Behaviour of Gilbert's Potoroo (Potorous gilbertii Gould) in captivity

Kylie Dijon Burke

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BEHAVIOUR OF GILBERT'S POTOROO (*POTOROUS GILBERTII* GOULD) IN CAPTIVITY

BY

KYLIE DJON BURKE

A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of Bachelor of Science in Biological Sciences with Honours in the Department of Science, Edith Cowan University.

Date of Submission: 20th February 1998
USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.
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ABSTRACT

In late 1994, Gilbert's Potoroo was rediscovered almost 120 years after it was believed to have become extinct. It was found at Two Peoples Bay Nature Reserve, near Albany, Western Australia. Since then, it has become urgent that detailed studies of the potoroo's behaviour and ecology be undertaken, so as to increase the understanding of the needs of this critically endangered marsupial. Due to its critical status, increasing the number of animals is of paramount importance to the continued survival of this species.

An understanding of the behavioural repertoire of the species will aid in its recovery and provide the basis for management decisions concerning breeding, habitat management and captive care. Behavioural studies of captive animals may also act as a guide for future field studies.

The present study was conducted on nine animals housed in the captive colony at Two Peoples Bay Nature Reserve to determine the behavioural repertoire of the species, with particular attention to breeding behaviour, interactions between males and females and the behaviour of males housed under different conditions. The latter was to determine if there was a behavioural cause for excessive encrustation of male genitalia. The activity patterns of the animals were also studied.
It was found that the behavioural repertoire of Gilbert's Potoroo is similar to that of other *Potorous* spp. and other closely related potoroid marsupials. No obvious behavioural differences between a male housed alone and males housed with one or two females were observed that would indicate a behavioural cause for penile encrustation. Some differences in the behaviours of sexually compatible and incompatible pairs were observed.

It was also found that although *Potorous gilbertii* is most active at night, activity before sunset and after sunrise was commonly seen throughout the study. Activity during the middle of the day was, however, observed on only a few occasions.
DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education; and that to the best of my knowledge and belief it does not contain any material previously published or written by any other person except where due reference is made in the text.

Kylie Dijon Burke
20 February 1998
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1 INTRODUCTION

In 1994, after almost 120 years of presumed extinction, the potoroid marsupial, *Potorous gilbertii* Gould was rediscovered at Two Peoples Bay Nature Reserve near Albany, Western Australia. Prior to its rediscovery, all published material on the ecology of Gilbert's Potoroo was based upon the original notes of the naturalist John Gilbert, who first described this small marsupial in the early 1840s (Start, Burbidge, Sinclair and Wayne, 1995). As such, almost nothing is known about the behaviour of Gilbert's Potoroo.

At present, there are 20 known living individuals of this animal, with twelve of these being held in a captive colony at Two Peoples Bay, Albany. As the number of individuals is so low, it is imperative that the size of the captive colony be increased, and to do this most efficiently, optimal breeding rates need to be achieved (Courtenay, pers. comm.).

The captive population was started with two females with pouch young and two males. Since then, six young have been conceived, indicating that some successful reproductive behaviour has occurred. *Potorous gilbertii* seem, however, to be selective of their breeding partners (Courtenay, pers. comm.), a situation not observed in *Potorous tridactylus*. There have, however, been compatibility problems in the breeding of *Potorous longipes* (Halley, pers. comm.). This could be a behavioural trait or it may be due to
external factors such as stress, diet or disease, and observations of the potoroos may highlight the reasons for the low levels of breeding success. A detailed study of the behaviour, primarily social behaviour, of *Potorous gilbertii* is, therefore, necessary.

1.1 Ethological Methodology

When studying the behaviour of an animal, an ethogram, or behavioural catalogue, must first be compiled (Drickamer & Vessey, 1992). The animals should be carefully observed, preferably in a natural or semi-natural state. Observations must be undertaken with an open mind, and it is imperative that a clear record be kept of what the animals do, as what initially appeared to be a trivial act could turn out to be important further down the track (Deag, 1980). Behaviour can be divided into restricted units (e.g. tail lashing, rubbing branch with chin) or into broad descriptive categories (e.g. feeding, nesting, vigilance). This serves as the foundation for posing questions about the ecological importance, adaptive value, and regulation of the behaviour patterns identified (Deag, 1980; Drickamer & Vessey, 1992).

