinerating. All enclosure support beams, furniture, walls and hard floors should be saturated with Microcide at anti-viral concentrations. Once a movable cage has been disinfected, it should be moved to another site. The exposed soil should be sprayed with Avisafe and allowed to dry out. Sand around koala forks should be raked into bags and removed. After underlying material has dried out, spray with Microcide then apply new sand around all the forks.

All staff involved in the clean up procedure should wear protective clothing consisting of overalls, rubber boots and disposable gloves. A facemask and protective goggles should be worn during disinfectant spraying for personal protection. All protective clothing should be taken to the hospital for cleaning and disinfection or disposal after use.

8. Behaviour

8.1 Daily Activity Cycle

Koalas generally rest and sleep in the forks of trees, but are occasionally found stretched along a branch. On hot days the limbs are extended and often lie free on either side of the trunk. The animal may recline along the limb and the head is held free of the chest, exposing the belly. On cold, wet and windy days they sit with their backs to the wind, with their arms folded against the chest and legs drawn against the belly. These changes in posture have an important role in temperature regulation (Lee & Martin, 1988).

The vocalisations of koalas are diverse. Calls include the bellow, which is primarily used by the males, although females do occasionally bellow as well. Bellowing may be used by the males to attract mates in sparse populations and as a warning to other koalas in the area. Fighting males often use a harsh grunt. Other vocalisations include repeated squeaks of joeys that may serve to attract the mother's attention. The wails, squawk, low grunt, snarls and screams of females probably serve as a defensive threat (Smith, 1980a; Lee & Martin, 1988).

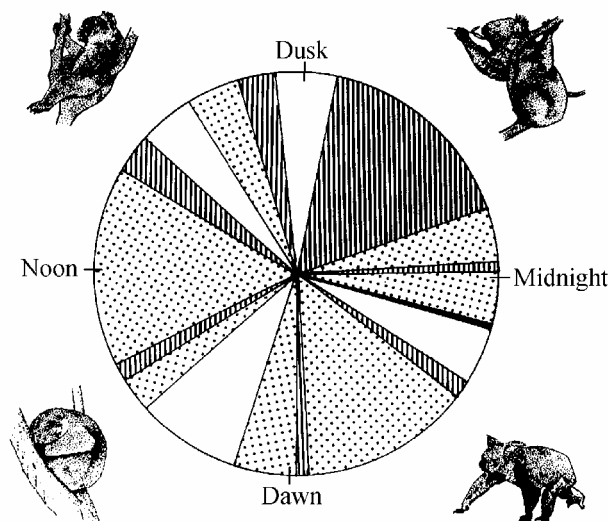


Figure 8. The daily cycle of activity of a koala. Vertical hatched areas signify periods of feeding; stippled areas, periods of sleeping; unshaded areas, periods of resting; and areas shaded black, periods moving between trees (Lee & Martin, 1988).

It has been consistently shown that koalas spend approximately 18-20 hours of each day resting or asleep, one to three hours spent feeding and the remaining time spent moving between branches or trees, grooming or in social behaviour (Fig. 8). Feeding episodes normally last from 20 minutes to two hours in duration with four to six of these bouts per day. Feeding can occur at any time of the day or night, however there is a tendency for koalas to feed immediately before or after dusk or dawn (Lee & Martin, 1988).

8.2 Aggression

There appears to be a dominance hierarchy among male koalas with an obvious dominant or alpha male in a given area. During the breeding season this tends to

become more pronounced with many aggressive encounters between males. The dominant male is usually the one that mates the most females, and vocalisations occur both before and after mating (Lee & Martin, 1988).

Encounters between males are sometimes aggressive, particularly during the breeding season. In these encounters, one animal (usually the one entering the tree) rushes up to attack the second animal. The second animal either retreats to the end of the branch, or races past the attacker and out of the tree. Sometimes the animal at the end of the branch tries to leave the tree, but is chased back by the attacker who is sitting on the same branch. If the attacker manages to reach the other animal, it thrusts one arm around its shoulders and grasps the elbow with its teeth (often causing deep wounds), so holding the second animal, or even pulling it from the tree. If the attacked animal leaves the tree, it is usually only chased a few metres before the attacker returns to the tree, where it often bellows and marks the trunk with secretions of the sternal gland. On occasions the resident male may quietly retreat to the end of a branch as the intruder enters the tree, and the resident is ignored by the intruder.

When adult males approach and enter trees occupied by females, the females often give low snarls or weak bellows, and sometimes retreat. As the male comes closer, the calls become louder and longer. If the male attacks he would attempt to hold the female between himself and the branch, sometimes even upside down, grasping the fur of the females head and neck with his teeth. When the female is in the right position, mating commences. The usual response of the females is to struggle away from the male, striking or biting his neck and squawking and screaming loudly. After such an attack, the male usually backs down the tree, bellowing as he goes. If one of the alpha males hears the sound of an attempted mating nearby, he immediately leaves his tree and approaches the sound, sometimes running. If the lower ranked male is still in the tree with the female, he is immediately attacked and evicted from the tree. The alpha male then remains in the tree occupied by the female and sometimes stays nearby for several hours.

8.3 Animal Introductions

Animal introductions are normally done first thing in the morning to minimise any public reaction during aggressive confrontations, and allow the whole day for animals to be observed before being left together overnight. After the introduction of a new animal into an enclosure it should be watched to check for any agonistic behaviour, which should decrease as the new animal works out its place amongst the group. If the aggression continues after several hours the new animal should be removed.

8.4 Behavioural Enrichment

Koalas generally don't display stereotypic behaviour as they don't have the energy to spare sleeping 18-20 hours per day. Some individuals will pace near the keeper entrance prior to the set feed times. Movement of individual koalas can be maximised and conflict minimised by ensuring adequate forks for feeding and resting and a number of cross branches.

8.5 Interspecific Compatibility

Koalas have been exhibited with other species including echidnas *Tachyglossus aculeatus*, pademelons *Thylogale* spp., quokkas *Setonix brachyurus*, parma wallabies

Macropus parma, various species of lizards and large birds such as magpie geese *Anseranus semipalmata*. They could potentially be displayed with other small macropods such as bettongs *Bettongia* sp. and potoroos *Potorous* sp. Wombats are generally not compatible with koalas as they have been known to cause injuries by biting koalas. If these species are used they should be supplied with a soil or grass substrate and provided with adequate hiding places with the addition of tussocks. They would also have to be given adequate ground space so they can move around freely in the exhibit. With the exception of the echidna, these species are generally nocturnal and would probably not be seen regularly by the public.

9. Captive Dietary Requirements

9.1 Species of Eucalypts Preferred

To ensure that the koalas held by an institution is kept in good physical condition it is important to ensure that the diet is varied and of high quality. A koala typically eats between 400 - 1000g (approximately 10% of its body weight) of eucalypts per day (Hawkes, 1978). Koalas show a definite preference toward some eucalypt species with some being highly preferred, others eaten occasionally, while others are rarely if ever eaten. Of more than 800 species of gum trees (which now include three genera *Eucalyptus*, *Corymbia* and *Angophera*), approximately 50 species have been recorded as having been eaten by koalas at some time. Each koala's choice varies according to locality and season. In captivity only a few species of eucalypts are suitable as staple foods (Table 1).

The staple browse species include *E. tereticornis*, *E. camaldulensis*, *E. microcorys*, (coastal NSW and Queensland), *E. punctata* (central coastal NSW) and *E. viminalis*, *E. viminalis* and *E. globulus* (Victoria and South Australia) (Hawkes, 1978). Taronga Zoo feeds three species which form the basis of the food supply; *E. punctata*, *E. tereticornis*, *E. camaldulensis*, and a variety of others to provide seasonal variations e.g. *E. viminalis*, *E. micocorys*, *E. obliqua*. At Melbourne Zoo the koalas are regularly fed foliage from six species of Eucalypts listed in order of preference: *E. viminalis*, *E. ovata*, *E. goniocalyx*, *E. radiata*, *E. obliqua* and *E. botryoides*. *E. camaldulensis* foliage also being provided when available and is readily accepted (Drake *et al.*, 1991).

9.2 Choice of Eucalypt Branches to Be Cut

Part of the skill of successfully maintaining koalas involves the knowledge of which species of gum is the most appropriate to feed at different times of the year. The factors that appear to be involved in the palatability of the different species of eucalypts include the level of eucalyptol, content of phenols, the content of cyanide precursors, and the fibre content of the leaves. Winter is considered the time of greatest nutritional stress on koalas as at this time there are very few, if any, new growth available, with most of the leaves being quite fibrous. It is important at this time to supply as wide a choice of species available as possible.

Depending on the species and time of year, branches should be chosen that possess mature leaves, especially new tips, avoiding juvenile foliage as they are often rejected and may contain cyanogenetic glycoside that releases cyanide into the gut (this is particularly found in Manna Gum *E. viminalis* in winter). Juvenile foliage (foliage

from young trees as opposed to new growth on old trees) and new coppice growth of *E. viminalis* and *E. goniocalyx* are avoided as they are always rejected by koalas (Drake *et al.*, 1991). Some species of eucalypts are almost wholly eaten, adult leaves included, while others have only the new growth is eaten. Branches cut are normally at least one metre long and contain as much fresh new growth as possible. The diameter of the branches cut is generally around 2-5cm and is best cut at an angle of 45° to facilitate maximum coppice regrowth.

The frequency of leaf collection varies from one or two times per week to every day. A minimum of 3-4 species of gum is collected each trip and the gum should be kept out of direct sun and wind (particularly during summer) to prevent dehydration of the tips. An outline of the protocols for leaf collection in Queensland is outlined in Appendix 3.

9.3 Storage of Leaves

The leaves should be stored for a maximum of one week or until the condition of the leaves has deteriorated. They should be stored in clean water (changed at most weekly) either in a refrigerated unit at 4-5°C, or in an enclosed shaded area with an overhead sprinkler system. The leaves can therefore be kept wet, by a fine mist of water spray, and prevented from drying out particularly in hot dry weather. The tips can also brown very quickly making them unpalatable for the koalas. The leaves should be stored in large bins that are approximately 60-80cm high with a diameter of around 60cm. Plastic pots work well as they won't rust and are easy to clean. It is important to clean these pots weekly to remove the build up of any algae and other rubbish in the water. Other containers such as troughs with partitioning can also be used.

9.4 Feeding of Leaves

A surplus of food should always be fed. Generally at least three branches, of at least two species should be placed in long thin pots (approximately 15cm in diameter and 60-70cm long) that are filled with water. However sometimes only one species can be fed depending on availability and preference. The provision of different species of eucalypt leaves allows the koalas to always have at least two species that they will eat. All branches should be free was foreign material such as dirt, insects and bird droppings. All browse should be fed out as fresh as possible, with no obvious signs of wilting. The branches should be positioned so that all tips are within easy access for the koalas.

These pots are connected to the tree trunk just below the tree forks so the koala can sit in the tree fork and feel secure while feeding. The leaf pots should be rinsed and refilled daily with water prior to the new leaves being added. The leaf pots should be placed in the shade to minimise desiccation of the leaves. There should be at least one leaf pot per individual that are spread out amongst various branch forks in the exhibit to reduce fighting of the koalas over food.

The leaf pots are usually, and are generally made of either plastic or stainless steel. The plastic pots are lighter, however they are not as good for wear and tear, particularly as the bottoms often fall out if they are dropped. The metal containers are a lot stronger however they are heavier to handle. The pots can be attached to the trunk by drilling a hole at the top of the leaf pot and attaching it to a bolt that has been screwed into the tree trunk. A second method used to attach the pots to the trunk consists of an arm with

an elbow which is connected to the tree with the use of a sleeve (Fig. 9). The height of the leaf pot is usually with the top of the pot approximately 1200 mm off the ground. This is so it is at a height that is convenient to manage as well as meeting the koalas needs for access.

The uneaten leaves in each enclosure should be changed daily. This is best done in the afternoon to stop them from drying out during the day. This is particularly important during hot weather and as the koalas generally won't eat the leaves until it is dark. Some institutions change the leaves in the morning and in the afternoon. In this case the morning feed is minimal due to the koalas general inactivity during the day.

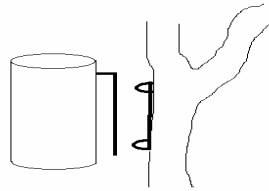


Figure 9. The koala leaf pot and its attachment to the tree trunk. Not drawn to scale.

Although most koalas rarely drink, fresh drinking water should be available at all times especially when sick.

9.5 Eucalypt Plantations

The maintenance of captive koalas increasingly requires the establishment of plantation grown trees as the native eucalypt stands are often inadequate, or in the case of overseas zoos not available, particularly as koalas require a number of species. In order to establish a plantation, the size of the population to be fed and the daily requirements will need to be established. For each koala there needs to be approximately 1000 trees planted (made up of at least 5-6 preferred species) approximately 4-6 years ahead of acquiring koalas. A brief outline is covered below for the establishment of a plantation. A more detailed description can be found in Hawkes (1978), and Congreve and Betts (1978) with a more recent outline being detailed in Appendix 5.

When first considering a plantation a number of aspects regarding the plantation will need to be considered. These include the location of the plantation, tenure, accessibility, construction of capital improvements, harvesting regime and other factors regarding the future management of the plantation.

Once planted, the area should be left untouched until the young trees are about 8-10 metres high and have a closed canopy. This occurs at about 4-7 years of age depending on the species and the site. At this stage, coppicing a proportion of the stems, approximately 20% of the stand, would allow continuing growth on the crowns of the more vigorous browse trees and provide for manipulation of the stocking of browse trees. When collecting branches it is important for the long-term management of the plantation not to over crop or coppice individual trees. If over-cutting is occurring, more trees should be planted. Eucalypt plantations are usually established for forestry

purposes with one tree per 4m square, giving an initial stocking of 625 trees per hectare. After treatment this stocking will be reduced to 500 plants per hectare. Ingrowth from the coppiced stumps will replace those stems removed with the effect of introducing a second age class into the plantation (Hawkes, 1978).

