DRAFT

HUSBANDRY MANUAL

for

GILBERT'S POTOROO

(POTOROUS GILBERTII)

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SUMMARY

Gilbert's Potoroo was rediscovered in December 1994 after being believed extinct since the early 1900's (Shortridge, 1909). A captive colony was immediately established as insurance against loss of the only known wild population, and an Interim Recovery Plan prepared (Start & Burbidge, 1995). Since the rediscovery, the main focus of the program has been to search for more animals in the wild, and to breed animals in captivity with a view to eventually translocating them into parts of their former range.

The captive animals were initially housed in Noisy Scrub-bird aviaries and in July 1995 were transferred to a custom build facility. This consists of eight cages built around natural vegetation. Six young have been born in captivity since the move to the new enclosures, and a further two young that entered the colony as pouch young have been raised to adulthood. Little is known of the social organisation of the species in the wild although several males and females occupy overlapping ranges. Animals in captivity are highly selective in their mate choice and it is possible that breeding is monogamous. Reproduction occurs throughout the year, with a possible break during the winter months.

The diet was based on that fed to Long-footed Potoroos at Healesville sanctuary, with some modifications. A preliminary study of the diet of the wild populations indicated that the diet in the wild consists of at least 90% fungi. The diet in captivity includes mushrooms, fruit, root vegetables, nuts and mealworms.

Health of the animals in captivity has generally been excellent. One old female died of renal failure caused by a build up of oxalate crystals in the kidney but the aetiology of the condition could not be determined. Another, also old female has developed cataracts and an haemangioma on the right hind leg which was surgically removed. Parasite loads in captivity include the same suite of species as in the wild, including an as yet unidentified blood parasite, possibly of the genus *Theileria*.

Hygiene in the colony is of the highest priority including daily cleaning of feeding bowls, separate footwear used in the pens and in the field and regular raking and changing of the substrate to remove faeces and food scraps. Water bowls are cleaned regularly and wather changed daily. After an intensive assault on the pens using multiple mouse traps which are kept in the cages on a permanent basis, the colony is entirely free of mice.

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INTRODUCTION

Gilbert's Potoroo (*Potorous gilbertii*) is Australia's most critically endangered mammal. The species was first described by Gould (1841) from a specimen collected by John Gilbert in the Albany area. A handful of additional specimens were collected over the next 40 years, but by the early 1900's it was thought likely to be extinct (Shortridge, 1909). In December 1994, Gilbert's Potoroo was rediscovered when four individuals were captured by Elizabeth Sinclair at Two Peoples Bay.

A captive colony was immediately established as insurance against the loss of the only known wild population which occurred in an area which had not be burned for 50 years and consequently was supporting extremely high fuel loads. The animals were initially housed in the aviaries kept for Noisy Scrub-birds and in July 1995 were moved into a new custom built facility.
Husbandry methods were developed in consultation with staff at Healesville Sanctuary who were caring for both Long-nosed (*P. tridactylus*) and Long-footed (*P. longipes*) Potoroos in Victoria.
This husbandry manual records the husbandry and management practices currently being implemented at the captive breeding facility at Two Peoples Bay and highlights areas for future research both for the captive colony and for the wild populations.

1. TAXONOMY

1.1. Taxonomic Position

Gilbert's Potoroo was originally described by Gould (1841) as *Hypsiprymnus gilbertii*. Ride (1970) considered it a synonym of the Long-nosed Potoroo, *Potorous tridactylus*, while Calaby (1971) considered it to be a subspecies of *P. tridactylus*. Work on the genetics (Sinclair and Westerman, 1997) and cranial morphology (Courtenay, in prep.) of Gilbert's Potoroo since its rediscovery has revealed marked differences between it and the other species of Potoroos in Eastern Australia and full species recognition is warranted.

1.2. Description and Diagnoses

Potorous gilbertii are very similar in external appearance to *P. tridactylus* and fall within the size range described by Johnston (1995) although at the lower end. Guiler (1961) reports that the mean pes length for *P. t. apicalis* is 82 mm for males and 79.5 mm for females which is considerably longer than the means of 68.3 mm for male and 67.1 mm for female Gilbert's Potoroos. *Potorous longipes* are considerably larger than *P. gilbertii* (mean weights 2.1 kg for males and 1.7kg for females) and are distinguished by having pes length longer than head length (Johnston, 1995). *P. platyops* (believed extinct) had a much broader head.

The skull of *P. gilbertii* is smaller than that of *P. tridactylus* but is relatively broader especially (as noted by Gould, 1841) in the maxillary region. The rostrum is very inflated both anterior to the incisors and above the molar row. The adult premolar is smaller in *P. gilbertii* and is flexed in appearance with a shelf like extension on the anterior lingual side. All the molar teeth are relatively smaller in *P. gilbertii* but the palate is broader (Courtenay, unpublished data).

1.3 Affinities with other groups

Genetic studies by Sinclair and Westerman (1997) comparing *P. gilbertii* with both *P. tridactylus* and *P. longipes* using allozyme electrophoresis and DNA sequencing revealed that *P. gilbertii* is at least as different from *P. tridactylus* and *P. longipes* as they are from each other. The exact interrelationships of the three species could not be established, however, with *P. gilbertii* being closer to *P. longipes* using cytochrome *b* sequence data and closer to *P. tridactylus* using allozyme data. Their study concluded that Gilbert's Potoroo is a separate species from *P. tridactylus* and should be referred to by its original name of *Potorous gilbertii* Gould 1841.

2. BIOLOGY

2.1 Morphometrics - adults

In the wild, adult Gilbert's Potoroos weigh between 800 and 1050g. Two females weighing 730g have been captured carrying pouch young. The measurements of these two females were head length 77.3mm and 77.9mm and pes length 67.5mm and 67.4mm respectively. The relatively low weights and small head lengths suggest that females are sexually mature prior to achieving full adult weight and size. Table 1 summarises the weights and measurements of wild caught adult animals.

Table 1: Weights and measurements of wild caught adult Gilbert's Potoroos. Two young females caught carrying pouch young who were less than adult size are not included in the measurements for females.