Behavioural studies may be conducted in the field, or on animals kept in captivity. Field studies are important in revealing the natural behaviour of animals. They are, however, often difficult to implement as the animals being studied may be nocturnal, shy, hidden in cover or difficult to recognise as individuals. Under these circumstances it may be necessary to observe captive animals. It must always be remembered, however, that the
behaviour of an animal in captivity may be abnormal (Deag, 1980) and that, whether observing animals in the field or in captivity, the animals' activities can be influenced by the presence of an observer (Drickamer & Vessey, 1992).

No matter where the study takes place, it is often necessary that individual animals are able to be identified. One way to do this is through the natural markings of the animals themselves, although this is not always easy. Another way is through artificial marking and tagging, such as leg bands in birds, fin punches or clips in fish, small dots of dye or paint in invertebrates and ear punches, dye marks and toe clips in mammals (Drickamer & Vessey, 1992).

Regardless of where the study takes place, the health and welfare of the subjects is of paramount importance. There are often guidelines and procedures that govern issues pertaining to the care and safety of research animals, under both captive and field conditions. These are most important, especially when dealing with endangered or threatened species, and they are aimed at facilitating research, not hindering it. There are enormous benefits to be gained from behavioural research of animals, provided it is undertaken in the best possible way (Drickamer & Vessey, 1992).
1.2 Social Behaviour and Communication

Ethologically, social behaviour is a group of behavioural patterns that involve interactions (potential or actual) with, or lead to the proximity of, another individual of the same species (Croft, 1980). Mammals have been shown to display both competitive and co-operative social behaviour and thus mammalian behaviour and communication can generally be classed as either agonistic (aggressive, submissive or defensive) or amicable (friendly or co-operative).

Mammals have been seen to communicate by various methods depending on their needs and circumstances, and they generally employ at least one of four methods of social communication, viz. chemical/olfactory, acoustic, visual and tactile. Each method of communication has distinct advantages and limitations (Ewer, 1968; Poole, 1985).

Most mammals have olfaction and possess scent glands, which secrete odours of communicative significance. By depositing scents the signaler can communicate directly with conspecifics either in close proximity or at a distance. A chemical message has the advantage that it can be deposited at a site and subsequently received in the absence of the signaler. Not only can scents convey information about the signaler, changes in composition
and other chemical changes may indicate the age of the scent mark, and thus when it was deposited. Olfactory communication may provide information about the age, sex, physiological state and status of the signaler (Ewer, 1968; Poole, 1985).

Acoustic communication can also be effective when the signaler is some distance away. Loud songs or calls may be used to alert conspecifics to the presence of predators or to alert other group members of the presence of other individuals or social groups in the area. Such signals may be used to attract group members or repel strangers. Acoustic signals may, however, attract predators and thus loud calling is generally restricted to species that are at least risk from predators. Vocalisations are also used in highly sociable species and in intimate situations. Acoustic communication lends itself to the production of graded signals through modulation of frequency (pitch) or amplitude (loudness) and is thus highly flexible (Ewer, 1968; Poole, 1985).

Visual signaling, on the other hand, is only viable when individuals are in close proximity and as such they have been seen to reach their highest complexity in highly sociable species or in large mammals inhabiting open areas. Visual signaling by the majority of mammals is much less complex than that of other animals (e.g. birds), as vision is not a primary sense in many small mammals which are commonly nocturnal and which may also need to stay inconspicuous.
Some mammals such as higher primates, plains ungulates and wolves have, however, evolved complex displays which can convey information about the emotional state of the signaler (Ewer, 1968; Poole, 1985).

Tactile communication is often important in maternal, amicable and sexual behaviour, but it also occurs in agonistic situations where a tactile signal such as a nip or a push may be used instead of a serious assault (Ewer, 1968; Poole, 1985).