If all the coppices are removed from a stump, foliage can generally be harvested from *E.viminalis* and *E.goniocalyx* at intervals of 12 to 14 months (Drake *et al.*, 1991). Some species such as *E.ovata* can be harvested every six to eight months because the koalas do not reject juvenile leaves and regrowth is rapid (Drake *et al.*, 1991).

9.6 Artificial Diets

The use of an artificial diet has been tested with koalas in the form of a thin flexible biscuit and a thick paste (Pahl & Hume, 1991). The moisture, nitrogen and fibre contents of the biscuits are similar to those observed in leaves preferred by koalas. Using dry weights, the biscuit cell-wall content is 24%, cellulose content 16%, lignin content 3%, ash content 6%, nitrogen content of 1.9% and a moisture content of 62%. The biscuit form of the artificial diet is 2 x 15 x 60mm in size (Pahl & Hume, 1991). The thick paste consists of "Presbo" powder, a constant amount of ground *Eucalyptus* foliage, and water. The biscuits are always dipped into the paste by hand prior to presentation to the koalas, but the paste is also administered orally with a syringe (Pahl & Hume, 1991). Although the use of artificial diets in conjunction with fresh foliage is able to sustain the weight of koalas for a limited period of time, it is very time consuming and the koalas appear to become less willing to eat artificial diets after an extended period of time.

9.8. Supplementary Milk Diets for Aged and Sick Koalas.

As koalas age (particularly over approximately 10 years of age) their teeth become quite worn so the cutting edge is less, resulting in less efficient grinding of the food which in turn results in larger particles to digest, less efficient digestion and ill-health due to malnutrition (Lanyon & Sanson, 1986; Gamble & Blyde, 1992). To assist the nutrition of old koalas with worn teeth or sick koalas, supplementary feeding using an artificial milk diet can be of use in improving the chances of recovery (Osawa & Carrick, 1990). Portagen (28g powder/100ml water) or a mixture of Portagen (14g powder/100ml water) and Infasoy (14g powder/100ml water) offered twice per day (Gamble & Blyde, 1992) has been used successfully by initially force-feeding using a syringe, although after two to three days the animals readily accept the milk substitute. Other alternative supplements include a mixture of 50/50 Prosobee/Portagen (14g powder/100ml), and BioActive (14g powder per 100ml water). Vytrate (as a hydration fluid) has also been offered in case the koala is thirsty, although they sometimes will not readily accept it (Phillips & Johnson, 1994). Supplementary feeding can be of great use in maintaining sick or old koalas that have unweaned young, as it provides additional nutrition to compensate for the increased energetic demands during lactation and alleviate the need to hand-rear a koala.

9.7 Vitamin and Mineral Supplement

None suggested.

10. Breeding

10.1 Breeding System

In the wild, the koala is normally territorial polygyny, with a male having more than one partner, during a single breeding season. There is strong evidence of sneaky mating by sub-ordinate males (Johnson pers. comm).

10.2 Ease of Breeding

Koalas breed readily in captivity.

10.3 Age at First Breeding

10.3.1 Males

Males are capable of reproducing at 18 months of age, but most are prevented from gaining access to females by older and larger males in the wild (Martin & Handasyde, 1991). It appears that wild male koalas may do little mating in the wild before they are fully physically mature at four or five years of age. In captivity males as young as 16 months have been observed attempting to mate mount, and have successfully produced young at 18 months of age (Thompson, 1987).

10.3.2 Females

Females occasionally have their first young when about 18 months of age in the wild (though births have been observed in a female from 12 months in captivity (O'Callaghan 1996)), when they approach adult size, but this young rarely survives pouch life. Most females breed first towards the end of their second year/beginning of their third year in the wild and may produce one young each year up until 10-15 years of age (Gall, 1980; Thompson, 1987).

10.4 Ability to Breed Every Year

Males are able to breed every year. The largest number of matings observed in a season is eight, although the libido of the males generally drops after four or five matings in captivity (O'Callaghan 1996).

Females are able to breed every year. A female cycles typically 51 days after the first mating of one cycle and the next if she failed to give birth. A female will only mate once during the cycle regardless of whether the mating was successful and will cycle up to five times in a breeding season (O'Callaghan 1996).

10.5 Timing of Breeding

They have a distinct breeding season.

Northern Australia

Mating Period: July-April (O'Callaghan 1996).

Birth Period: August-May (O'Callaghan 1996).

Southern Australia.

Mating period: September - February (Lee & Martin, 1988).

Birth Period: October - April (Lee & Martin, 1988).

North America

Mating Season: March – May. (Thompson, 1987).

10.6 Ability to Breed More Than Once Per Year.

They can only raise one young per year.

10.7 Oestrous Cycle

The koala is unusual amongst marsupials in that ovulation appears to be induced by the physical act of coitus (Johnson pers. comm.). The average length of the oestrous cycle is about 35 days (Handasyde, 1986). Previous estimates of oestrous cycle length have been based on non-mated presumably anovular oestrous cycles which had a duration cycle of approximately 33 days (Johnson pers. comm.). Females are polyoestrous, with oestrous being determined on the basis of behavioural clues including, an increase in activity, jerking or convulsive movements (this involves the female clinging vertically to a tree and then jerking the whole body, less often the upper part alone, vigorously about once per second), a decrease in appetite, weight loss, bellowing vocalisations and occasionally make-like mounting behaviour (Smith, 1980c; Thompson, 1987). This behaviour normally lasts from one day to two weeks and normally stops once copulation has occurred (Thompson, 1987).

10.8 Breeding Strategy

In the wild, koalas are generally a solitary species. Females have home ranges of approximately one hectare with some overlap with the ranges of males and other females, and the occasional sharing of trees. Males also have home ranges that overlap with other males and females. Some males, usually the older and larger males, have home ranges of about 1.5ha, while smaller males have home ranges that are similar in size to those of females. It has been suggested that koalas might defend some type of territory against other koalas, although there is no evidence for this to date (Lee & Martin, 1988; Lee, 1988; Martin & Handasyde, 1991).

10.9 Reproductive Behaviour

The beginning of the breeding season is heralded by an increase in the frequency of bellowing by males (Lee, 1988). Male koalas scent mark trees by grasping the tree trunk and rubbing their chest (containing the sternal gland) up and down against the base of the tree trunk and branches as they climb. The second mode of scent marking involves the use of urine, with both sexes occasionally urinating on the trunk or on the ground close to the tree. The use of scent marking may help to establish the dominance of the male and the reproductive status of the female (Smith, 1980b; Lee, 1988).

Loud bellowing is used by both sexes of koalas, especially by males during the breeding season. The use of vocalisations and scent marking appears to be involved in the spatial separation of mature males and in the competition for mates. There is a strong selection for larger and more vigorous males as they are able to exclude other males from mating.

During the breeding season dominant males become active at dusk and move from tree to tree, checking the status of females and fighting with and excluding satellite males from access to oestrus females. Dominant animals stay close to and repeatedly mate with females in oestrous. These activities generally decline as summer progresses and are not observed during the cold months (Lee & Martin, 1988; Lee, 1988; Martin & Handasyde, 1991).

10.10 Breeding Methods

There are three major types of breeding system or methods that can be used (O'Callaghan & Blanshard, 1991). Each has its advantages and disadvantages with respect to convenience, knowing the paternity of offspring and hence avoiding inbreeding. In

some species inbreeding has been found to result in male-biased sex ratios, decrease in survivorship and/or growth rate, and evidence to date suggests that in some areas in the wild, such as on several islands, koalas are highly inbred, resulting in malformation of the testes in males.

10.10.1 Selective Breeding Method

This method of breeding involves placing a single male and female koala together. This system appears to be most effective when the male and female koalas are kept separate and placed together when the female is in oestrous (O' Callaghan & Blanshard, no date).

10.10.2 Harem Breeding Method

This system involves a single male being placed in with a group of female koalas. This system allows the paternity of any offspring to be established for a number of females. Care needs to be taken not to let any particular male over breed otherwise a loss of genetic variation can occur over the long term.

10.10.3 Random Breeding Method

This method involves placing a number of male and female koalas into the one enclosure. This is not as good as selective breeding as there is little control over which animals mate. Paternity of most of the young will not be known, particularly as many matings will be unobserved (O' Callaghan & Blanshard, no date). Determining the pedigree is therefore almost impossible except with the use of expensive techniques such as DNA fingerprinting (profiling).

Female koalas housed in an enclosure with several males often get little rest during the breeding season as they are repeatedly harassed by different males. This can result in trauma and/or mortality of pouch young if present. Another disadvantage is that sub-adult females can be overpowered and mated, and give birth at a small size and weight (O' Callaghan & Blanshard, no date).

10.10.4 Breeding Group Sex Ratio

Generally a single male is placed with one or more females as discussed with the Selective and Harem Breeding Methods. This is so the paternity of the young is known and to avoid fighting by males trying to achieve alpha status and mating rights. Lactating and non-lactating females are normally separated to avoid accidental adoption of young by non-lactating females. Some females who have had their young removed for hand-rearing are often found with the young of other females, seemingly in an attempt to replace the loss of their own.

10.10.5 Aggression

Generally mature males are separated from each other to reduce aggressive interactions. This is particularly important during the breeding season, although if adequately separated and depending on the nature of the individuals, 2-3 male koalas can be housed together for significant lengths of time.

10.11 Mating Site

Mating takes place in the branches of the trees. Sometimes specific enclosures are used for the mating and then the animals are moved back to their previous enclosure.

10.12 Gestation Period

33 -36 days (Handasyde, 1986).

10.13 Number of Young Born

Approximately 65-70% of adult females breed per year in the wild, each producing a single young, although very rarely two young may be produced. In captivity 50-70% of females breed each year depending their age, with conception rate decreasing once over seven years old where it reduces to 20 for females over 13 years of age (O'Callaghan 1996). It is presumed that the female is unable to rear two young at the same time successfully to independence (Lee & Martin, 1988; Lee, 1988; Martin & Handasyde, 1991).

10.14 Number of Young Surviving

Koalas have an approximately 70-90% juvenile survival rate in captivity, however this does vary with age as it is lowest for females 9-10 years old and highest for animals 11-12 years old (O'Callaghan, 1996). The time of highest pouch young mortality is in the first three months of life, before it is obvious from the physical appearance of the pouch that it contains a joey, so some joey losses may go undetected (O'Callaghan, 1996). If the young is lost, the female has a 70% chance of losing any subsequent joys (O'Callaghan, 1996). More recent information on koalas in south eastern Australia found survival rates for dependent young are 86-96% for the period from birth to permanent pouch emergence and 88-100% for the period from first permanent emergence to the completion of weaning (Martin & Handasyde, 1991).

A number of practices can be implemented to reduce the death rate of koalas (O'Callaghan, 1996). These include: 1) separation of males away from females as they can increase the level of stress in the female and dislodge the joey while trying to mate, 2) grouping females with same age young together as some joeys can die when the joey climbs onto a female that is not lactating or has a very small pouch young, 3) isolating females with pouch young so that neither the mother or pouch young are interfered with by other koalas, 4) pouch observation by feeling the young from inside or outside of the pouch to determine approximate size and growth rate of joeys, and checking to make sure the pouch is moist and not wet or contain yeasts or bacteria, 5) observation of young looking for ruffled fur, head tilt, eyes, and 6) transferring pouch or back young, if the mother dies, to another female that is lactating.

10.15 Pouch Checking

The pouches of the females should be checked regularly and this can be achieved by systematically checking pouches by inserting an index finger into the pouch from between the animals hind legs whilst she is walking along a branch (Drake, 1982). This method is gentler and is less traumatic than if the female has to be caught.

10.16 Growth and Development

Young are 0.5g and 19mm long when born (Lee & Martin, 1988; Lee, 1988; Martin & Handasyde, 1991). This neonate bears a strong superficial appearance to those of other marsupials. The forelimbs, shoulders and lips are well developed, and the digits are equipped with deciduous claws. By contrast, the toes of the hind limbs are buds.

The relationship of head length versus age in days, until the head length is around 120mm and 600-700 days can be found in Figure 10. It should be noted that this figure

uses koalas from French Island (Victorian koalas), therefore the average weights will be greater than those expected for both New South Wales and, in particular Queensland koalas at the same stage of development. Thompson (1987) examine the relationship between age and weight for Queensland Koalas, while Blanshard (1990) examines the relationship between head length and age.

Development of pouch young is very slow with them young remaining in the pouch for 5-6 months and relying only on the mothers' milk. When the joey is approximately five months of age the female produces a second type of faeces (known as pap) which the joey eats over several days up to a week. This is to introduce the appropriate gut flora and bacteria into the developing juveniles' stomach and caecum so that it can begin to digest the eucalyptus leaves and begin to be weaned from the mother (Table 3). The joey commences eating eucalypts at 5-6 months of age and will progressively consume greater amounts of leaf until it is weaned at around 11-12 months after birth.

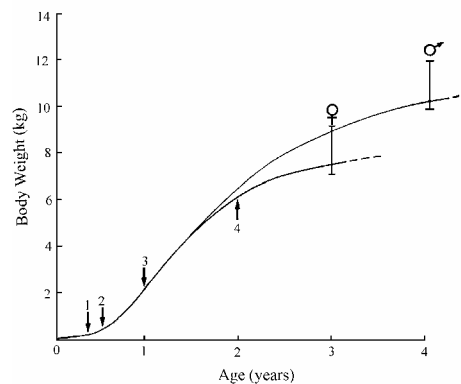


Figure 10. Growth in body weight of males and females on French Island, Victoria. Numbers indicate when the head first appears out of the pouch (1), permanent vacation from the pouch (2), independence of the mother (3), earliest reproduction in females (4). Vertical bars indicate the range in body weight. Males continue to grow until at least 4 years of age (Lee & Martin, 1988).

Table 3. Timetable of major developmental stages in juvenile koalas. Derived from Smith (1975), Thompson (1987) and Blanshard (1990).

Stage of Development	Age Range
Head out of pouch	162-203
First total emergence	166-224
Maternal faeces eaten	171-213
First total emergence	175-182
Eucalypt leaves eaten	192-232
First seen off mother	214-275

10.17 Weaning Weight and Age

The joey at commencement of weaning onto *Eucalyptus* is approximately 900-1000g (NSW subspecies) and would be 5-6 months of age. The adult male should be removed when the female is first observed to have a pouch young. The young koala should be removed from the female when independent to avoid metabolic drain and prolonged lactation, and to allow the female time to recover condition before giving birth again.