	Males	Females
Weight (g)	906.3 ± 66.6(826-1040 n=6)	893 ± 43.1 (830-965 n=7)
Head length (mm)	85.2 ±1.97 (82.8-87.6 n=6)	84.1 ± 2.09 (82.3-88.8 n=7)
Pes length (mm)	68.3 ± 1.46 (66.8-71 n=6)	67.1 ± 2.07 (63.1-69.4 n=7)

2.2 Habitat in the Wild

Very little information is available on the preferred habitat of Gilbert's Potoroo. The original collector, John Gilbert (as reported by Gould, 1863) described the preferred habitat of the Potoroo as "the dense thickets and rank vegetation bordering swamps and running streams" and noted that they were the "constant companion" of Quokkas, *Setonix brachyurus*.

The habitats in which the species has so far been trapped on Mt. Gardner are characterised by low, dense heath often dominated by *Melaleuca striata*. Accumulations of *Allocasuarina fraseriana* needles are sometimes used for shelter. A detailed study of microhabitat use by one sub-population of Gilbert's Potoroos showed that the animals are not confined to the thick vegetation and spend a considerable portion of each night foraging in the relatively open patches of sedge between *Melaleuca* thickets or in open ground under patches of *Banksia* spp., *Eucalyptus marginata* or *Eucalyptus calophylla* (Vetten, 1996).

2.3 Diet in the Wild

Studies of the diet of *P. tridactylus* indicate that they eat roots, tubers, fungi, insects and their larvae as well as other soft bodied soil invertebrates (Johnston, 1995). The diet of *P. longipes* is less varied consisting principally of the fruiting bodies of underground fungi which account for over 80% of the diet. Some invertebrates and a small amount of vascular plant material are also eaten (Seebeck, 1995). Analyses of the scats from five animals collected between December 1994 and March 1998 revealed that the diet of *Potorous gilbertii* consisted almost exclusively of fungi. Over 90% of the material in the scats was either fungal spores or undigested fungal material, the remainder being unidentifiable detritus. No plant or insect material was found. Since the scats were collected at different times throughout the year, it seems that fungi (both epigeal and hypogeal) are the principle component of the diet at all stages of the annual cycle (Bougher, 1998)

2.4 Behaviour - inter- and intra- specific

Inter-specific

Nothing is known of the interactions between *P. gilbertii* and other species. Other mammals which are common in the same areas are Quokka (*Setonix brachyurus*), Quenda (*Isoodon obesulus*) and Bush rat (*Rattus fuscipes*) but the extent of interaction or competition with any or all of these species for food resources or nest sites is unknown. Competition with *R. fuscipes* for food resources is a possibility as they are known to eat hypogeal fungi (Lunney, 1995). Competition with Quokkas would most likely involve nest sites (if anything) rather than food resources.

Intra-specific

Very little is known of the intra-specific behaviour of *Potorous gilbertii* in the wild. Johnston (1995:302) notes that while Long-nosed Potoroos are "solitary and sedentary, trapping records indicate that individuals tend to aggregate in small groups". Similar results have been obtained in trapping and spooling Gilbert's Potoroos, indicating that several adult males and females occupy largely overlapping ranges (Vetten, 1996, Courtenay unpublished trapping data).

The cages in the captive colony are fitted with infrared lights and low light video cameras to enable observation of behaviour with minimal disturbance to the animals. A preliminary study of the reproductive behaviour of the captive animals was conducted by Kylie Burke during 1997. This study

resulted in a preliminary behavioural catalogue and descriptions of various sequences of behaviour including sexual, agonistic, feeding and marking (Burke, 1998, Courtenay, Burke and Needham, in prep.). Food sharing was observed between mother and young on a number of occasions and nest sharing between both mother-young and male-female dyads is not uncommon. Male-female pairs are generally socially compatible, frequently sitting, feeding and nesting in close proximity. Continuing study of these groups will provide further information on intra-specific interactions including aggression, courtship and mating behaviour, mother-young relationships, and feeding behaviour.

2.5 Physiology - adaptations to climate etc

The condition of wild caught animals is variable but it is not yet known whether these variations represent seasonal fluctuations in body weight. Other aspects of physiology of this species are not known.

2.6 Reproductive Biology

Very little is known of the breeding behaviour of *Potorous gilbertii*, although quite detailed information is available for both *P. tridactylus* and *P. longipes* (eg. Bryant, 1989, Seebeck, 1992, Shaw & Rose, 1979).

Gestation in *P. tridactylus* is the longest known for any marsupial at 38 days, or 29 days for an embryo that has been in diapause (Shaw and Rose, 1979). Female Long-nosed potoroos become sexually mature at about twelve months of age and appear to breed throughout life. Young are apparently born throughout the year in the wild but with birth peaks in early spring and late summer (Johnston, 1995). Seebeck (1992) reports, however, that in *Potorous longipes* breeding in captivity occurs only in the second half of the year, and no young have been born in captivity earlier than June.

All reproduction of Gilbert's Potoroo in captivity has occurred since the animals were moved from the Noisy Scrub-bird aviaries into the new facility in July 1995. The absence of breeding prior to this was the result of a combination of factors including the set up of the Noisy Scrub Bird facilities which limited the opportunities for pairings, the stress of being brought into captivity or moving into the new facility (which resulted in two females ejecting pouch young), and the fact that only one of the males was of breeding age.

Between July 1995 and April 1998, six young have been born in the captive colony, four of which have been reared to independence (one died prior to

weaning about a month after its aged mother died and the sixth is still unweaned at the time of writing). In addition, two young which entered the colony as pouch young when their mothers were captured have been raised to maturity. The following results are therefore based on data from between 6 and 8 young in captivity plus up to 12 young which have been measured in the wild.

Of the six young of Gilbert's Potoroo raised in captivity between April 1996 and April 1998, three were born in December, one in October and two in April. One of the April young was a known diapause young from a December mating. Wild caught females have been found carrying pouch young of all sizes throughout the year, although young born in the middle of the year may be diapause young from summer matings. Figure 1 illustrates the distribution of births for 21 young born to both wild and captive females. Birth date estimates of wild animals are based on the size of the young at capture. The pattern at this stage suggests that breeding occurs through most of the year with a possible break during the winter months, with most births (16/21) occurring during summer and autumn. Further data are required to confirm this but it is not inconsistent with the apparent period of anoestrus from March to late June noted in *P. tridactylus* by Hughes (1962) .