1.2.1 Observed marsupial social behaviour

Many studies of marsupial behaviour have been carried out where their behaviour has been observed and analysed and inferences and comparisons made on their behavioural patterns and repertoires. Marsupials have been shown to display all of the above behavioural types whether in captivity or in the wild.

1.2.1.1 Chemical/Olfactory communication

It has been shown that many individual mammals can distinguish between an odour from its own species and that of a closely related species. The sex of an individual may be distinguished by the scent, as has been observed in numerous marsupials (Macropus rufus: Croft, 1980; Macropus robustus: Croft, 1981; Macrotis lagotis: Johnson & Johnson, 1983). Most female marsupials communicate their sexual receptiveness to males by way of
vaginal secretions, as most are only fertile for short periods between pregnancies or, in species that breed seasonally, at a certain time of the year. Sexual receptivity of the female may also be communicated by an odour in her urine at oestrus. Sexual checking, or sniffing of the female's cloacal, pouch or genital region is commonly seen in marsupial behaviour (*Macropus rufus*: Croft, 1980; *Macropus robustus* Croft, 1981; *Macropus antilopinus*: Croft, 1982; *Dasyuroides byrnei*: Gansloser & Meisner, 1984; *Lagorchestes hirsutus*: Lundie-Jenkins, 1993).

Many marsupials are able to identify conspecifics as individuals which enables them to recall past experiences with a particular individual and thus to remember if it was dominant or subordinate, aggressive or friendly. Marsupials have been shown to have the ability to recognise conspecifics by their scent and an individual may not only be recognisable by its scent at close quarters but may also leave individually distinguishable scent marks throughout its territory (Poole, 1985).

The way different species scent-mark varies. Some animals urinate on strange conspecific urine to leave a record of their presence (*Macrotis lagotis*: Johnson & Johnson, 1983) while others defecate at distinct points in their territory (*Isoodon macrourus*: Day, Kirkby & Stenhouse, 1973). Numerous mammals mark the environment directly with their scent glands. For example some potoroids use the anal glands (Johnson & Johnson,
1983), while other mammals use preorbital glands, sternal glands (kangaroos: Croft, 1981), or chin glands (Poole, 1985). Thus, many marsupials rely heavily on olfaction and chemical communication and are able to receive a wide variety of messages.

1.2.1.2 Acoustic communication

There are two types of acoustic communication: distant signaling and intimate signaling. The loud, usually high pitched, alarm calls of mammals are a typical example of a distance signal and these alert conspecifics to the presence of danger.

When sighting different predators, some species give different alarm calls (Poole, 1985). The Yellow-bellied Glider (Petaurus australis) has six basic calls that have been recognised, two of which are associated with gliding and another which is given immediately after a glide and which frequently elicits a reply from other animals, often from other home ranges (Craig, 1985).

Intimate signaling is usually graded and is often accompanied by visual signaling. Vocalisation as a means of communicating with conspecifics when mating is used by even the least sociable of mammals, for example, the male Yellow-footed Antechinus makes a 'cha-cha-cha' type sound during the precopulatory chase (Poole, 1985).
Vocalisation often precedes aggressive behaviour, for example, when threatening another animal, quolls (Dasyurus spp.) make hissing or panting noises (Poole, 1985), however, Vombatus ursinus vocalise at burrowing sites (Taylor, 1993) and Euros (Macropus robustus) have been shown to vocalise during aggressive interactions at waterholes (Croft, 1985). The female Rufous Hare-wallaby (Lagorchestes hirsutus) vocalises when unreceptive to an approaching male (McLean, 1993).

The loser of an aggressive encounter may vocalise before fleeing or submitting, with screaming, squeaking or squealing being sounds commonly associated with submission. As a defensive gesture Sminthopsis crassicaudata commonly hiss (Morton, 1978) while the Antilopine Wallaroo (Macropus antilopinus) gives a small hiss just prior to fleeing. This is usually followed by a foot thump and then flight (Croft, 1982).