10.18 Age at Dispersal

The joey remains with its mother until about 12 months of age, at which time it weighs approximately two kilograms. If another young is born about this time the bond between the yearling and mother abruptly breaks down. Yearlings attempting to suckle are treated aggressively by their mother, and although often found in the same tree as the mother, they are no longer tolerated on her back. Yearlings are sometimes found with a surrogate mother, an adult female without a back young, and even occasionally with a male courting the mother.

Yearlings usually stay in the general vicinity of the mother for another year. Some females settle in a home range nearby to the mother. These females may be mated by their father in subsequent breeding seasons. Young males usually disperse from their mothers' home range at about two years of age and may roam for the next two or three years before settling.

11. Artificial Rearing of Koalas.

11.1 Initial Strategy

When the koala first arrives:

- Minimise handling.
- Have it examined by a vet.
- Get a history of it.
- Take an initial body weight and measurements.
- Estimate its age.
- Do not attempt to feed it until warm as it may aspirate milk.
- Organise bedding or a hot box.
- Organise the appropriate diet.

11.2 Housing

As with all native mammals that have been taken into care, minimising stress is a major consideration. Choosing suitable housing can help to create a stress free environment. To achieve this, several factors should be considered including:

- Is the area secure from children and animals?
- Is the area easy to maintain in a hygienic manner?
- Is the area escape proof?
- Is the area clear of obstacles and hazards?
- Does the area offer shelter from the weather and noise?

For joeys under 6-7 months of age, an artificial pouch is needed which simulates, as closely as possible, the security and warmth of a natural pouch. Natural fibre products such as wool and cotton are recommended as they retain temperature better and have a decreased chance of causing rubbing sores. A basket or rack sack with suitable heating, clean pouches and blankets, and the provision of a soft toy for the joey to hold onto provide an ideal environment. It is also easy to transport. At Healesville sanctuary a hotbox is used which has a 25 watt lamp underneath the base that maintains an even temperature. The joey is placed on its toy and then into a pouch made of a sewn up windcheater, with woolly inlays/blankets. The pouch is changed when soiled.

The use of a soft toy as a substitute for the mother koala has been found to be very successful. From the onset of hand raising the joey, it is placed onto the soft toy, which it clings to eagerly. This eliminates the need for the handraiser to constantly carry the koala joey with them as the soft toy offers companionship and warmth. The soft toy also makes the introduction of the koala into new environments less stressful as the soft toy can go as well. Even when hand raised koalas are fully grown they often readily accept climbing onto the soft toy which makes it easy to carry them.

When the joey gets older, two thick barked branches should be placed in an upright position, making sure the branches have a good fork in them at approximately chest high for the koala to sit. A horizontal branch connecting the two uprights will create a good climbing structure. By 12 months of age the koala should be in an outdoor enclosure with various climbing structures.

11.3 Health and Hygiene

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

- 1) Clean pouch lining at all times. Older joeys can be trained to urinate on newspaper by keeping a piece of newspaper with the smell of urine on it. The joey is placed on the paper while it is clinging to the toy. Slowly turn the toy until the koalas' bottom is touching the paper. They usually place their rear legs on the paper, urinate and jump back on their toy.
- 2) Personal hygiene – wash and disinfect hands before and after handling the joey. Use antibacterial solution for washing hands with furless joeys as their immune system is not well developed.
- 3) Wash hands between feeding different joeys.
- 4) Boiled water should be used when making up formulas for very young joeys.
- 5) Spilt milk formula, faeces and urine should be cleaned from the joeys skin and fur as soon as possible, then dried.
- 6) All feeding equipment should be soaked in suitable disinfectant such as Halasept or Milton.
- 7) Only heat up milk once, then discard leftovers.
- 8) Contact with other animals should be avoided unless you are sure they pose no health risk.
- 9) Stimulate to toilet before or after feeding.
- 10) If furless, cover the joeys body with Sorbolene cream after each feed until fur appears.
- 11) Use a new liner for joey pouch after each feed.
- 12) The water of leaf pots should be changed daily.

11.4 Temperature Requirements

For furless joeys, special attention needs to be made to maintain a constant temperature, and be monitored from underneath the joey. A temperature of approximately 32-35°C should be maintained which can be achieved with the use of a heating pad or hot water bottle. Furred joeys can be given a heat pad in an upright position in a corner of their basket which will allow the joey to move to and from the heat source to adjust its own temperature. By 8-9 months of age heating should only be needed at night and by 11 months of age should be completely weaned from heating.

11.5 Diet

There are many formulas available to feed young koalas. These include:

- 1) Wombaroo – as per manufacturers instructions. The age of the koala will determine which strength milk to use.
- 2) Biolac – as per manufacturers instructions.
- 3) Divetalact – 16g per 100ml of water.
- 4) Portagen – 28g per 100ml of water.
- 5) Portagen and Farex – 1 tablespoon of Portagen and 2 tablespoon of Farex per 100ml of water.
- 6) If these ingredients are unavailable, a milk formula made from evaporated milk, boiled water and glucose is adequate for the short term. This is made with one part evaporated milk to two parts water and 10% glucose.

When a young koala comes into care it is important to assess the age of the koala and whether or not it has consumed pap already. Generally if a young koala has started eating leaves, it is assumed that it has already eaten pap from its mother. A way of determining if a koala has consumed leaves (and therefore pap) is by checking for brown staining on the erupted cheek teeth or plant cell walls in faecal smears.

If the joey has not consumed pap prior to acquisition it is important that at about six months of age it is offered substitute pap. This can be done by collecting pap from a female koala with a pouch young of similar age. If pap is not available, then collect fresh faeces from an adult koala and mix it into a slurry. Offer the joey as much as it wants over a four week period. It can also be included in the milk for bottle feeds.

When the joey starts to eat leaves for the first time, they often need the carer to sit and hand feed them, as they do not move about searching for leaves by themselves. Normally they would come into contact with leaves as their mother moves about.

11.6 Feeding Routine

The milk formula should be heated until it is warm to touch (not too hot that it burn the mouth of the joey). The milk is given to the joey with the use of a plastic bottle and a rubber teat. Each day approximately 10-20% of the bodyweight of the individual should be given 24-hour period (or the amount specified on the Wombaroo chart for a joey of that age). This amount is divided up into the number of feeds given per day. Care needs to be taken not to over feed Wombaroo as diarrhoea can occur. Initially only one person should feed and handle the koala. Once settled, two people can be used if required.

Feeding is initially required every three hours regardless of the age of the joey, until the animal is well established. Once the joey has been established and is feeding well the time between feeds can be increased if the joey is over 180 days old (Table 4). The number of feeds should also be varied depending on the health and keenness of the joey. For example, a poor feeder may require more frequent small feeds than an animal that feeds well of the same age.

Table 4. The number of feeds per day for different aged koala joeys.

Age (days)	Number of Feeds
90 – 180	8
180 – 270	6

270 – 300
300 - 365

4
2*

*Reduce slowly to two feeds and then one feed depending on the quantity of eucalypt leaves eaten.

As the joey begins to start eating eucalypt leaves, the quantity of Wombaroo will remain the same but the number of feeds will vary depending on how much leaves have been eaten. During more advanced stages of leaf eating (300-365 days), when the joey is eating a lot of leaves (or should be), it is important to make sure they get a good milk feed in the morning and at night. This should encourage them to eat the majority of eucalyptus leaves during the day. Hand raised joeys are often fed on milk for slightly longer than a parent raised animal to ensure they can cope with any extra stresses and have a good bodyweight before weaning.

Each animal should have its own chart that includes:

- Animals sex, age on arrival, history, accession number and diet.
- The amount of food offered and taken at each feed.
- Production of urine.
- Production of faeces and its consistency.
- Other notes eg. fed well, fed poorly, active, or lethargic.
- When pap or faeces was offered.
- Species of leaves offered and eaten.
- Changes to the environment. Eg. spending more time on perches.

For very young koalas a small syringe with a tapered piece of rubber attached to the end works well at providing adequate food. As the joey grows, a catheter tip syringe can be used. Alternatively a plastic bottle and koala teat can be used.

Newly acquired koala joeys take a while to get used to being fed, so during this adjustment period it is often necessary to wrap the joey in a clean cloth, with only its head exposed. Joeys often feed better initially if their eyes are covered, as it removes the fear and distraction of the carer. This technique tends to make the feeding process lot easier.

Koalas appear to gain a taste for the milk formulas as they are 'weaned' onto it. Hand-raised juvenile koalas appear to be able to digest leaves without trouble even though they appear not to have had access to the soft faeces from their mother (Finnie, 1988b). Soft faeces or pap is a different type of faeces produced by the female when her joey is approximately 6 months old. The joey eats these faeces and it is suggested that they provide the joey with the adequate bacteria for it to starting the weaning process and be able to digest eucalyptus leaves.

When deciding on a feeding regime for the koala joey several things need to be considered.

- 1) Read and understand the manufacturers guidelines for making the milk formula.
- 2) How much the animal can comfortably consume in one feed.
- 3) How old is the joey.
- 4) Is it eating leaves yet.
- 5) Is it dehydrated and need more frequent fluid intake.

11.7 Weighing

The animal should be weighed daily initially to ensure weight gain. Once fully furred and approaching weaning it can be weighed every 2-3 days to ensure they are continuing to gain weight. If there is a failure to gain weight or a change in the rate of gain this should be investigated by a veterinarian and the diet investigated if necessary.

11.8 Weaning.

At approximately 6–6½ months of age, after the consumption of pap, the joey should be feeding on eucalyptus leaves. The joey should be given the fresh light green tips of leaves from at least three species of eucalypt per day. The leaves should be placed in leaf pots filled with water to keep them fresh. Make sure the leaf pots always have browse in them as juvenile koalas may fall into them and get stuck.

The joey should be completely weaned by approximately 11-12 months of age. Often the koala will start to refuse the formula anyway at this time and start weaning itself. The basic rule is to decrease the milk content as the leaf intake increases.

11.9 Rehabilitation Procedures.

When it is getting closer to the release stage start collecting leaves from the future release site so the koala is familiar with those species of leave.

11.10 Legalities of Hand Rearing Koalas

There are stringent laws relating to the koalas in each state. The relevant state authority should be contacted prior to any koala being hand reared.

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13. References

- * Anon. (1994) Recommended Minimum Standards for Exhibiting Fauna in Queensland. Part A. Koalas *Phascolarctos cinereus*. Queensland Wildlife Parks Association, Brisbane.
- * Anon. (1997) Standards for Exhibiting Koalas (*Phascolarctos cinereus*) in New South Wales. NSW Agriculture, Orange.
- * Australian Nature Conservation Agency (no date) *Draft - Conditions for the Overseas Transfer of Koalas*, ANCA, Canberra.
- * Blanshard, W.H. (1990) Growth and development of the koala from birth to weaning. Pp 193-202. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- Booth, R. (1989) *The Effects of Handling on Koalas*. Lone Pine Koala Sanctuary, Queensland. ASZK Proceedings. Melbourne Zoo and Healesville Sanctuary.
- Booth, R. (1991) Husbandry, handling, anaesthesia and common diseases of Australian native mammals. Pp. 8-38. In Blood, D.C. (ed) *Diseases of Exotic and Zoo Animals*. Recent Advance Series. Seminars for Veterinarians. Melbourne Zoo, Parkville.
- * Booth, R.J. & Blanshard, W.H. (1999) Diseases in koalas. Pp. 321-33. In M.E. Fowler & R.E. Miller (eds) *Zoo and Wild Animal Medicine*. W.B. Saunders, Philadelphia.
- * Brown, S. & Woolcock, J. (1988) Epidemiology and control of chlamydial disease in koalas. pp 495-502, in *Australian Wildlife. The John Keep Refresher Course for Veterinarians, Proceedings 104*. Post Graduate Committee in Veterinary Science, University of Sydney.
- * Congreve, P. & Betts, T.J. (1978) Eucalyptus plantations and preferences as food for a colony of Koalas in Western Australia. pp 87-103. In *The Koala - Proceedings of the Taronga Symposium on Koala Biology*, edited by T.J.Bergin, Zoological Parks Board of NSW, Sydney.
- * Cronin, L. (1987) *Koala - Australia's Endearing Marsupial*. Reed Books, Sydney.
- * Drake, B. (1982) Koala *Phascolarctos cinereus*: its husbandry at the Royal Melbourne Zoological Gardens. pp 129-131. In D.D. Evans (ed.) *Proceedings of the Scientific Meeting of the Australian Mammal Society*. Victoria. Zoological Board of Victoria, Melbourne.
- * Drake, B., Miller, M. & Morley, N.W. (1991) Management of koalas in captivity. pp 323-9. In A.K.Lee, K.A.Handasyde and G.D.Sanson (eds.) *Biology of the Koala*. Surrey Beatty & Sons and the World Koala Research Corporation, Sydney.