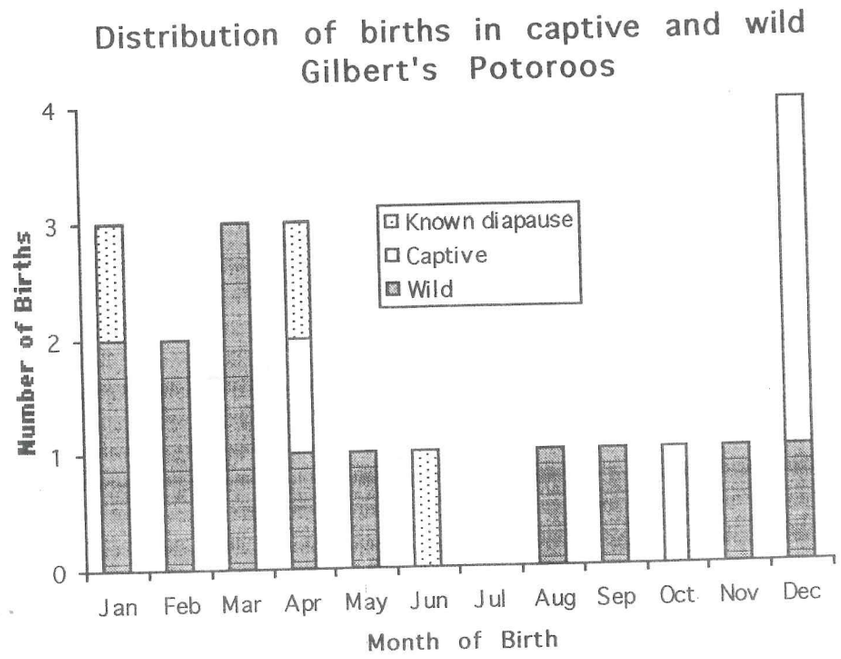

Figure 1: Monthly distribution of births in wild and captive Gilbert's Potoroos. All known diapause young were born in captivity.

The youngest known age animal to reproduce in captivity sired his first young at 14 months of age. No known age females have yet produced young but it is likely that they reach sexual maturity at a similar age. One female caught in the wild carrying at least her second pouch young (a neonate in the pouch and an unweaned young at heel) was aged about 18 months (based on dental eruption and wear). This suggests that sexual maturity is reached at around 12 months. This has not been confirmed with known age animals, however, as none of the young females born in captivity have bred, even though three of them are now over two years of age.

Among the known adult animals strong mate preferences appear to exist. Certain pairings are infertile even though both male and female are proven breeders with other partners. It is possible that breeding is monogamous, or that the social arrangements within the colony are somehow not ideal for reproduction although varying combinations of males and females have been tried. Some females have been left with their mothers during their first pairing with an adult male as it has been shown in Brush tailed Bettongs, *Bettongia penicillata*, that young females housed with their mother experience improved breeding success (Lissowsky, 1995). Unfortunately, none of the older adult females bred successfully with any males other than the young female's father and thus were presumably not modelling receptive behaviour when housed with other males.

No information is yet available on the length of either the oestrus cycle or gestation period, although the gestation period at least seems to be of similar length to the 38 days observed in *P. tridactylus* (Hughes, 1962). This is based on a combination of behavioural observations and the dates of pairing and separating male/female pairs and the birth of young. Embryonic diapause occurs in *Potorous gilbertii*. One female produced young in the captive colony following the loss of an existing pouch young and without further access to a male, and another, having reared a young to permanent pouch exit, was found to have a new young in the pouch, again without having had access to a male.

2.7 Growth and Development of Young

Female *Potorous gilbertii* have well developed deep pouches containing four teats but only single young have ever been observed. Of the eight young which have been born in the colony, six have survived to permanent pouch exit. Two were lost in the early stages of pouch life, the first shortly after the mother was brought into captivity at the time of the rediscovery, and the

second, shortly after the mother was moved from the Noisy Scrub-bird aviaries to the new facility. No other young are known to have been lost since the animals have been settled in the new cages.

Because increasing the population is the highest priority at this stage and disturbing the females may cause them to eject their young, no studies have yet been done on the growth of young during pouch life. Young remain in the pouch for about four months. The period between first exit and permanent exit from the pouch is very short with young first venturing out at about 150-180g body weight and exiting permanently about five days to one week later at around 190g. Once they leave the pouch the young gain weight at a rate of about 6g per day and are weaned about eight weeks later when they weigh around 500g. Preliminary growth curves in later pouch life and following pouch exit based on seven individuals (including 2 which were wild born but exited the pouch in captivity) are presented in Figure 2.

The teeth of young at pouch exit include the deciduous upper and lower central incisors, the deciduous premolar and M^1. The second deciduous incisor and M^2 are erupting. The deciduous canine begins eruption just prior to weaning.

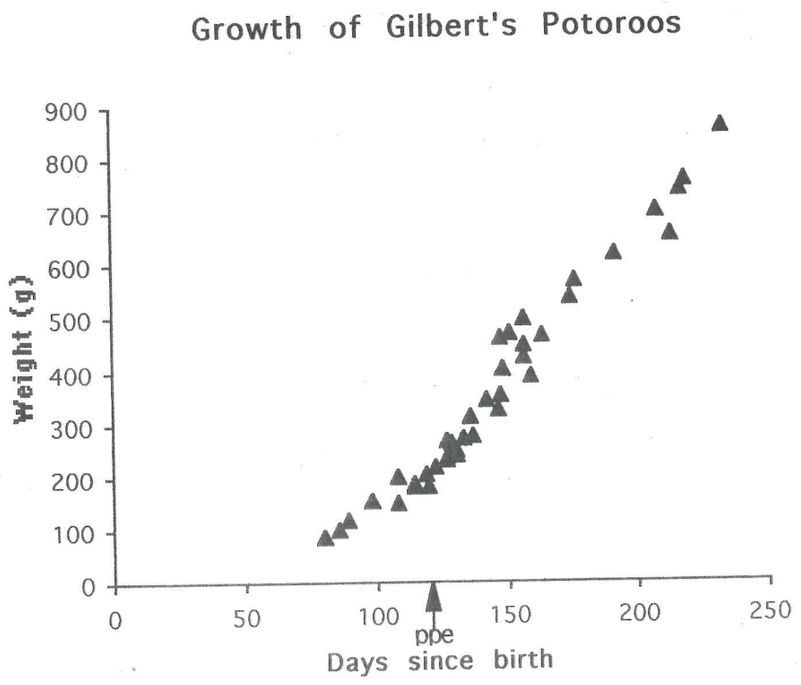

Figure 2: Growth patterns of seven young Gilbert's Potoroos beginning in late pouch life.

2.8 Activity Patterns

Potorous gilbertii in captivity are not strictly nocturnal. While animals are inactive during the middle of the day, all animals are occasionally (or in some cases, commonly) active either before sunset or after sunrise. Activity before sunset is sometimes encouraged by food being placed in the cages, however animals are active earlier even in the absence of food. In a recent behavioural study (Burke, 1998) food bowls were removed from the cages in the early morning and replaced with food after sunset to avoid distorting activity patterns. All of the animals were observed to be active prior to sunset and after sunrise on at least some days. Cages were videoed using low light cameras and infra-red lights, therefore animals were not being affected by the presence of an observer.

2.9 Longevity

Longevity of this species either in captivity or in the wild is not yet known since less than 4 years have elapsed since the rediscovery. Animals are aged at first capture based on tooth eruption and wear patterns and over the next five to ten years more information will become available as known age animals age and die. One adult female in the colony is believed to be about 8 years old. This female has extremely worn teeth with large pools of dentine exposed, and began developing a cataract in her left eye in 1996. Ullman and Brown (1983) report that a male *P. tridactylus* began to develop cataracts at 6 years of age.

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3. HUSBANDRY

3.1 Housing

Since July 1995, the potoroos have been housed in a custom built facility consisting of eight cages with removable interconnecting doors and a handling and food preparation area (Figure 3).

Enclosure

Each cage is 3m wide by 10m long with sand substrate. The cages are built around existing shrub/heath vegetation. A 3m space adjacent to the access door is cleared for a feeding and observation area and the remaining 7m of natural vegetation provides shelter and an environment which resembles the potoroo's natural habitat. The 3m space adjacent to the door is also roofed to provide additional shelter and nesting material is placed in this area. Water taps are located in each pen and water bowls are cleaned frequently and refilled daily.

Substrate

The substrate consists of sand and native vegetation. Piles of *Allocasuarina* needles are provided for nesting.

Lighting and Temperature

Natural lighting and temperature. All cages are also fitted with overhead 40 watt red 'party' lights for opportunistic observations and infra-red lights (150 watt halogen lights fitted with layers of red and purple glass) for use with the low light video cameras for more detailed study. The light cast by the infra-red lights is invisible to the human eye.

As of April 1998 the eight cages house 13 individuals including 11 adults (5 males and 6 females), a sub-adult female and a juvenile male.

Animals are housed in a number of social arrangements in order to maximise breeding and avoid aggression. In captive colonies of *Potorous tridactylus* in the United Kingdom aggression, especially between males, has been a problem (Ullman & Brown, 1983). In the absence of equivalent information for Gilbert's Potoroo housing arrangements are organised to minimise such risks. One or two adult females are generally placed with an adult male (either two in one cage, or in two cages with the connecting door open) until they are found to have a pouch young. They are initially left with the male for about two weeks to ensure that they have the opportunity to mate in their

Figure 3 Diagram of the captive breeding facility - (the final diagram will be more detailed, to scale, and will include a side view of the enclosures illustrating the natural veg etc)

PREP ROOM		
(1) Adult Female #4		(5) Adult Male #11 Sub-adult Female #18
(2) Adult Male #28		(6) Adult Female #1
(3) Adult Male #3		(7) Adult Male #6 Adult Female #27
(4) Adult Female #10 +py Sub-adult Female #32		(8) Adult Male #7 Adult Female #19

post-partum oestrus, after which they are housed alone to avoid disturbance during routine handling of cage mates. Young are generally left with the mother either until adolescence (males), or until the female is paired again with the young animal's father (females).

One old adult female is housed alone because she is apparently post-reproductive as all attempted pairings have been infertile and resulted in injury. She is kept for education and publicity purposes because she can be handled without risking interference to the breeding program. Individual males are also sometimes housed alone, for example, when there are no available females with which to pair them.

3.2 Handling and Transportation

Animals are handled approximately once per fortnight for routine weighing and general health checks. All cages are fitted with a soft plastic mesh drift fence which is angled into the side of the cage, ending in a short tube (Figure 4 - to be prepared). These fences are left permanently in the enclosure to allow animals to become accustomed to moving past the fence and through the tube. When animals are to be captured, a hessian bag is placed over the end of the tube and held firmly in place by a wire arch. The animals are then shepherded into the back of the cage, along the drift fence into the tube, and into the hessian bag. The bag is then detached from the tube and the animal transferred into a calico handling sack. This procedure is generally accomplished with minimal stress to the animal. All handling is carried out with the animal held in the calico bag with the bag covering the animals eyes.

Adult animals are weighed in the bag using a Sartorius electronic balance, teeth, gums and claws checked and any scats collected for parasite analysis. Females are checked for the presence of pouch young and, if present, the crown-rump length and sex of the young are recorded. As noted above, they are then initially left with the male for about two weeks to ensure that they have the opportunity to mate in their post-partum oestrus, after which they are housed alone until the young exits the pouch. Scrotal length and breadth measurements are taken on all males and the penis is checked for inflammation or infection. Once the animal is fully grown, other measurements such as head length, pes and tail length are taken at about six monthly intervals.

Young animals are examined more thoroughly including measurements of head, pes, tail and ear length, and examination of teeth to determine eruption sequences and timing. These measurements are being used to develop growth curves and methods for estimating age in wild caught animals.

All animals are injected with a Trovan microchip for individual identification.