- * Eberhard, I.H. (1978) Ecology of the koala, *Phascolarctos cinereus* (Goldfuss) Marsupialia: Phascolarctidae in Australia. Pp. 315-28. In G.G. Montgomery (ed) *The Ecology of Arboreal Folivores*. Smithsonian Institution Press, Washington.
 - * Finnie, T. (1990) *The Role of Zoos in the Conservation of Koalas*. pp 109. In D.Lunney, C.A.Urquhart & P.Reed (eds). *Koala Summit - Managing Koalas in NSW*, NPWS, Sydney.
 - * Finnie, E.P. (1988a) Diseases and injuries of other Australian mammals, pp 91. in *Australian Wildlife. The John Keep Refresher Course for Veterinarians, Proceedings 104*. Post Graduate Committee in Veterinary Science, University of Sydney.
 - * Finnie, E.P. (1988b) Care and husbandry of other Australian animals, pp 63-4. In *Australian Wildlife. The John Keep Refresher Course for Veterinarians, Proceedings 104*. Post Graduate Committee in Veterinary Science, University of Sydney.
 - * Gall, B.C. (1980) Aspects of the ecology of the koala, *Phascolarctos cinereus* (Goldfuss), in Tucki Tucki nature Reserve, New South Wales. *Australian Wildlife Research* 7: 167-76.
 - * Gamble, J. & Blyde, D. (1992) Artificial milk diets as a supplement for aged and infirmed marsupials. *International Zoo Yearbook* 31: 90-2.
- Goldfuss, G.A. (1817) *Lipurus cinereus* in Schrebers's die Säugethiere, in Abbildungen nach der Natur, mit Beschreibungen. Fortgesetzt von A.Goldfuss. 65^e cahier.
- * Gordon, G., Brown, A.S. & Pulsford, T. (1988) A koala (*Phascolarctos cinereus* Goldfuss) population crash during drought and heatwave conditions in south-western Queensland. *Australian Journal of Ecology* 13: 451-61.
 - * Gordon, G. (1991) Estimation of the age of the koala *Phascolarctos cinereus* (Marsupialia: Phascolarctidae) from tooth wear and growth. *Australian Mammalogy* 14: 5-12.
- Handasyde, K.A. (1986) *Factors affecting reproduction in the koala (Phascolarctos cinereus)*. PhD Thesis Monash University, Clayton Victoria.
- * Handasyde, K.A., Martin, R.W. & Lee, A.K. (1988) Field investigations into chlamydial disease and infertility in koalas in Victoria. pp 505-15. In *Australian Wildlife. The John Keep Refresher Course for Veterinarians, Proceedings 104*. Post Graduate Committee in Veterinary Science, University of Sydney.
 - * Hawkes, N.H. (1978) Identification and Management of Koala Eucalypt Trees in New South Wales. pp 89-96. In T.J.Bergin (ed.) *The Koala - Proceedings of the Taronga Symposium on Koala Biology*, Zoological Parks Board of NSW, Sydney.
 - * Houlden, B.A., Costello, B.H., Sharkey, D., Fowler, E.V., Melzer, A., Ellis, W., Carrick, F., Baverstock, P.R. & Elphinstone, M.S. (1999) Phylogeographic differentiation in the mitochondrial control region in the koala, *Phascolarctos cinereus* (Goldfuss 1817). *Molecular Ecology* 8: 999-1011.

- * Hume, I. (1982) *Digestive Physiology and Nutrition of Marsupials*. Cambridge University Press, Cambridge.
- * Lanyon, J.M. & Sanson, G.D. (1986) Koala (*Phascolarctos cinereus*) dentition and nutrition. II. Implications of tooth wear in nutrition. *Journal of Zoology* (London) 209: 169-81.
- * Lee, A.K. (1988) Life histories of marsupials, with particular reference to the life history of the koala, pp 613 – 21. In *Australian Wildlife. The John Keep Refresher Course for Veterinarians, Proceedings 104*. Post Graduate Committee in Veterinary Science, University of Sydney.
- * Lee, A.K & Martin, R. (1988) *The Koala - A Natural History*. New South Wales University Press, Sydney.
- * Lee, A.K. & Carrick, F.N. (1989) Phascolarctidae. Pp. 740-754. In Walton, D.W. & Richardson, B.J. (Eds.) *Fauna of Australia*. Vol. 1B. Australian Government Publishing Service, Canberra.
- * Martin, R. & Handasyde, K. (1991) Population dynamics of the koala (*Phascolarctos cinereus*) in southern Australia, pp 75-83. In A.K.Lee, K.A.Handasyde and G.D.Sanson (eds.) *Biology of the Koala*. Surrey Beatty & Sons and the World Koala Research Corporation, Sydney.
- * Meikle, W. (1990) The Exhibited Animals Protection Act: standards for the display of koalas. pp 110 –111. In D.Lunney, C.A.Urquhart & P.Reed (eds.). *Koala Summit - Managing Koalas in NSW*. NSW NPWS, Sydney.
- O' Callaghan, P. & Blanshard, W. (1991) *Breeding Koalas in Captivity*. ASZK Conference Proceedings, Lone Pine Koala Sanctuary, Queensland.
- * O' Callaghan, P. (1996) *Growth and mortality of koala pouch and back young*. Australian Koala Foundation Conference Proceedings, Greenmount Collangatta, Queensland.
- * Osawa, R. & Carrick, F.N. (1990) Use of a dietary supplement in koalas during systematic antibiotic treatment in chlamydial infection. *Australian Veterinary Journal* 8: 305-7.
- * Osawa, R & Mitsuoka, T. (1990) Faecal microflora of captive koalas, *Phascolarctos cinereus* (Marsupialia: Phascolarctidae). *Australian Mammalogy* 13: 141-147.
- * Osawa, R., Blanshard, W.H. & O'Callaghan, P.G. (1993) Microbiological studies of the intestinal microflora of the koala, *Phascolarctos cinereus*. II. Pap, a special maternal faeces consumed by juvenile koalas. *Australian Journal of Zoology* 611-20.
- * Pahl, L.I. & Hume, I. (1991) Preferences for *Eucalyptus* species of the New England Tablelands and initial development of an artificial diet for koalas. pp 123-28. In

A.K.Lee, K.A.Handasyde and G.D.Sanson (eds.) *Biology of the Koala*, Surrey Beatty & Sons and the World Koala Research Corporation, Sydney.

* Phillips, A. & Johnson, S. (1994) The supplementary feeding of two Victorian koala joeys at Melbourne Zoo. *Thylacinus* 19(1): 6-8.

* Smith, M.T.A. (1980a) Behaviour of the Koala, *Phascolarctos cinereus* (Goldfuss), in captivity. III. Vocalisations. *Australian Wildlife Research* 7: 13-34.

* Smith, M.T.A. (1980b) Behaviour of the Koala, *Phascolarctos cinereus* (Goldfuss), in captivity. IV. Scent-marking. *Australian Wildlife Research* 7: 35-40.

* Smith, M.T.A. (1980b) Behaviour of the Koala, *Phascolarctos cinereus* (Goldfuss), in captivity. V. Sexual behaviour. *Australian Wildlife Research* 7: 41-51.

* Strahan, R. (Ed. 1995) *Mammals of Australia*. Reed Books, Sydney.

Thomas, O. (1923) On some Queensland Phalangeridae. *Annual Magazine of Natural History* 11(9): 246-250.

* Thompson, V. (1987) Parturition and development in the Queensland Koala *Phascolarctos cinereus cinereus* at San Diego Zoo. *International Zoo Yearbook* 26: 217-222.

Troughton, E. le G. (1935) The southern race of the koala. *Australian Naturalist* 9: 137-140.

* Tyndale-Biscoe, H. & Renfree, M. (1987) *Reproductive Physiology of Marsupials*. Cambridge University Press, Cambridge.

* Worthington, Wilmer, J.M., Melzer, A., Carrisk, F. & Moritz, C. (1993) Low genetic diversity and inbreeding depression in Queensland koalas. *Wildlife Research* 20: 177-88.

14.0 Bibliography

- * Archer, M. (1984) On the importance of being a koala, pp 809-15. In M.Archer & G.Clayton (eds.) *Vertebrate Zoogeography and Evolution in Australasia*, Hesperian Press, Carlisle, Western Australia.
- * Backhouse, T.C. & Bollinger, A. (1961) Morbidity and mortality in the koala (*Phascolarctos cinereus*). *Australian Journal of Zoology* 9: 24-37.
- * Bergin, T.J. (ed.)(1978) *The Koala. Proceedings of the Taronga Symposium on Koala Biology, Management and Medicine*. Zoological Parks Board of New South Wales, Sydney.
- Brown, A.S., Carrick, F.N., Gordon, G. & Reynolds, K. (1984) Diagnosis and epidemiology of an infertility disease in the female koala. *Veterinary Pathology* 25: 242-8.
- * Brown, S. & Woolcock, J. (1990) Strategies for disease and prevention of chlamydial diseases in captive koalas. Pp 295-98. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- * Butler, R. (1978) Patterns in koala mortality. Pp. 174-5. In T.J. Bergin (ed) *The koala (ed) Proceedings of the Taronga Symposium on Koala Biology, Management and Medicine*. Zoological Parks Board of New South Wales, Sydney.
- * Canfield, P. (1990) Disease studies on New south Wales koalas. Pp 249-54. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- * Cleva, G. M., Stone, G. M. & Dickens, R. K. (1994) Seasonal changes in haematocrit in captive koalas (*Phascolarctos cinereus*). *Australian Journal of Zoology* 42: 233-236. (File)
- * Cork, S.J., Hume, I.D. & Dawson, T.J. (1983) Digestion and metabolism of a mature foliar diet (*Eucalyptus punctata*) by an arboreal marsupial, the koala (*Phascolarctos cinereus*). *Journal of Comparative Physiology B*. 153: 181-90.
- * Cork, S.J. & Hume, I.D. (1983) Microbial digestion in the koala (*Phascolarctos cinereus*, Marsupialia) an arboreal folivore. *Journal of Comparative Physiology B*. 152: 131-35.
- * Eberhard, I.H. (1978) Ecology of the koala, *Phascolarctos cinereus* (Goldfuss) Marsupialia: Phascolarctidae, in Australia. Pp. 315-28. In G.G. Montgomery (ed) *The Ecology of Arboreal Folivores*, Smithsonian Institute Press, Washington.

* Fleay, D. (1937) Observations on the koala in captivity. Successful rearing in Melbourne Zoo. *Australian Zoologist* 9: 68-80.

George, G.G. (1977) Food preferences of Koalas at Healesville. *Bulletin of Zoo Management* 8: 30-33.

Glassick, T., Gifford, P. & Timms, P. (1997) Outer membrane protein 2 gene sequences indicate that *Chlamydia pecorum* and *Chlamydia pneumoniae* cause infections in koalas. *Systematic Applied Microbiology* 19: 457-464.

Gordon, G., McGreevy, D.G. & Lawrie, B.C. (1981) Social organisation of male koalas. pg 13 in, *Proceedings of the Lone Pine Koala Symposium 21-22 August 1981*. Department of Veterinary Anatomy, University of Queensland and Lone Pine Sanctuary, Brisbane.

* Gordon, G., McGreevy, D.G. & Lawrie, B.C. (1990) Koala population turnover and male social organisation. Pp 189-92. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.

Gould, J. (1863) *The Mammals of Australia*. Taylor & Francis, London.

* Harrop, C. J. F. and Degabriele, R. (1978) Food and water requirements of the koala in captivity. Pp. 45-61 in *The Koala*. ed by Bergin, T. J. John Sands Pty Ltd, Artarmon, New South Wales. (SHELF)

* Hindell, M.A., Handasyde, K.A. & Lee, A.K. (1985) Tree species selection by free-ranging koala populations in Victoria. *Australian Wildlife Research* 12: 127-44. (File)

* Hindell, M.A. & Lee, A.K. (1985) Habitat use and tree preferences of koalas in a mixed eucalypt forest. *Australian Wildlife Research* 14: 349-60. (File)

Hughes, R.L. (1974) Morphological studies on implantation in marsupials. *Journal of Reproduction and Fertility* 39: 173-86.

* Iredale, T. & Whitley, G. (1934) The early history of the koala. *Victorian Naturalist* 51: 62-72.

* Jones, F.W. (1924) *The Mammals of South Australia. Part II. The Bandicoots and the Herbivorous Marsupials*. Government Printer, Adelaide.

Lanyon, J.M. (1982) Aspects of tooth wear nutrition in the Koala *Phascolarctos cinereus* (Goldfuss). Unpublished Honours Thesis, Monash University, Clayton.

- * Lanyon, J.M. & Sanson, G.D. (1986) Koala (*Phascolarctos cinereus*) dentition and nutrition. I. Morphology and occlusion of cheek teeth. *Journal of Zoology* (London) 209: 155-168.
- * Lee, A.K. & Cockburn, A. (1985) *Evolutionary Ecology of Marsupials*. Cambridge University Press, Cambridge.
- * Lee, A.K., Handasyde, K.A. & Sanson, G.D. (ed)(1991) *Biology of the Koala*. Surrey Beatty & Sons, and the World Koala Research Corporation, Sydney.
- * Lithgow, K.A. (1982) Koala feeding on Monterey pine. *Victorian Naturalist* 99: 259.
- * Lunney, D., Urquhart, C.A. & Reed, P. (Eds.)(1990) *Koala Summit - Managing Koalas in New South Wales*. Proceedings of the Koala Summit held at the University of Sydney 7 - 8 November 1988, NSW National Parks & Wildlife Service, Sydney.
- McCull, K.A., Martin, R.W., Gleeson, L.J. Handasyde, K.A. & Lee, A.K. (1984) Chlamydia infection and infertility in the female koala (*Phascolarctos cinereus*). *Veterinary Record* 115: 655.
- * Marshall, V., Carrick, F., Doherty, M.D. & Maclean, D.J. (1990) Aspects of the composition of koala milk. Pp 229-41. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- * Martin, R.W. (1981) Age Specific Fertility in three populations of the Koala, *Phascolarctos cinereus* (Goldfuss) in Victoria. *Australian Wildlife Research* 8: 275-283.
- * Martin, R.W. & Lee, A.K. (1984) The koala, *Phascolarctos cinereus*; the largest marsupial folivore. Pp. 463-7. In A.P. Smith & I.D. Hume (Eds.) *Possums and Gliders*. Australian Mammal Society, Sydney.
- Minchin, K. (1937) Notes on the weaning of a young koala (*Phascolarctos cinereus*). *Records of the South Australian Museum* 6: 1-3.
- * Mitchell, P. (1990) Social behaviour and communication of koalas. Pp 151-70. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- * Mitchell, P. (1990) The home ranges and social activity of koalas – a quantity analysis. Pp 171-87. In A.K. Lee, K.A. Handasyde & G.D. Sanson (eds) *Biology of the Koala*. Surrey Beatty & Sons, Sydney.
- Obendorf, D. (1981) Pathology of the female reproductive tract in the Koala, *Phascolarctos cinereus* (Goldfuss) from Victoria Australia. *Journal of Wildlife Diseases* 17; 578-92.

Obendorf, D.L. (1983) Causes of mortality and morbidity of wild koalas. *Phascolarctos cinereus* (Goldfuss), in Victoria, Australia. *Journal of Wildlife Diseases* 19: 123-131.