3.3 Nutrition and Diets

The Two Peoples Bay colony are fed a diet modified from that used for the Long-footed Potoroo (*Potorous longipes*) at Healesville Sanctuary (Merril Halley pers. comm.). Animals are fed daily in the late afternoon. Sweet potato and apple are supplied daily. In addition, banana, mushroom and carrot, or sweet corn, bean and firm pear are provided on alternate days. Nuts (either 2 almonds and one pecan, or 2 peanuts and 1 brazil nut) are provided daily, as are natural dog food cubes. Mealworms are given twice per week. Various other vegetable and root foods are tried at intervals, and foods discontinued either temporarily or permanently if the animals cease to eat them. All food is weighed prior to being placed in the cages with an aim to providing at least 100g of food per animal. Table 2 lists the components of the diet and approximate weights of each food when feeding 13 animals.

Young at heel are provided with their own dish of food once they reach about 200g body weight. Prior to this size only one dish is provided but quantities are increased slightly to ensure adequate nutrition for the lactating female, and for the young to begin eating solid food without reducing the mother's intake.

All visible leftover food is removed from the cages prior to feeding and consumption recorded. This provides a check that the animals are eating well (and if not alerts the keeper that veterinary attention may be required) and provides information on preferred (or ignored) foods, thus enabling modifications of diet.

3.4 Hand-raising Techniques

No pouch young have yet been hand reared for this species. If it is necessary at some stage to hand rear an individual, techniques will initially be based on those which have been used successfully to rear young Woylies (*Bettongia penicillata*) and modified as necessary. These involve regular feeding (at least 3-6 hourly depending on the size of the young) using either Divetalact or Wambaroo milk made up to manufacturers directions. Bottles with "Possum" teats with a small hole (made by snipping the tiniest amount off the tip) have been found to be most successful in feeding young Woylies. It is important that the hole is not too large or the animal may inhale the

Table 2: Food items included regularly in the diet fed to captive Gilbert's Potoroos. Amounts given as weights are then divided equally between the 13 animals. All weights given are an approximate range because they vary from day to day with, for example, the size of the fruit or vegetable. The total weight of all food given is about 1300g on banana and mushroom days and 1500g on sweetcorn days (to allow for the weight of the inedible cob). Amounts given as a number (eg 2 Almonds) are the amount given to each individual animal.

Food item	Daily (g)	Alternate Days (g)
Sweet potato	350-450g	
Red apples	250-300g	
Banana		150-200g
Mushroom		~200g
Carrot		150-200g
Sweet Corn		350-500g
Runner bean		25-30g
Pear		150-250g
Almonds		2
Brazil Nuts		1
Peanuts		2
Pecan Nuts		1
Mealworms		4 per animal (Wed & Sun)
Pet food cubes	1 or 2 (alternate days)	

milk if it is coming too fast and can quickly develop pneumonia and die within hours.

If scouring occurs, milk should be diluted to 50% strength and then gradually built back up to full strength. Young which are not fully haired should always be started on half strength milk. Solid food in the form of rolled oats, grated carrots, finely diced mushroom, baby sweetcorn and nuts, and fresh water should also be provided once the young is fully furred and weighing around 200g or more. Elimination should be encouraged after each feed in small pouch young by gently wiping the cloaca with a damp tissue or soft cloth. Young should be weighed daily before a feed and should gain an average of about 6 g per day. Some young Woylies will wean themselves by refusing milk at various feeds until they stop taking it altogether. Others will continue drinking milk as long as it is offered and weaning should be

encouraged by increasing the time between feeds (for example cutting out the midday feed) and gradually reducing the amount of milk offered.

Young should be kept at a constant temperature of around 37° or slightly warmer (unfurred or lightly furred ie black young should feel slightly warm to the touch). This can be achieved using a humidicrib or incubator, or if this is not available, a basket with a heating pad, electric blanket or hot water bottle well wrapped up. Pouch substitutes can be made out of a sock, beanie or a soft cloth bag. Young which are not fully haired (ie not thermoregulating independently) should be kept with the carer at all times, either in their heated basket or in their pouch in a waist bag. This is essential as hand reared young will climb out of their pouch much younger than maternally reared young and can quickly become cold.

3.5 Behaviour - breeding and non-breeding

Breeding

No completed matings have been observed. Observ ed courtship sequences generally involved a male closely following a female in a slow quadrupedal hop. When the female stopped moving the male would approach her, usually from behind, raise up into bipedal stance and lay his forefeet on her back. Mating attempts usually lasted less than 5 seconds with the male thrusting once or twice per second. In all observed mating attempts the female failed to raise her rump to facilitate intromission, and the male was frequently either too far away or in the wrong position (eg off to the side) for a completed mating to occur (Burke, 1998).

Non-breeding

Potorous gilbertii appears to be socially tolerant with adult males and females sharing nests and feeding side by side. Aggression between opposite sex adults generally involves short chases, cuffs and hisses. Young-at-heel and juveniles have been observed sharing food with their mother. An unweaned male young was also observed sniffing at the forefeet and muzzle of an adult male. The adult was not feeding at the time and tolerated the young animal without aggression.

Two vocalisations have been identified - a hissing used in aggressive and sexual contexts and a loud "chirruping" vocalisation usually emitted by young at heel. This second vocalisation is thought to be a distress call by young separated from their mother, although it was once emitted by an adult male when he was captured for regular handling.

Marking behaviour by males has been observed and involves rubbing the chin and chest on upright branches and vegetation.

3.6 Management of Breeding Groups

3.6.1 Purpose of the captive colony

The captive colony was established at the time of the species rediscovery as insurance against the loss of the wild population (for example through wildfire) and to eventually provide animals for reintroduction into parts of the species former range (Start & Burbidge, 1995).

3.6.2 Current practices

Figure 5 illustrates the genealogy of the captive population as of April 1998.

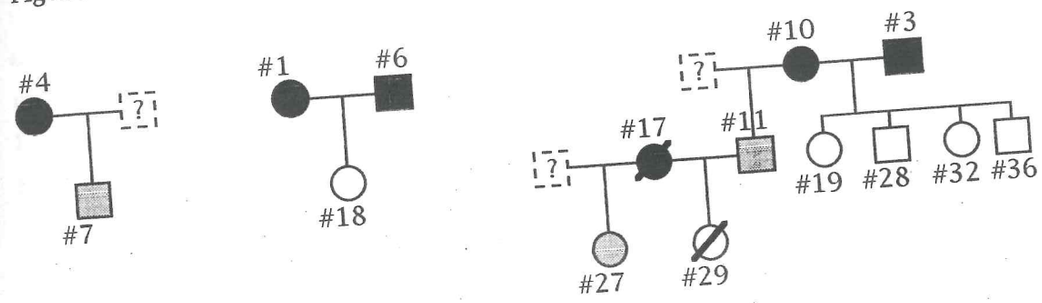

Figure 5: Known relationships of Gilbert's Potoroos in the captive colony. Key: Circle=Female, Square=Male, Solid black=Founder animal, Grey=mother known, father unknown wild, White=captive born, both parents known. Incomplete squares with question mark are unknown fathers of wild born young. Line through=animal deceased.

Table 3 lists the origins, estimated or known age and reproductive histories of all animals ever maintained in the captive colony.

As noted above, behavioural incompatibility appears to be the major challenge in achieving reproduction in this species. Currently only one male-female pair is reproducing (#10 & #3), and neither animal breeds successfully when paired with other individuals. Over the past 3 years, three couples have produced young in the colony. One couple (#10 & #3) is continuing to reproduce, the second couple (#1 & #6) produced only one young and all other pairings have failed to produce more, and the female of the third couple (#17), an aged animal, died in April 1997. All surviving animals have been paired with other individuals without success.

Table 3: Histories of all individuals ever held in the captive colony indicating their approximate (or known age), origin and reproductive history

Id #	Sex	Age	Origin	Reproduction
1	F	Adult at capture, est dob 1993[1]	Wild caught Dec 1994	Mother of #18
3	M	Adult at capture, est dob 1993[1]	Wild caught Dec 1994	Father of #19, #28, #32, #36
4	F	Adult at capture, est dob 1990[2]	Wild caught Dec 1994	Mother of #7 (in pouch at capture)
6	M	Juvenile at capture, est dob Sept 94[3]	Wild caught Jan 1995	Father of #18
7	M	Py at capture, est dob Oct 94[3]	Wild caught (in pouch) Dec 1994	No young
10	F	Adult at capture, est dob 1993[1]	Wild caught May 1995	Mother of #11, #19, #28, #32, #36
11	M	Juvenile at capture, est dob Jan 1995[3]	Wild caught (at heel) May 1995	Father of #29
17	F	Adult at capture, est dob 1990[2]	Wild caught April 1996	Mother of #27 and #29. Deceased.
18	F	Captive born Dec 1995	Captive born	No young
19	F	Captive born Dec 1995	Captive born	No young
27	F	Py at capture, est dob Jan 96	Wild caught (in pouch) April 1996	No young
28	M	Captive born April 1996	Captive born	No young
29	F	Captive born October 1996	Captive born	Deceased before maturity
32	F	Captive born April 1997	Captive born	Subadult
36	M	Captive born Dec 1997	Captive born	Juvenile

[1] Age is estimated from a combination of current tooth wear and sexual maturity (ie at least 12 months of age) at capture.
[2] Age is estimated from tooth wear and, for #4, other indicators of old age, such as the development of cataracts first noted in 1996 which in captive *P. tridactylus* appear at about 6 years of age.
[3] Ages of animals which were juvenile or pouch young at capture are the most reliable and are based on body weight at capture (compared with growth curves for captive animals) and tooth eruption and wear.

Pairings are initially chosen based on Mean Kinship Values with preferred pairings being those between animals of approximately equal values. This ensures continuing genetic balance in the colony and avoids the problem of

the genes of animals from uncommon lineages (ie those with only one or a few individuals in the colony) becoming mixed with those of common lineages (those with larger numbers of individuals). If the genes of common and uncommon lineages do become mixed, it then becomes impossible to increase the "uncommon" genes without also further increasing the "common" ones and thus contributes to genetic domination by common lineages.

If the "best" pairings based on Mean Kinship are unsuccessful, the "next best" pairing is chosen. Inbreeding is avoided until all other possible pairings have proven incompatible.

Individuals have been paired in a number of different combinations and for varying periods of time. Combinations that have been trialed include one male with one female, one male with two unrelated females, one male with mother-daughter pair, and one male with adult female and sub-adult young. Pairing more than one male with one or more females has been avoided because of fear of aggression between the males. Ullman and Brown (1983) report that male *Potorous tridactylus* can be housed compatibly together in the absence of a female but if an oestrus female is presence extreme violence resulting in serious injury can occur.

Generally, pairings are give a minimum of three months before it is decided that the pair are incompatible and other combinations trialed. Three months was chosen as the absolute minimum as this allows sufficient time for a full oestrus cycle and gestation to occur. All females who have conceived in the colony have done so within the first oestrus cycle of being paired with the male (mean time from pairing to conception for five pregnancies is 23 days). This indicates that if a couple are compatible, successful reproduction will occur quickly and that if a young has not been conceived within three months it is unlikely that it will be. Nevertheless, some animals have been paired for considerably longer than this to allow for compatibility to develop but this has not occurred.

3.6.3 Future Management of Reproduction

Maintenance of genetic variability

Maintenance of genetic variability in the captive colony is important to insure that the colony remains viable, and that any translocated population created using captive animals has a sound genetic base. As noted above, pairings are initially planned on the basis of Mean Kinship values in an

attempt to maintain genetic balance in the colony. The strong mate preferences exhibited by the animals have, however, made genetic considerations become a secondary concern. As can be seen from Figure 5 above, the captive colony is becoming increasingly dominated by animals from the #3/#10 lineage. If oestrus studies (and possibly simultaneous behavioural studies) can be carried out to enable the recognition of oestrus in the females, the use of artificial insemination may become the most important technique for ensuring ongoing genetic variability. More detailed behavioural and ecological studies may also assist in planning pairings and groupings to achieve behavioural compatibility between genetically desirable individuals.

Management of inbreeding

It has so far been possible to avoid inbreeding in the colony by breeding animals from different sub-populations and avoiding pairings of known relatives. All successful pairings have so far been between animals originating from different sites. Since May 1998, it has, however, become necessary to trial several pairings which involve inbreeding. For example, there are only two unrelated males (#6 & #7) with which to pair female #19 and neither pairing produced young. A pairing with her (proven fertile) half-brother #11 is now being attempted. Similarly, #32 (who may not yet be sexually mature) has been left with her mother #10 while she is paired again with male #3 (the father of #32). #10 and #3 are known to be compatible, and work with Woylies has shown that females left with their mother during their first breeding attempt experience improved reproductive success (Lissowsky, 1995). It was considered worth risking inbreeding between #32 and #3 if it improved her chances of breeding successfully in the future.