* Osawa, R., Carrick, F.N., Hashimoto, N., Takashima, I. & Takahasi, T. (1991) Application of a blood sampling paper method for the complement fixation test detection of anti-chlamydial antibody in koalas (*Phascolarctos cinereus*). pp 277-9. In A.K.Lee, K.A.Handasyde and G.D.Sanson (eds.) *Biology of the Koala*, Surrey Beatty & Sons and the World Koala Research Corporation, Sydney.

Pocock, R.I. (1921) The external characters of the koala (*Phascolarctos cinereus*) and some related marsupials. *Proceedings of the Zoological Society of London* 1921: 591-607.

Post Graduate Committee in Veterinary Science University of Sydney (1988) *Australian Wildlife - The John Keep Refresher Course for Veterinarians*, Proceedings 104.

* Pratt, A. (1937) *The Call of the Koala*. Robertson & Mullins, Melbourne.

Scoggins, B.A. & Barlow, R. (1981) The effect of capture, confinement and adrenocorticotrophic hormones on blood corticosteroids in the Koala. Pp 7. In, *Proceedings of the Lone Pine Koala Symposium* 21-22 August 1981. Department of Veterinary Anatomy, University of Queensland & Lone Pine Koala Sanctuary, Brisbane.

Smith, M.T.A. (1979a) Notes on reproduction and growth in the Koala, *Phascolarctos cinereus* (Goldfuss). *Australian Wildlife Research* 6: 5-12.

* Smith, M.T.A. (1979b) Behaviour of the Koala, *Phascolarctos cinereus* (Goldfuss) in captivity. I. Non-social behaviour. *Australian Wildlife Research* 6: 117-28.

* Smith, M.T.A. (1979c) Behaviour of the Koala, *Phascolarctos cinereus* (Goldfuss) in captivity. II. Parental and infantile behaviour. *Australian Wildlife Research* 6: 129-40.

Sonnag, C.F. (1921) The comparative anatomy of the Koala (*Phascolarctos cinereus*) and Vulpine Phalanger (*Trichosurus vulpecula*). *Proceedings of the Zoological Society of London* 1921: 547-77.

* Starr, J. (1990) Koalas. pp. 83-90. In Hand, S.J. (ed) *Care and Handling of Australian Native Animals*. Surrey Beatty & Sons & the Royal Zoological Society of New South Wales. Sydney.

* Troughton, E. leG. (1941) *Furred Animals of Australia*. Angus and Robertson, Sydney.

* Ullrey, D.E., Robinson, P.T. & Whetter, P.A. (1981) Composition of preferred and rejected eucalyptus browse offered to captive koalas, *Phascolarctos cinereus* (Marsupialia). *Australian Journal of Zoology* 29: 839-46.

Weigler, B. J., Booth, R. J., Osawa, R. and Carrick, F. N. (1987) Causes of morbidity and mortality in 75 free-ranging and captive koalas in south east Queensland, Australia. *Veterinary Record* 121: 571-572.

White, N.A. (in press) Ecology of the koala (*Phascolarctos cinereus*) in rural south-east Queensland, Australia. *Wildlife Research*.

* Williams, H.D. (1975) *The Year of the Koala*. Charles Scribner's Sons, New York.

Williams, P.C. (1971) Observations on food preferences as displayed by Koalas in Melbourne Zoo. *Melbourne Zoo Newsletter* 3: 6-11.

* Wood, A. D. (1978) The diseases of the captive koala. Pp. 158-165 in *The Koala*. ed by Bergin, T. J. John Sands Pty Ltd, Artarmon, New South Wales.

Appendix 1. Draft 2. ARAZPA Monotreme and Marsupial Taxon Advisory Group Recommendation on Subspeciation in Koalas

There has been considerable debate over the subspeciation of koalas in both our zoos and in the wider scientific community. Historically it was thought that koalas were divided into three separate sub species, which were managed in our zoos accordingly;

<i>Phascolarctos cinereus cinereus</i>	New South Wales
<i>Phascolarctos cinereus adustus</i>	Queensland
<i>Phascolarctos cinereus victor</i>	Victoria.

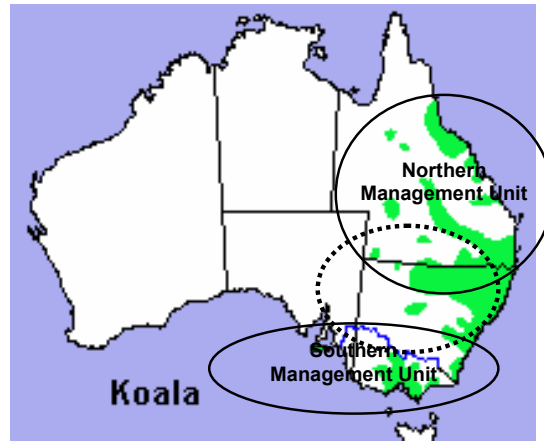
Recent genetic studies by Dr Bronwyn Houlden of Taronga Zoo have shown that this earlier assumption of three subspecies is incorrect. Molecular genetic analysis suggests that the variation in koala morphology is clinal, rather than a consequence of three separately evolving subspecies.

The Monotreme and Marsupial TAG believes that we are therefore managing artificial units at the subspecies level at present. The recommendations, the Monotreme and Marsupial TAG is making, are based on the two primary groups being managed in zoos at present. These comprise the Victorian/South Australian koalas, and the Queensland/New South Wales koalas. These animals are maintained principally as display animals and, they or their progeny, will not be returned to Australia to participate in a release-to-the-wild program. Most Queensland and New South Wales animals in captivity are from southern Queensland and northern New South Wales, and are therefore unlikely to be significantly differentiated in an evolutionary sense. Whereas the levels of gene flow between Queensland and Victorian populations would naturally be quite restricted over this distance.

In order to clarify the management of koalas in our zoos the Monotreme and Marsupial TAG has prepared the following recommendations:

1. Koalas in Zoos are to be managed as an evolutionary cline.
2. Captive koala programs should be to maintain regionally sustainable populations over the long-term, with occasional supplementation to maintain genetic diversity, in line with basic species management principles.
3. Three overlapping management areas, that are practical, are designated (as per map) to define the management units by which zoos will manage their populations. Effectively this results in two management units - Northern and Southern.

4. The Queensland and New South Wales overlap koalas, (see map), should be managed as one unit in zoos together with the North Queensland koalas. This group of koalas is to be known as the “Northern Management Unit” *Phascolarctos cinereus* (Northern management unit).



For overseas zoos this effectively means that there are no New South Wales koalas. Those derived from Taronga Zoo would be considered in the Northern New South Wales and Southern Queensland overlap. Animals from this area would now be managed as one with the North Queensland animals.

5. The Victorian and Southern New South Wales overlap koalas, (see map), should be managed as one unit, along with the rest of Victoria and South Australia Koalas, in zoos. This group of koalas is to be known as the “Southern Management Unit” *Phascolarctos cinereus* (Southern management unit).
6. Mixing of Queensland stock with Victorian stock is prohibited.
7. Zoos that choose to have a wild/captive interaction (eg releases through animal shelters, surplus stock released) of stock must retain animals of known provenance. These animals will not be considered a part of the global zoo management collection.
8. Animals that are a part of the global zoo collection of koalas will not be considered for reintroduction to the wild.

As of the published date of this notification, studbook managers can assimilate any koalas they are managing into the most appropriate of the two approved management units. Should you have any questions in relation to any aspect of this recommendation please do not hesitate in calling me.

Appendix 2. NSW EAPA Standards for Exhibiting Koalas in New South Wales

Standards for Exhibiting Koalas

(Phascolarctos cinereus)

in New South Wales

Exhibited Animals Protection Act

A publication of the Director-General, NSW Agriculture
Pertaining to the conditions of display of koalas
(pursuant to Clause 8(2) of the Exhibited Animals Protection Regulations, 1995).

Clause 1

Facilities

GENERAL REQUIREMENTS

1.1 Construction

- a) Enclosures shall be constructed of such materials and be maintained in sufficiently good repair to ensure that they will contain the animals at all times and are to be safe for the animals, for the staff attending them, and for the public.
- b) Enclosures, or the perimeter fence in the case of an establishment where koalas are permitted to free range, shall be designed in such a way as to prevent the entry of wild koalas. This requirement only applies to establishments located in areas where wild koalas are known to occur.
- c) Enclosures may be of open, semi-enclosed or totally enclosed design.
- d) Sufficient shelter must be provided to allow protection from wind, rain and extremes in temperature and allow sufficient access to shade during the hot periods of the day.
- e) The size and shape of enclosures for *P. cinereus* shall provide freedom of movement, both vertically and horizontally.
- f) The enclosure shall be well drained and have either a readily cleanable substrate or be of a material that can be replaced to avoid the accumulation of faeces and urine.

1.2 Isolation Facilities

Suitable isolation facilities shall be provided for quarantine of incoming or sick animals.

1.3 Protection from Noise, Harassment and Stress

- a) The establishment shall satisfy the Director-General that sufficient numbers of experienced, identifiable employees are in attendance to protect koalas from

abuse and harassment where koala handling occurs and to ensure that stress on the koalas does not occur.

- b) Koalas must not be placed directly on any visitor or directly held by any visitor for any purpose. If koalas are to be held by visitors, the koala must already be clinging to some suitable object. The visitor can then be permitted to hold the object with the koala on it.
- c) The licensee shall ensure that koalas are not repeatedly removed from objects to which they are clinging.

1.4 Enclosure Furniture

- a) There must be at least two tree forks per koala not less than 1.8 metres above ground and not closer than 0.9 metres to the next fork.
- b) All supports and branches shall provide sufficient traction for koalas to climb easily and safely.

Clause 2

Hygiene

Substrate of enclosures shall be cleaned daily. The supports and branches shall be replaced as necessary and be maintained in a clean and hygienic condition, free from the accumulation of faeces and urine.

Clause 3

Records

3.1 Identification

Each koala shall be individually identified by an approved method of identification.

3.2 Record-Keeping

- a) Establishments shall keep records of all koalas on an individual basis in a form which can be quickly and easily examined, analysed and compared with those kept by other establishments.
- b) All documents and other information pertaining to each animal, including records from previous locations, must be kept safely. Copies of all records relevant to those animals must accompany animals moving to new locations.
- c) The records shall provide for each koala at least the following information:

- i) the correct identification number, scientific name, any personal name and any distinctive markings;
 - ii) the origin (i.e. details of the wild population or of the parents and their origin, and of any previous location);
 - iii) the dates of acquisition and disposal, with details of circumstances and addresses;
 - iv) the date or estimated date of birth, and the basis on which the date is estimated, or the date of the first emergence of the juvenile from the pouch;
 - v) weight on arrival, and thereafter monthly. The requirement for weighing animals monthly shall not apply to koalas which are either free-ranging within the perimeter barrier of the establishment, or are not dependent on hand-feeding for nourishment.
 - vi) clinical data, including results of physical examination by a qualified veterinarian and details of and date when any form of treatment was given, together with results of routine health examinations;
 - vii) breeding and details of any offspring;
 - viii) the date of death and the results of the post mortem reports which must be performed by a qualified veterinarian.
- d) The Director-General may require records of daily leaf collections to be maintained, including details of –
- i) leaf species,
 - ii) area of collection,
 - iii) weights of leaves before and after feeding,
 - vi) the identities of the koalas which fed on the leaves.

Records may be required to be submitted to the Director-General at three monthly intervals for a period of two years from the date of initial issue of a permit to exhibit koalas.

3.3 Transaction Records

- a) A written report, including records of any clinical observations, shall be submitted to the Director-General within 30 days, on every transport operation, in particular detailing any problems arising and with suggestions as to how these may be avoided.
- b) The Director-General must keep a current summary of transport advice, based on these reports and provide a copy to applicants for their information.

Clause 4

Diet and food collection

4.1 General

- a) An establishment applying for a permit to exhibit koalas must satisfy the Director-General that it has guaranteed access to adequate fresh supplies of leaves from at least three suitable koala food tree species. This is important when particular species can be susceptible to insect attack at particular times of the year. Known food trees include the species listed below:

<i>E.botryoides</i>	Southern Mahogany
<i>E.camaldulensis</i>	River Red Gum
<i>E.camphora</i>	Broad-leafed Sally
<i>E.citriodora</i>	Lemon-scented Gum
<i>E.cypellocarpa</i>	Mountain Grey Gum
<i>E.goniocalyx</i>	Long-leafed Box
<i>E.grandis</i>	Flooded Gum
<i>E.haemastome</i>	Scribbly Gum
<i>E.maculata</i>	Spotted Gum
<i>E.microcorys</i>	Tallowwood
<i>E.nicholii</i>	Small-leafed Peppermint
<i>E.obliqua</i>	Messmate
<i>E.ovata</i>	Swamp Gum
<i>E.paniculata</i>	Grey Ironbark
<i>E.pilularis</i>	Blackbutt
<i>E.propinqua</i>	Small-fruited Grey Gum
<i>E.punctata</i>	NSW Grey Gum

<i>E.radiata</i>	Narrow-leafed Peppermint
<i>E.robusta</i>	Small Mahogany
<i>E.rubida</i>	Candle Bark
<i>E.saligna</i>	Sydney Blue Gum
<i>E.scoparia</i>	Wallengarra White Gum
<i>E.sideroxylon</i>	Red Iron Bark
<i>E.tereticornis</i>	Forest Red Gum
<i>E.viminalis</i>	Manna Gum

- b) A sufficient quantity of eucalypt leaves shall be provided continuously and replaced at least once daily.
- c) Preferred species of eucalypt should be supplemented by a variety of different species of eucalypt as a precaution against local or seasonal differences in digestibility and palatability of dietary leaf matter. Both young and mature leaves should be provided.
- d) Feed must be presented as close and accessible to the koalas perch as possible and care taken to prevent wastage of feed placed out of reach.
- e) Fresh soil shall be provided, but not around the base of perches, to provide for supplementation of mineral intake or alternatively a mineral salt lick be provided.
- f) Clean accessible drinking water facilities shall be provided. Water shall be replaced at least once daily.