Maximisation of reproduction

Maximisation of reproduction is clearly the most important consideration in the management of this critically endangered species. The relatively limited reproductive success achieved so far raises a number of important questions. (a) Are the animals (both males and females) fertile? The fact that one couple are reproducing with each other on a regular basis and two other couples have reproduced once suggests that the wild caught animals are or have been fertile at least some of the time. The complete absence of reproduction in the captive reared individuals is a concern, however. Factors that may reduce fertility could include inadequate diet, overweight and stress. A small grant has been awarded to Wildlife Veterinary Services by

WWF-Australia to investigate the oestrus cycles of the captive females using faecal hormone analysis. It is hoped that this study will be able to determine whether or not the females are actually cycling. Electro-ejaculation of males to examine sperm counts and motility could also be attempted. A preliminary survey of underground fungi is being carried out (funded by a WWF-Australia Community Conservation Grant to the Denmark Environment Centre) with a view to identifying which fungi are eaten by the Potoroos. It is hoped that nutritional analyses of consumed fungi can eventually be carried out which may reveal some inadequacy in the captive diet (for example shortage of an important mineral or trace element).

(b) If the animals are fertile, why are they not reproducing? If the investigations indicate that the animals are in fact experiencing oestrus cycles and sperm counts and motility are normal it would suggest that some behavioural factors are limiting reproduction. Such factors could include stress, overcrowding, inappropriate social groupings, or reproductive suppression by dominant animals. A short term study of the behaviour of compatible and incompatible couples failed to identify any clear differences in their behaviour (Burke, 1998). More detailed, longer term studies are, however, needed. In addition, detailed studies of the social organisation, grouping and ranging patterns, and reproductive behaviour of the wild population are urgently required. This could involve radio-tracking and spooling of adult animals combined with genetic studies of offspring to determine paternity.

3.7 Artificial Breeding Techniques

No artificial breeding techniques are employed at present. Two techniques are possible for future action: (1) Creation of a sperm bank using electro-ejaculation and sperm storage techniques to preserve as much as possible of the genetic diversity present in the known population. This may be extended to electro-ejaculation of wild males and the sperm used for artificial insemination of captive females to maximise genetic diversity in the captive colony without bringing further animals into captivity.

(2) Development of techniques for cross fostering to maximise reproductive potential has been proposed. This technique may have applications in the future after improved rates of conception have been achieved. Issues of care of foster mothers, prevention of disease transfer and behavioural implications also need to be addressed.

4. MEDICINE

4.1 Diseases in the Wild

4.1.1 Ectoparasites

Almost all animals captured have had considerable infestation of ticks, fleas and mites. Ectoparasite samples are collected from all animals captured. One of the tick species was identified as *Ixodes australiensis* (Brown Besier, pers. comm).

4.1.2 Endoparasites

Scats are collected where possible from captured animals. Samples that have been analysed for endoparasitism indicate varying levels of infestation with "strongyle type" eggs and unidentified larvae. No coccidia have been observed. Identification of endoparasites and establishment of baseline parasite loads is continuing. Microscopic analysis of blood smears revealed the presence of a red blood cell parasite. The identity of the parasite has not yet been confirmed, however preliminary identification suggests that it is most likely either a *Theileria* sp or *Babesia* sp. Transmission electron-microscopy is planned to obtain better detail and, hopefully, a positive identifictation (Kevin Ellard, pers. comm.). *Theileria* has previously been reported from *Potorous tridactylus* (Collins, 1973).

4.1.3 Other diseases

Preputial inflammation/infection

An inflammatory preputial condition was observed in captive males in early 1997 (detailed below). In order to determine whether or not the condition was normal, wild males were captured and cloacal swabs taken for bacteriology. The four males sampled were found to have varying degrees of sand incrustion and swabs revealed a similar suite of bacteria to that found in the captive colony. The presence of the spirochaete identified in the captive colony could not be confirmed, although it was possibly present in one of the males. Several wild females were also swabbed and cultures revealed a similar mass of mixed bacteria and some blood cells.

No other diseases have been noted in wild animals.

4.2 Diseases in Captivity

4.2.1 Ectoparasites

Ticks and fleas have very occasionally been removed from captive animals. Generally, however, the animals do not have any ectoparasites.

4.2.2 Endoparasites

The blood parasite discussed above was first identified in the captive animals. There was initial concern that the animals may have become infected since being brought into captivity, however, the presence of the parasite in wild caught individuals indicates the the parasite is naturally occurring and probably non-pathogenic (Kevin Ellard, pers. comm.).

Scat analyses have revealed a similar suite of endoparasites to those identified in the wild animals. Any diarrhoea found in the cages is routinely sent for bacteriological anaysis but to date results have always been normal, no treatment has been required and the condition has resolved itself in one or two days. The diarrhoea was most likely due to a minor change in diet (eg introduction of a new food) or stress.

The following endoparasites have been identified from captive potoroos: *Pasteurella hemolytica*, *Actinobacillus* sp., *Lactobacillus* sp, Coccidial oocysts.

4.2.3 Other Diseases

Cataracts

Female #4 who is quite old has developed cataracts in both eyes. The catarcat first appeared in her left eye in 1996, and one in her right eye was first noticed in May 1998. Ullman and Brown (1983) noted that cataracts developed in a captive *P. tridactylus* at about 6 years of age.

Haemangioma

In March 1998, Female #4 was noted to have a blood filled lump on the inner right thigh. Blood was drained from the lump but ten days later it had refilled and increased in size. The lump was removed under local anaesthetic and the wound sutured with non-dissolvable sutures. The condition was identified as a benign haemangioma but its aetiology was not determined (David Forshaw, pers. comm.).