4.2 Quality of Food Leaves

Frequency of leaf cutting and the operation of leaf storage facilities shall ensure the koalas receive palatable, uncontaminated, nutritionally adequate food leaves.

Clause 5

Transport

5.1 Quarantine

- a) Koalas to be transferred between establishments must be subject to a period of 30 days quarantine at either the importing or exporting establishment unless an exemption from the quarantine period is advised and certified by a veterinarian following a complete veterinary examination.

The certificate must also establish that the koala is –

- i) not in a weakened or emaciated condition; and

- ii) is free from
 - keratoconjunctivitis,
 - pneumonia,
 - dermatitis, and
 - urogenital discharge,

before release from quarantine.

5.2 Transport Cage

Koalas must be transported individually in solid framed cages measuring at least 95cm x 75cm x 95cm high. The cages must have removable, leakproof metal drop trays fitted at the base. Sides and top must be of stout wire mesh and be fitted with light hessian or shade cloth covers. Each cage must be fitted with a resting branch providing at least two forks.

5.3 Feeding in Transit

- a) Koalas must each be accompanied by at least 3.6kg of the leaves on which they are normally fed; the leaves being left on the stem and the base of the stem remaining in water or sealed.
- b) One kilogram of these leaves must be placed in the cage with the koala before departure.

5.4 Stress Reduction

- a) Koalas must not be subjected to temperatures greater than 30 degrees or less than 10 degrees Centigrade during the trip.
- b) Koalas must be accompanied by a keeper familiar with the animals being transported at all times except during air transport.
- c) Noise must be minimised during transport.
- d) Time from caging to destination must be minimised.

References

Bergin, T.J. (ed) 1978. The Koala. Proceedings of the Taronga Symposium, Sydney 1978. Zoological Parks Board of New South Wales.

Brown, S. 1986. "Management of Captive Koalas" from Koala Management – Proceedings of the Australian Koala Foundation Inc. Conference on Koala Management, Australian Koala Foundation, Queensland.

Collins, L.R., 1973. Monotremes and Marsupials. A Reference for Zoological Institutions. Smithsonian Institution Press, City of Washington.

Drake, B., 1982. Koala, *Phascolarctus cinereus*: its husbandry at Royal Melbourne Zoological Gardens in D.D.Evans (ed.) Proceedings of the Scientific Meetings of the Australian Mammal Society, Healesville, Victoria. February 1979. The Zoological Board of Victoria.

Lee, A. & Martin, R. 1988 The Koala. A Natural History. University of New South Wales Press.

Anon. Policies for the Exhibition of Native Fauna in New South Wales. National Parks and Wildlife Service.

Anon. Conditions for the Export of Koalas. Australian National Parks and Wildlife Service.

Appendix 3. Queensland Wildlife Parks Association Guidelines

Code of Practice

Q.W.P.A.

Recommended Minimum Standards

**For Exhibiting Fauna in
Queensland**

Part A

Koalas

Phascolarctos cinereus

Ratified by the QWPA on 6 May 1994

Approved by the Minister for Environment and Heritage 24 March 1995

GENERAL INFORMATION.

The Koala *Phascolarctos cinereus* is a highly specialised arboreal marsupial which feeds primarily on the Genus *Eucalyptus*. Other genera of the family Myrtaceae are also browsed (as are a variety of other non-eucalypt species) depending of the area concerned, the individual Koala and the availability of or access to preferred browse species. Free ranging populations of Koalas tend to be clustered around areas of “core” habitat (ie. areas with variable densities of preferred food trees but usually influenced by changing edaphic features such as soil fertility). Preferred food trees also change from area to area.

Adult Koalas generally live in discrete home range areas which vary in size depending on both the sex of the individual (males tend to have larger home ranges than females) and the quality of the habitat (in terms of access to preferred browse species). Areas of “core habitat” subsequently tend to be occupied by the same animals on a year round basis in a socially stable structure of essentially mutually exclusive home ranges with varying degrees of overlap. Successful captive management of Koalas is contingent upon the provision of an adequate diet, an understanding of the social behaviour of the species at the population level and the recognition of such socio-biological considerations in captivity.

Due to the low nutrient content of their diet, koalas conserve their energy by spending long periods asleep or resting. Koalas have low body fat reserves and loss of appetite for any reason leads rapidly to loss of body condition, dehydration and possibly increased susceptibility to secondary infections.

Every effort should be made to obtain koalas from existing captive stocks. Apart from *bona fide* scientific research or educational purposes, permits to take koalas from the wild are normally not issued by the Department of Environment and Heritage.

The breeding of Koalas in captivity by persons authorised to keep the species is to be encouraged.

1. Husbandry

- a) A suitably qualified attendant must be nominated to be in charge of the proposed display. Such an attendant is to have the following minimum experience and ability:
 - i. Either at least six months full time work with a koala display, during which time he/she was primarily responsible for collecting food and supplying it to koalas, or at least twelve months work as a full time animal attendant in charge of the maintenance of mammals in a zoo or similar institution. (Note that in this situation, the attendant must be capable of monitoring koala reaction to offered food and of early detection of any deterioration of koala health/condition); and

- ii. A demonstrated ability to identify koala food trees.

Koalas require a substantial amount of fresh eucalypt leaves daily for their healthy maintenance in captivity. Unless alternative arrangements are identified, persons proposing to keep koalas must establish and control a plantation of feed eucalypts sufficient to meet the need of the proposed colony. Details of the plantation arrangements must accompany the application.

The plantation must be partially established prior to the arrival of the koalas and must be capable of sustaining 50% of the colony within 5 years, and aim for total self sufficiency within 10 years.

Wildlife Parks with existing koala colonies must comply with the conditions in 1(c) taking the date of promulgation of these conditions as the base date to comply with the 5 year recommended time span.

2. Facilities

The following minimum guidelines will apply to structures used to house koalas for display:

Each enclosure is to have a wall with a minimum height of 1.2 metres and is to be constructed of a material with an internal and external surface which will prevent the escape of the koalas (and prevent entry of wild koalas) or such other minimum standard as is determined by Government legislation.

Each cage or enclosure is to provide protection for the koalas against interference from other animals and the public.

Where a mixed sexes exhibit is proposed, each cage or enclosure with less than 50 square metres of floor space must not contain more than two male koalas thirty months of age or older. This requirement shall apply proportionally to enclosures of up to 500 square metres of confined floor area in size.

Enclosures may be of open, semi-enclosed or totally enclosed design.

The size and shape of enclosures must provide freedom of movement, both vertically and horizontally.

Each cage or enclosure is to be fitted with stout branches and/or tree limbs.

Each cage or enclosure is to have reticulated water available for both cleansing and koala drinking purposes.

Fresh soil may be provided, but not around the base of vertical supports, to provide for supplementation of mineral intake.

There must be at least two resting forks per koala not less than 1.2 metres off the ground on a vertical support and no closer than 0.9m to the next vertical support.

Horizontally aligned limbs at a minimum height of 1.2 metres off the ground may also be used to connect the resting limbs and cleaned.

All supports and branches must provide sufficient traction for koalas to climb easily and safely.

3. Diet and Feeding

- a) An establishment applying for a permit to exhibit koalas must satisfy the QDEH that it has guaranteed access to adequate fresh supplies of eucalypt leaves from at least five suitable koala food tree species.

Known food trees growing naturally in Queensland include the species listed:

<i>E. camaldulensis</i>	River red gum
<i>E. crebra</i>	Narrow-leaved red ironbark
<i>E. drepanophylla</i>	Grey ironbark
<i>E. dunnii</i>	Dunn's white gum
<i>E. exserta</i>	Queensland peppermint
<i>E. grandis</i>	Flooded or Rose gum
<i>E. henryi</i>	Large-leaved spotted gum
<i>E. maculata</i>	Spotted gum
<i>E. major</i>	Grey gum
<i>E. melliodora</i>	Yellow box
<i>E. microcorys</i>	Tallowwood
<i>E. moluccana</i>	Gum-topped or Grey box
<i>E. nicholii</i>	Narrow-leaved black peppermint
<i>E. ochrophloia</i>	Yapunyah
<i>E. pellita</i>	Large fruited red mahogany
<i>E. pilularis</i>	Blackbutt
<i>E. populnea</i>	Poplar or Bimble box
<i>E. propinqua</i>	Small-fruited grey gum
<i>E. punctata</i>	Large-fruited grey gum
<i>E. resinifer</i>	Red stringybark or Red mahogany
<i>E. robusta</i>	Swamp mahogany or Swamp messmate
<i>E. saligna</i>	Sydney blue gum
<i>E. seeana</i>	Narrow-leaved grey or Narrow-leaved red gum
<i>E. sideroxylon</i>	Red ironbark or mugga

<i>E. signata</i>	Scribbly gum
<i>E. tereticornis</i>	Queensland blue or Forest red gum
<i>E. viminalis</i>	Ribbon or Manna gum
<i>L. conferta</i>	Brush or Pink or Queensland box

- b) Fresh food in the form of acceptable browse species is to be provided within reach of koalas sitting in the resting forks. This browse must be secured with the cut ends in clean water and must be replaced at least once daily.
- c) Frequency of leaf cutting and the operation of leaf storage facilities must ensure the Koalas receive palatable, uncontaminated, nutritionally adequate food leaves.
- d) A variety of different species of suitable koala food trees must be offered as a precaution against local or seasonal differences in digestibility and palatability of dietary leaf matter. Both young and mature leaves should be provided whenever possible.

4 Identification

Each individual koala will be marked at all times by a serially numbered implantable transponder (or other identifying device as regulated by the Department of Environment and Heritage) affixed by a veterinary surgeon under the Department of Environment and Heritage direction.

4.1 Records

- a) Each koala must be weighed at least monthly and a permanent record of these weights maintained (See Appendix 3a.)
- b) The requirement for weighing animals monthly may not apply to koalas which are free-ranging and are not dependant on provision of hand-cut browse for nourishment.

4.2 General

All requirements for maintaining records in the general conditions will apply.

5 Transport

5.1 General

All conditions for transport outlined on the document on general conditions will apply.

5.2 Journeys over two hours

- a) Koalas must be transported individually in solid framed cages measuring at least 95cm x 75cm x 95cm high.
- b) The cages must have removable, leak proof drop trays fitted at the base. The sides and top must be stout mesh and be fitted with light covers of hessian or shade cloth. Each cage must be fitted with a resting fork.
- c) For the trip, fresh browse leaves must be placed in the cage with the koala, the amount to be determined by the qualified person in charge.
- d) Within each transport cage, koalas must not be subjected to temperatures greater than 25°C or less than 10°C during the trip.
- e) The koalas must not be removed from the cages or handled in transit unless it is considered essential for the well-being of the animal by the veterinarian or accompanying keeper.
- f) The person accompanying road transported koalas must provide a detailed report to the receiving institution on the animals behaviour prior to and during transport. In the case of air transport, a detailed written report should be forwarded to the receiving institution with the koala.

5.3 Journeys of less than two hours.

- a) Koalas must be transported individually in solid framed cages measuring at least 55cm x 45cm x 60cm high.
- b) Solid cages must have air holes on all sides and the top.
- c) Each box must be fitted with at least one vertical support or resting fork.
- d) Conditions c), d), e), f) of Section 5.2 also apply.

5.4 Movement reports

The Executive of the QWPA recommends that a written report be submitted to the Executive within 30 days on transport operations, in particular detailing any problems arising and offering suggestions to avoid future problems.

6 Quarantine

- a) Koalas to be transferred between establishments must be subject to a period of 30 days quarantine at either the importing or exporting establishment unless an exemption from quarantine period is advised and certified by a veterinarian following a thorough physical examination.

The certificate must also establish that the koala is not:

- i) in a weakened or emaciated condition, and
- ii) is free from clinical signs of disease.

7 Photographic opportunities and handling requirements.

7.1 Types of photographic opportunities.

- a) Note: The handling of koalas is currently subject to review by ANZECC which is proposing to introduce a national standard.
- b) Body to body handling: This is the direct transferring of a koala from a keeper to the body of a member of the public.
- c) Keeper assisted photography: This is when the keeper holds the koala at all times and the public stand beside them.
- d) Pole photography – animals relocated: This is where a koala is removed from its current resting fork and is placed in a low fork where the public can stand or be seated beside the koala for a photo.
- e) Pole photography – animals not relocated: This is when a visitor is allowed into the koalas usual enclosure and can stand beside the resting koala for a photo opportunity.

7.2 Conditions on handling for Section 7.1a) b) c) – Types of photographic purposes.

- a) All time that an individual koala is handled is to be recorded. Handling time includes any time when a koala is removed from its normal place of residence (i.e. time the disturbance of its normal routine, not just the time in contact with persons other than keepers).

- b) A record sheet and roster schedule, in an approved format, including all times of all koalas handled must be maintained, and be available for inspection at any time. (See Appendix 3b.)
- c) The maximum period that an individual koala may be handled is 30 minutes a day.
- d) The maximum period that an individual koala may be handled is 180 minutes a week.
- e) An individual koala must not be used more than 3 days consecutively before receiving a rest day.
- f) Every individual koala must be adequately tagged to allow accurate and easy recognition by the koala keepers.
- g) Only trained koala keepers are to place onto or remove a koala from another person's body or a tree fork.
- h) Only captive bred koalas of suitable temperament, which is to be determined by the responsible koala officers, are to be handled.
- i) Only fully weaned or independent koalas are to be handled.
- j) At absolutely no time is a female koala to be handled when it has pouch young or back young.
- k) Sufficient numbers of experienced, identifiable employees must be in attendance where any koala handling occurs, to protect the koalas from abuse and harassment and to ensure that the koalas are not upset.

7.2 Conditions relating to Section 7.1 d) – Types of photographic purposes

- a) At no time are the koalas within the enclosure to be disturbed. This includes disturbance by touching, movement of resting forks or by audible distractions.
- b) Sufficient numbers of experienced, identifiable employees must be in attendance to protect the koalas from abuse and harassment and to ensure that the koalas are not upset.

8 Death of Stock

Under the Department of Environment and Heritage requirements deaths of koalas must be reported in writing to the Chief Executive of the Department of Environment and Heritage or to the relevant Regional Director within one month. The report must be

accompanied by an autopsy report prepared by a qualified veterinarian.