Oxalate Toxicity/Renal Failure

In April 1996 an aged female(#17) died from renal failure resulting from an accumulation of oxalate crystals in the kidneys. She had an unweaned young at heel at the time. Possible causes of oxalate accumulation are excessive oxalate in the diet, inadequacy of Vitamin B6 (which assists in the metabolism of oxalate), spoilage of food, excessive Vitamin C or metabolic failure of unknown cause (although old age combined with the pressure of lactation may be a factor in this case). Oxalate toxicity has been reported from a number of species of captive animals including koalas at Yanchep (Ellard, pers. comm.) and Scaly tailed possums, Parma wallabies and a Peruvian Cavey at Perth Zoo (Ellis, Copland & Gaynor, 1983).

All diets were analysed for oxalate and found to be oxalate free, pears and meal worms introduced into the diet, dog cubes given as a daily item rather than *ad libitum* to elimate the risk of their being a source of "spoilage" mould, and other captive animals tested for renal function.

No firm conclusions can be drawn as to the cause of the oxalate build up in this female. The complete absence of oxalate in the diet indicates that a dietary source can probably be ruled out. Only the freshest food has always been used for the animals so the presence of spoilage moulds is unlikely. While Vitamin B6 deficiency can also result in a similar condition to that seen, other symptoms associated with Vitamin B6 deficiency were not observed (Kevin Ellard, pers. comm.). In the absence of an obvious dietary source, it seems most likely that the condition occurred as a result of metabolic breakdown caused by lactational stress in an old animal.

Preputial inflammation/infection

On 30th December 1996 during routine handling of animals it was noted that the cloaca of Male #3 appeared to be inflamed and a small (pinprick) pustule was present on the outer edge. Examination of the animal in question by Dr Kevin Ellard on January 16th revealed the presence of a thick sandy encrustation of the penis with some inflammation and possible infection. The area was cleaned and washed with dilute Betadine. All other males were then checked to determine if the condition was widespread in the colony and swabs were taken for bacteriological analysis. Swabs were also taken from 6 females, including one juvenile female who had never been paired with a male. Bacterial swabs and smears revealed the presence of a large number of inflammatory cells and a diverse population of bacteria including a rare spirochaete.

While the condition has not been noted by staff caring for other Potoroo species, this may be because it has never been looked for. Penis encrustation has, however, been noted in a number of other species such as wombats and bilbies and may therefore be a normal condition (David Taggart, pers. comm.). The condition is nevertheless monitored at all routine handlings and veterinary attention sought if any active infection or inflammation is noted.

4.3 Prophylactic Routines

No drugs or vitamin supplements are given routinely. Any diarrhoea found in the cages is sent for bacteriological analysis but the condition has never persisted beyond one or two days and no treatment has been required.

Disease prevention routines in the colony primarily involve hygiene practises.

4.3.1 Shoe changing policy

Separate shoes are worn for working in the enclosures and field work. Shoes for work in the enclosures are kept in the preparation room and worn for that purpose only to avoid the risk of walking disease (specifically avian tuberculosis and toxoplasmosis from bird and cat faeces respectively) into the pens. Field work shoes are also used only for that purpose and are not used in the captive enclosures to avoid walking any diseases or parasites which may have become established in the captive colony into the wild habitat.

4.3.2 Substrate changes

Substrate in the pens is changed 3 monthly to remove accumulations of both potoroo and bird faeces which may harbour disease. All visible left over food is removed on a daily basis and pens raked and the surface material removed as required.

4.3.3 General hygiene

Feeding bowls and food preparation equipment are washed daily. Water bowls are washed every second or third day and water changed daily to avoid algal build up. The preparation room and corridor are swept on a regular basis and all surfaces in the preparation room are wiped down daily after food preparation. All handling sacks are washed and bleached after every use using soap flakes (Lux Flakes) and nappy bleach (Napisan) to minimise irritating residues.

4.3.4 Mouse control

Mouse control in the captive breeding facility was of considerable concern during 1996 when mice could be seen running around the pens and stealing food from the feeding bowls. In late 1996 four Ketchall multiple mouse traps were placed in the pens. About seventy mice were captured over a period of several weeks in late 1996 which apparently completely removed the population. The facility has been essentially mouse free since. The multiple mouse traps remain set in the pens and are checked daily. The feeding area of each cage is also searched daily for mouse tracks to ensure that no mice have managed to enter the cages, although only juveniles are small enough to squeeze through the cage mesh. A mouse barrier is to be installed with the planned construction of the pen extension to completely eliminate this (already minor) risk.

4.4 Drug Tolerances

No drug tolerances known.

4.5 Normal Physiological Values

4.5.1 Renal function values

Blood samples from 7 animals were analysed to check renal function following the death of Female #17 from renal failure. Blood samples from two animals were too small to analyse separately so were combined. Creatinine and urea values were within the range expected in other species. Gamma glutamyl transferase (GGT) levels were all slightly higher than normal values for domestic species (Dave Forshaw, pers. comm.). The mean and ranges of values for the ten substances analysed are presented in Table 4 (Data from Dave Forshaw, pers. comm.).

4.5.2 Body Temperature

Core temperatures have been taken on three occasions. The temperature of an adult male was 37.66°C while that of an adult female was 37.99° and 37.56° on two separate occasions. The temperature of the male was taken at a time when he appeared to have an infection of the penis prepuce. The first temperature for the female was taken when she was apparently healthy but the second was taken at a time when she suspected of having some dental problems although no infection was apparent. It is therefore unclear whether these temperatures are those of normal healthy animals.

Table 4: Mean and range of values for ten indicators of renal function from seven captive Gilbert's Potoroos.

	Mean and SD	Range
Creatinine (μmol/l)	78.5 ± 9.74	60-86
Urea (mmol/l)	5.48 ± 1.21	3.77-7.15
Protein (g/l)	59.78 ± 2.26	57.1-63.3
Magnesium (mmol/l)	1.158 ± 0.15	0.77-1.16
Calcium (mmol/l)	2.894 ± 0.19	2.11-2.74
Phosphorus (mmol/l)	1.88 ± 0.51	1.29-2.67
TBIL (μmol/l)	10.36 ± 4.06	2.6-15.9
GGT (U/l)	62.5 ± 14.58	51-93
GLDH (U/l)	49.9 ± 21.66	25.4-89.5
AST (U/L)	129.3 ± 47.75	90-231

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