9 Provisions of other Acts.

The above exhibit standards of the QWPA are to be regarded as being the recommended minimum standards for wildlife parks to achieve and are not in derogation of the provisions of the *Nature Conservation Act 1992* and Regulations under the Act.

Where applicable, the Acts and Regulations of other statutory bodies must be complied with.

Appendix 3a. Koala monthly weighing record

Institution name:

Koala weights

Name:

ID number:

Date	Weight	Note
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Appendix 3b. Koala handling time records

Institution:

Date:

Koala name	Time out	Time in	Total	Handler
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Institution:

Daily time delegation sheet for koala handling

Date:

Name	Enclosure no.	Tattoo no.	Max. allowable	Actual time used	Total
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Appendix 4. Review of Environment Australia's Conditions for the Overseas Transfer of Koalas

ARAZPA

**Australasian Regional Association of Zoological Parks
and Aquaria**



A Guide to Koalas in Your Zoo.

February 1999

Introduction

Many zoo's today are building theme exhibits to display and interpret their animals as well as the conservation role they undertake. An Australian theme exhibit is generally very popular because of the unique nature of Australia's flora and fauna. Koalas are often sought as the centrepiece of such Australian exhibits.

For zoos outside of Australia to include koalas in their collection planning they will need to plan many years in advance. There are many aspects of koala management and husbandry to consider prior to and during the journey to include this Australian icon as a part of their collection.

The acquisition of koalas, by overseas zoos, can take up to five years. Planning and communication are vital ingredients to the success of a koala export project. Environment Australia and Australian zoos have developed this koala information package to assist prospective overseas zoos to obtain this fascinating species as a part of their Australian displays.

At present there are three regional koala programs in operation; the United States of America region, the Asian region and the Australian region. New koala regions can and are being developed however Australian zoo authorities are very cautious about establishing new regions. There must be demonstrable ability by the proposed region to care for and manage koalas.

Existing koala programs breed animals in accordance with agreed management plans. Surplus animals are not readily available. Expansion of koala colonies by zoos and by regions is undertaken in a planned and managed manner. The most restrictive component of having koalas in your zoo are the animals feed requirements. Koalas have very specific eucalypt needs. Daily eucalypt supplies of fresh, good variety eucalypts of appropriately aged browse must be available. In most cases, this means the zoo must establish an eucalypt plantation to support their koala population. Depending on your local climate this may take three to five years of growth until it can be harvested for koala food.

The responsibility and authority for transfers of koalas, from Australia to Overseas, rests with the Commonwealth Government. Each State or Territory Government, in Australia, is responsible for approving the transfer of an animal out of that state.

Zoo's intending to establish a koala population will need to acquire a broad range of approvals prior to the transport of Koalas. The first and most specific requirement is for the potential zoo to be approved under the Australian Wildlife Protection Act, in part it reads as follows:

The export of live native Australian animals may proceed when the animals are intended for display and breeding purposes undertaken by a

zoological organisation approved under the Wildlife Protection (Regulation of Exports and Imports) Act 1982.

Among other matters an organisation may only be declared an approved zoo if it is:

- *owned or administered by a government or government instrumentality in the country in which the zoo is established; or*
- *owned, administered or controlled by a learned zoological society.*

It should be noted that there is no cost or price attached to the acquisition of koalas. Costs if incurred will relate to those associated with the transport of koalas and the training of staff. These may be shared or otherwise as determined by the exporting and importing zoo.

Should you have any queries in relation to this document or any aspect of the process's outlined within then please contact your Zoo Association, Monotreme & Marsupial Taxon Advisory Group, Regional Koala Coordinator, an Australian zoo holding koalas or Environment Australia.

Pre Planning

a) Learn about Koalas and their maintenance

- Background Information
- Maintaining koalas in captivity requires specific skills and understanding.
- You must become conversant with all aspects of keeping koalas in captivity.

What you will need:

- A copy of the Koala Husbandry Manual.
- Information on establishing and maintaining Eucalyptus plantations.
- Reference books, videos, cd's and journals, Internet sites.

What you must do:

- Obtain copies of information from your regional M&M TAG or a zoo currently maintaining koalas.
- Undertake some research. Look up books, papers and articles in your library and on the Net.
- The Koala captive husbandry guide has an excellent bibliography.
- Acquire appropriate books (references provided at end of document under recommended reading)
- If possible, undertake a study tour of recommended zoos maintaining koalas.

What others will do:

- Regional zoo associations will provide as much as they have.
- The Australian M&M TAG will provide information.
- Australian zoos maintaining Koalas will provide as much information as possible.

b) Current Koala Programs

- Background Information
- There are at present three, well managed, Koala programs operating throughout the World. Where possible you will be directed to participate in an existing managed program. This is designed to minimise the export of koalas from Australia and minimise the cost of transferring animals.

What you will need

- You will need to determine which program best suits your requirements.
- You must consider:
 - Koala region to become associated with.
 - Which of the Koalas are most suited to your climate.
 - Availability of stock from within the region you will be operating in.
 - Timetable for acquisition from your koala region or from Australia.
 - The costs associated with acquiring and maintaining Koalas.
 - The implications of the "Ambassador Agreement" you may be required to sign.

What you must do:

- Communicate with the Regional Koala Program Managers.
- Communicate with other zoos in the region you might consider working with.
- Communicate with M&M TAG in your region (if none contact the Australian M&M TAG).
- Communicate with zoos in your region with existing koala populations.
- Communicate with Australian M&M TAG if you are considering creating a new region
- Acquire a copy of each Regional koala program "management plan".

What others will do:

- Provide you with:
 - Information on koala race suitable for your conditions.
 - Present options for obtaining koalas.
 - Advise on accreditation requirements.
 - Detail current stock situation and timetable for the need of future acquisitions.

c) Program selection

- Background Information:

- You will be encouraged to join an existing koala program where possible. You may acquire koalas from the region you choose to work with or at their direction, from Australia.
- Establishing a new koala program or region will need endorsement from the Australian M&M TAG and Environment Australia.

What you will need:

- You will need to determine, from the information you have gained:
- Which program to become affiliated with?
- Do you need to establish a new koala region?
- What race of koalas to maintain?
- What are the program options you have?

What you must do:

- Obtain the approval of your Regional koala program manager.
- Determine your National Permit requirements.
- Communicate with the Australian M&M TAG if you intend to start a new koala region.

What others will do:

- The Australian M&M TAG will consider the merits and of starting a new koala region.
- Your National Wildlife, Quarantine, and Agricultural agencies will provide details on their permit requirements.

d) Prepare Your Draft Koala Plan

- Background Information
- To facilitate your acquisition of koalas you must provide the information that various organisations will want prior to undertaking major expenditures. A Draft Plan is required. The draft plan also enables changes to be made if it is required after you get feedback. Sufficient detail is to be provided to enable Environment Australia and the M&M TAG's to give an "In Principal Approval".

What you will need:

- Details/Plans of exhibits.
- A copy of your regional Koala plan.
- Koala browse plantation plans.
- Letters of intent/agreement from Koala browse suppliers.
- Zoo masterplan/Australian zone masterplan/long term exhibit plans.
- Staff curriculum vitae.
- Details on co-operative species management.
- Environment Australia's R1 and R2 forms.
- Koala Project timetable.

What you must do:

- You will need to provide:
- Reasons why the koala region was selected.
- Why the koala race was selected.
- Proposed and planned number of animals to be maintained.
- Proposed method of feeding, include size, location, contingency plan, security of supply of your koala browse.
- Concept for koala facility/display.
- Koala keeping skills; current or plans for acquisition.
- Demonstrations of your commitment, co-operation and communication (reporting) on species programs.

What others will do:

- Environment Australia will supply:
- R1 & R2 accreditation and application forms
- Blank Ambassador Agreement.
- Conditions of Export.
- A zoo in your region already holding koalas the regional koala manager or the regional M&M TAG will be able to advise on the appropriateness of your zoo koala plan.

e) Submit Proposal

- Background Information
- Environment Australia and Australian zoos will be considering your ability to manage, feed, maintain, house, care and interpret koalas.
- They will also consider how koalas fit into your Australian theme exhibits.

What you will need:

- Completed- proposed koala plan for your zoo.
- Completed – proposed koala browse supply plan for your zoo.
- Koala project timetable.
- Support documentation.
- Draft R1 and R2 forms.

What you must do:

- If joining an existing regional koala program:
- Submit your draft zoo plans to the regional program coordinator for finalisation and agreement.
- Submit the agreed plans to Australian M&M TAG for agreement.
- Submit the agreed plans to Environment Australia for "in principal" approval.

If starting a New Region:

- Submit draft regional plan to Australian M&M TAG for finalisation and agreement.
- Submit approved regional plan to Environment Australia for "in principal" approval.

What others will do:

- Receive from Environment Australia:
- "In principal" approval/non approval to be accredited as an approved Environment Australia Institution and undertake your koala plan.
- Reasons why the project was not approved.
- A nominated Australian zoo to communicate with.

Note: "in principal" approval does not guarantee final approval. It indicates that as long as all conditions and criteria are met and your proposed plans are adhered to and carried out, then approval is likely.

From Australian M&M TAG:

- In principal agreement/non agreement.
- Reasons why the project was not approved.

2. Final Documentation & Construction

a) Project Development

- Background Information
- Assuming all of the "in principal" approvals were given.
- Next phase is to prepare the final documentation and begin putting in place the koala requirements.

What you will need:

- Draft zoo koala plan.
- Environment Australia "in principal" approval.
- Australian M&M TAG in principal agreement.
- Nominated Australian zoo contact.

What you must do:

- Advise your regional koala program manager of the status of your approvals.
- Establish your koala eucalypt plantation.
- Commence design and construction of your koala facility.
- Establish a transaction timetable with Regional koala group or nominated Australian Zoo.

What others will do:

- Commence their preparations such as breeding, swapping animals.

b) Accreditation & Final Approvals

- Background Information

- Every institution that receives animals from Australia must be accredited with Environment Australia.
- The exhibit and holding facility proposed for the koalas must be accredited as well.
- Not every zoo holding koalas in Australia is accredited to export.
- The criteria for accreditation are outlined in Environment Australia's R1 & R2 forms.

What you will need:

- Environment Australia's R1 & R2 application form (you should have received this earlier). This needs to be revised if required, completed and signed.
- Photos and plans of your koala facility.
- Photos of your Eucalyptus supply.
- Verification of your Eucalyptus supply.
- Details on your zoo's financial stability.
- Details on your proposed koala staff.

What you must do:

- Submit all completed documentation, compiled in an indexed folder, to the nominated Australian Zoo.
- Sign the "Trading Policy Declaration". This is a part of the R1 & R2 form.

What others will do:

- If the Australian zoo facility is not accredited with Environment Australia, then it must apply for accreditation as well.
- The nominated Australian zoo will endorse and submit your documentation as your sponsor. The Australian zoo will apply on your behalf for the approval to export.
- Environment Australia may arrange for a site inspection of your facility by a government official.
- Environment Australia will, pending completion of your plans as detailed for the "In principal" approval, accredit your zoo and approve the transfer.

c) Ambassador Agreements

- Background Information
- Every institution acquiring koalas may be required to become a signatory to a Tripartite Ambassador Agreement. This signed agreement is between Environment Australia, the importing zoo and the exporting zoo.
- Section 47A of the *Wildlife Protection (Regulation of Exports and Imports) Act 1982* provides that, in the case of native Australian animals as an inter-zoological gardens transfer, conditions may be imposed on an export permit requiring the exporter of such animal(s) to enter into a specified kind of legally enforceable Agreement about the treatment or disposal of the animal(s) and any progeny of the animal(s).
- The agreement shall apply where the importing zoo receives animals either directly from Australia or from any other source.

The principle areas the agreement addresses are:

- Display and holding facilities.
- Management of the animals.
- Care of the animals.
- Handling of the animals.
- Health of the animals.
- Reporting requirements.
- Use of the animals for commercial/ publicity purposes.
- Cooperative management and variations to the agreement.

What you will need:

- An unsigned Ambassador Agreement.

What you must do:

- Discuss with the nominated Regional koala group or Australian zoo the detail required in the ambassador Agreement.
- Forward your signed copy of the Ambassador agreement to the Australian Zoo.

What others will do:

- The zoo nominated to work with you will advise on any specific requirements.
- Environment Australia may include specific requirements if needed.

d) Internal Permits

- Background Information
- Often the importing country will require you or the exporting zoo to obtain their permits or meet their requirements.

What you will need:

- This is dependant on your Country's Wildlife or Agriculture Agency requirements.
- In Japan you should check to see if you need a permit from the Ministry of International Trade Industry and the Ministry of Agriculture, Forestry and Fisheries. (at present it is not required)

Currently in the USA koala's are not listed by USFWS. There is no permit required but checks should be made. However any plant material accompanying the animals must have a Phytosanitary Certificate issue by the Australian government.

What you must do:

- Discuss with your Wildlife or Quarantine agencies the permits required and the pre-departure requirements that may be imposed on the exporting zoo eg. animal isolation for 30 days.

What others will do:

- Zoos in your country, who have imported stock recently should be able to provide the relevant information and contacts.

3. Transportation & Training

a) Training

- Background Information
- Keeping staff who have not already worked with koalas will need to be trained.
- Veterinary staff who have not worked with Koalas will need experience.
- Training can take place in an approved zoo.

What you will need:

A training program for your keeping and Veterinary staff.

Approval from M&M TAG regional Koala program on training zoo selection.

What you must do:

- Undertake a training program in another approved zoo that is maintaining Koalas.
- Complete training after approvals and prior to arrival of stock.
- A training program should be designed in consultation with the exporting zoo. It will depend on the level of experience your staff have had with koalas. A "basic training" course for Keepers and often Veterinarians will cover the following elements:

Time: 2 weeks or more dependent on experience.

Methods: Video, slide lectures, observation, hands on practical experience, written material.

Content:

Husbandry

Health, behaviour, pedigree, mating breeding, juvenile breeding, stage of young leaving pouch, lactating female, birth, cleaning regime, feeding, collection of eucalyptus, storage and care of eucalypts, diet (amount of eucalyptus intake) capture and restraint, transport.

Exhibition

How to design and maintain koala exhibits, koala escape ability, enclosure furniture.

Eucalyptus Plantations

Species, soil/plant interaction, climate effects, care and maintenance, collection methods.

Health

Diseases - causes, diagnosis, treatments, stress levels, stomach flora and digestion, anaesthesia, after care.

Information

Keeper presentations/talks.

What others will do:

- Regional Koala program or M&M TAG will provide a contact for a suitable training zoo.
- Zoos already holding koalas in your region will offer their zoo as a training venue.

b) Export Conditions

- Background Information
- To ensure the safe, overseas transfer of koalas Environment Australia and Australian Zoos have developed and endorsed a set of conditions that need to be adhered to.

What you will need:

- Conditions for the Overseas transfer of Koalas document.

What you must do:

- Follow the conditions of export as described.
- Discuss with the exporting zoo and gain approval from Environment Australia for any variations
- Prepare transport boxes and itinerary.
- Prepare browse supplies. If possible arrange for your browse to be fed to the koalas you are importing prior to their travel.

What others will do:

- Environment Australia, your Regional Koala Program or M&M TAG will provide copies of documents. Australian exporting zoos will provide advice on variations to document if required.

c) Permits

- Background Information
- You will require a range of permits from many different agencies in Australia and in your country.
- Occasionally you might require permits from agencies in countries where the aircraft stops to refuel
- Your agencies will often require you to obtain the Australian Government Export Permit prior to you being able to obtain your various import permits.

What you will need:

- Import permit.
- Stopover permits.
- Phytosanitary Certificate (In the USA any plant material accompanying the animals must have a Phytosanitary Certificate issued by the Australian government).
- Flight schedules.
- Copy of Environment Australia's export permit and the Australian Quarantine Inspection Service (AQIS) health certificate.

What you must do:

- Obtain any import permits at least 60 days in advance of the koalas arriving.
- Send to the exporting zoo any importing health requirements eg. pre-export checks, isolation periods.
- Determine if a customs invoice is required by the importing country and advise the Australian zoo.

What others will do:

- The Australian zoo will obtain:
- State export permit for Koalas and browse.
- Environment Australia export permit.
- Australian Quarantine Inspection Service (AQIS) health certificates.
- Veterinary Health Certificate.
- Airway Bill (weight of boxes with koalas and browse included).
- IATA form and approved crate.
- Freight warranty form if not prepaid.
- Customs invoice if required by importing country.
- A Phytosanitary Certificate for accompanying plant material.

d) Travel

- Background Information
- Often the travel arrangements from the point of arrival in your country need to be arranged separately. This may include light plane or road transport.
- The introduction of koalas to a new environment after a long journey needs to be fully planned
- The shipment may be required to be accompanied by an Australian keeper or veterinarian experienced in the care of koalas. They will stay with the animals until they are satisfied that the settling in to the new environment and routine is satisfactory.

What you will need:

- Conditions for the overseas transfer of Koala.
- Transport crate dimensions and weights.
- Depending on climate, a heated or airconditioned vehicle.

- Example introduction protocols for releasing the animals into a new environment.

What you must do:

- Determine your internal travel arrangements.
- Ensure transport crates can be carried (particularly fit through doorways).
- Arrange access to crates at the arrival airport.
- With the exporting zoo determine the most appropriate Introduction Protocol.

What others will do:

- Exporting zoo will ensure appropriate travel arrangements for Koalas and staff to the departure point is arranged.
- The exporting zoo will use an existing Introduction Protocol or they will assist you to design one specific to your situation.

4. Completion

a) Ongoing reporting

- Background Information
- The transfers have been completed and the animals have settled into their new surroundings.
- Reporting of major events such as births, deaths, significant disease should occur as they happen.

What you will need:

- Veterinary post mortem reports if warranted.
- Breeding notes.

What you must do:

- Provide regular (at least annual) information on health, condition, breeding status, births, deaths, transfers, browse status etc. to regional koala manager.
- Report regularly, as per the terms of the Ambassador agreement, to the Australian zoo or other zoo you received the koalas from and Environment Australia.

What others will do:

- The regional koala manager will include relevant information into annual studbook and species management plan.

Definitions

Region - A "Region" is defined in this document as any geographic area in which koalas are managed collectively by two or more zoos.

Koala Group - A "Koala group" is defined in this document as the total number of koalas held in any one zoo.

Notes

M&M TAG refers to Monotreme & Marsupial Taxon Advisory Group.

Regional Koala Coordinator refers to person managing a koala population for a group of zoos. Not necessarily in one geographic area. The person may be the studbook keeper, or a Zoo Association approved position such as program manager or coordinator.

Appendix 5. The Management of Eucalyptus plantations for Koala Fodder. ASZK WORKSHOP 14 August, 1999.

SUMMARY SHEET

This summary sheet information is presented as a guide to institutions wishing to acquire koalas or produce eucalypt fodder for other animals. Australian Zoos, who have exported koalas, can provide additional information. Qualified horticulturists, experienced with eucalypt plantation management, should be consulted at all stages of plantation development.

The growth rates of plantation eucalypts will vary depending on the climate, soil conditions, insect pests and harvesting rates. Growth rates must be taken into account when planning your plantation and species of eucalyptus from cold climates tend to grow slower.

General Principal: Successful plantations aim to produce high quality, palatable leaf by removing factors that adversely affect the growth of the tree.

Paul O'Callaghan
Lone Pine Koala Sanctuary
Jesmond Road
Fig Tree Pocket
Queensland Australia 4069

1. Why Plantations.

- Plantations, although costing more initially in capital expenditure, are generally cheaper than the costs associated with roadside collection or purchase from commercial sources.
- Plantations provide a reliable and controlled supply of leaf fodder for koalas as well as other animals.
- Zoos and Wildlife parks have an obligation to educate their visitors about the sustainable use of our natural resources. We have responsibility to be environmental role models.
- Plantations allow absolute control of the quality of food being given to the koalas we care for.

2. Site Selection.

Factors to consider when purchasing or selecting land to be used for plantations:

- Distance to institution eg Travelling time = staff time and affects leaf quality.
- Soil types and fertility:
 - i) Check for salinity levels. This will vary from species to species but generally low salt levels are preferred.
 - ii) Need to check drainage as this will determine species selection. Most species prefer well-drained soils.
 - iii) Select a soil type that suits 80% of the species you intend to grow.
 - iv) Soil test for fertility. High soil fertility will save costs though less use of fertiliser and will generally produce highly palatable leaves.
 - v) Avoid heavy clays and loose sands. A limited number of species will grow well on these soils.
- Existing vegetation:
 - i) Don't plant a plantation under a canopy of any species as competition for light and water will hinder growth.
 - ii) Existing vegetation will give an indication of soil conditions eg Ironbarks and Bloodwoods = poor soil; Redgums = fertile soils.
- Access to good, year round, quality and quantity water supply for irrigation.
- Accessibility to the site in inclement weather eg clays stay wet a long time.
- Surrounding land use that may cause damage to the plantation or leaf quality eg fires, use of chemicals, smoke and ash.
- Aspect of land eg avoid slopes that do not face the sun and slopes facing strong prevailing winds.

3. Land Preparation.

- Land preparation aims to provide optimum conditions for tree growth by reducing competition for nutrients, light and water and any hindrance to root development.

- All existing vegetation should be removed except in areas that are not going to be planted. May leave some existing specimen trees to attract birds.
- Retention of vegetation surrounding the plantation is encouraged as it attracts birds into the area and reduces eucalyptus specific pest opportunities.
- Rows should be formed according to land contours to prevent erosion.
- Ripping of rows essential to breakup hard pans and compaction.
- All rows should be mounded to prevent water logging and to provide extended depth for root penetration.
- Rotary hoeing may be required to provide friable soil for root/soil contact, particularly when the trees are small.

4. Species Selection.

- You must look at the eucalypt species that the animals are being fed at present and which are the preferred species.
- Confirmed preferred species should make up majority of trees that are planted. 70-80%.
- Other species and new species not fed before should be planted in small 'trial' numbers to gauge animal's response, novelty value and the effect of plantation palatability versus – wild eucalyptus palatability.
- Plant at least five staple ie-preferred species and three other species. The greater number of species planted the greater the flexibility in feeding the animals.
- New species and species for other climatic or geographic areas should be trialed first in small numbers as they may not grow well or be palatable.
- Select species according to soil type and conditions eg wet soil = water loving species etc.
- Different Eucalypt 'types' have different growth rates that generally relate to the amount of leaf on the tree (large amount of leaf = faster growth rates). Iron-barks and boxes tend to be slower growers than the gum and stringy-barks.

5. Planting Density

- Will depend on the size pieces and age of browse preferred eg tips versus leaves, to be collected and the growth habit of each species.
- Closest planting should be one a metre apart with the largest gap between trees being 2 metres.
- Space between rows needs to be large enough for maintenance eg vehicle access moving, spraying etc, without causing damage to the trees.
- A koala eats between 400-1000gm (10% of its body weight), per day. The quantity will depend on the age of the leaf, moisture content, season, activity level of koalas eg breeding, lactating etc, and the age and weight of the koala. A general ratio of trees to plant is 1000 trees per koala.

6. Planting.

- Trees selected should be tube stock.
- Whether to mix plant or block plant species will depend on the number of animals to be fed. Recommend to block plant for ease of collection.
- Trees should be planted after being grown in grow tubes to promote straight root growth. Allows the tree to establish faster because the roots are facing downwards instead of having formed a ball.
- Trees must be removed from the growth pots as soon as possible as failure to do so have been shown to cause poor root growth and stem rot.
- Don't stake trees for any reason. Staking can artificially support the tree and weaken root growth. Rubbing on stakes can also cause stem rot.
- Planting should occur late winter after the last frost.
- Consideration should be given to vertebrate pest control eg tree guards.

7. Soil Fertility and the Relationship to Palatability

- Research has shown that soil type and the amount of available nutrients in the soil determine leaf palatability.
- Koala leaf preference has been shown to be directly related to the percentage of nutrients to anti-nutrients (tannins etc) in the leaf.

- Research has shown that wild areas of high soil fertility have higher densities of koalas.
- Trees produce fewer anti-nutrients in fertile soils. These include tannins and cineols etc which makes the leaf taste bad and protect it from leaf insects.
- Important nutrients for good Eucalypt growth are Nitrogen (N), Phosphorus (P), Potassium (K) plus Calcium (Ca), Magnesium (Mg), Copper (Cu), Sulphur (S) and Borax (B).
- It is important to have High N, High K and Low P.
- Fertiliser should be applied twice per year.
- Quantity of fertiliser used is determined by harvesting rates.
- It is preferable to use organic fertilisers however chemical fertilisers can be used if they are checked to ensure they do not effect leaf palatability.
- Soil test at least once every 3 years to determine effects on soil fertility.
- Feeder roots occur in top 10cm of soil so avoid excess watering after application.
- Don't clump fertiliser as this may cause burning and tree death.
- Avoid fertilising immediately before or after spraying with herbicides as may cause a chemical reaction and affect tree growth.

8. Irrigation

- The ability to provide water to the trees is essential to eliminate drought as a limiting factor to tree growth.
- Can use Dripper lines, T tape or overhead. Overhead is preferable as there are fewer problems and the sprinklers wash the leaves regularly removing any foreign substance.
- How much and how often to irrigate will depend on soil type and natural weather conditions.
- When trees are planted, they should be irrigated until well established eg noticeable development or growth eg usually around two weeks.

- After trees are established they should be stressed to encourage root growth. Stress the trees over the first year to the point where new growth starts to droop. At this point trees should be well watered. This will only need to be done two or three times in the first year.
- Irrigation on mature trees can be used to promote new growth in blocks.

9. Weed Control.

- Competing vegetation growth is a major limiting factor to growth through competition for light and more importantly nutrients.
- Grass is a major consumer of nutrients due to fast growth rates.
- Weed control should ensure a one (1) metre square area around the base of the tree free of vegetation.
- The two most effective preventative weed controllers are weed mat and mulch.
- When spraying weeds, use a non-residual herbicide such as Bioactive®.
- Avoid sprays with surfactants as they are damaging to the environment.
- Care must be taken when spraying young trees as green stem absorbs poison at 1/3 the rate less than foliage.

10. Pest Control.

- Avoid using sprays as it may affect the palatability of the leaf and kill friendly bugs.
- Where practical, manual removal of most pests can quickly achieve results.
- Insect deterrents may be beneficial eg permiculture.
- Planting mixed species in stands will attract less insect pests.

11. Harvesting Techniques

As a general guide:

- Trees must be at least 10 months, post planting presuming you have planted trees 2-3 metres in height and you have good seasonal growth for harvesting.
- A trial comparing coppicing trees to pollarding trees showed that pollarding produced a branch suitable for cutting faster than a coppiced tree. It also showed that far fewer trees died from being pollarded.
- Trees react to the stimulus of having branches removed. This allows the harvester to shape the tree how they prefer.
- Removal of a branch on a tree can often stimulate the tree to produce young growth on all the remaining branches.
- Trees are competing between themselves for light and this affects the extent of growth of the lateral branches.
- Individual pieces on a tree are also competing with each other and thinning loads are required to reduce timber production and increase leaf production on the tree.
- Trees should be harvested at a height that is comfortable for the person harvesting and above the height that maintenance equipment will cause damage.
- All harvesting cuts should attempt to be on a 45° angle to allow maximum exposure to sun and to encourage water runoff.
- Saws or similar equipment should always be used to harvest to prevent splitting of the trunk.

12. General Plantation Maintenance.

- Lower branches and shoots should be removed to allow air movement at ground level through the plantation.
- Replanting all gaps and replacing all dead trees every 2 years will ensure continued leaf production.
- A major coppice of individual trees may be required if the bole at harvesting level becomes too large or if large amounts of dead timber are present.
- Because of the effect of constant, young growth, production and removal, the expected tree life will be greatly reduced eg some tree species that usually live over 200 years may be old at 10 years in a plantation. Signs of this may be reduced leaf production, increased insect attack and death.