1.2.1.3 Visual communication

In an aggressive context, the eye closest to the opponent is often closed, which is most likely for protection but may also block out the visual fear-inducing stimuli produced by the opponent. This is known as “cut-off” (Poole, 1985). Macropus rufus males throw back their heads when fighting and this is also believed to protect both their eyes and ears and is known as “forearms locked” as the animals seem almost locked together by the
forearms (Croft, 1980). Male Antilopine Wallaroos display threatening behaviour by tossing their heads and Eastern Grey Kangaroos display head arching behaviour during agonistic encounters (Croft, 1982).

Most species display postures and gaits that change with differing circumstances. For example, the undisturbed posture of the Rufous Hare-wallaby (*Lagorhestes hirsutus*) is a bipedal stance with forearms held loosely in front of the body and a curved vertebral column. When disturbed, however, the animal takes on a bipedal stance with the forearms slightly extended forward from the body and a vertebral column that is perpendicular to the ground (Lundie-Jenkins, 1993). The Bilby (*Macrotis lagotis*) has been seen to display a distinct crouching posture after a burst of activity shortly after emerging from their burrow (Johnson & Johnson, 1983) and *Peradorcas concinna* crouch as a defensive mechanism and possibly also to display appeasement (Goldstone & Nelson, 1986).

Many species present their genitalia and this can be either an aggressive gesture or a submissive one. Sexually receptive females often present their genitalia to the male, as in the lordosis-like posture of *Lagorchestes hirsutus* where the hindquarters are raised, the genitalia shown and the tail deflected to one side (McLean, 1993).

It is common for more than one part of the body to be involved simultaneously, particularly by highly sociable species which issue graded signals. Movement is often used to reinforce the signal. Some mammals
may charge or circle an opponent, while a submissive animal may slink past a dominant, or may not make eye contact, whereas the dominant will display confidence and show decisive movements (Poole, 1985).

1.2.1.4 Tactile communication

The earliest form of tactile communication to develop in a mammal is suckling. The suckling movements of the young's mouth not only stimulate milk production but also induce milk release. It is believed that nocturnal, crepuscular and burrowing animals rely heavily on tactile signaling as a form of social communication (Poole, 1985).

Aggressive interactions commonly involve some forms of tactile communication. For example, the Rufous Hare-wallaby (*Lagorchestes hirsutus*) uses cuffing, pawing and airborne and sideways kicks, during aggressive interactions. This is behaviour that more closely resembles potoroid behaviour than that of larger macropodoids (Lundie-Jenkins, 1993), while the Eastern Barred Bandicoot (*Perameles gunnii*) may hit, kick, bite, scratch or even jump on an opponent (Murphy, 1993).

Biting, while undoubtedly having the capacity to inflict injury, may also serve to communicate. Some animals commonly use “snap-biting” as a warning signal, while inhibited biting often occurs in social play and sexual behaviour of many species of animals. Male dasyurids, for example, grip the neck of the female prior to mounting (Poole, 1985). Red Kangaroos (*Macropus*
rufus) have been observed to initiate sternal biting during aggressive behaviour (Croft, 1985). Body rubbing and nuzzling often occurs in an affectionate or sexual context and genital licking prior to copulation is common (Poole, 1985).

Allogrooming is a very important form of tactile communication and has been observed in many different species including the Antilopine Wallaroo (Macropus antilopinus), (Croft, 1982), Rufous Hare-wallaby (Lundie-Jenkins, 1993) and some potoroids (Serena, Bell and Booth, 1996). Allogrooming and other forms of tactile communication may be of great importance between members of the opposite sex where a pair-bond has developed. The pair may often sit in close physical contact (huddle) such as that which has been observed in captive held Tammar Wallabies and potoroids (Serena et al., 1996).

Social play commonly involves much physical contact and may help juveniles develop skills for adulthood. Kangaroos and other macropods often display ritualised play-fighting (Croft, 1981; Croft, 1982; Croft, 1985; Wilhelm & Ganslosser, 1989).

1.3 Sexual Behaviour

For a species to continue to exist, contact between members of the opposite sex, for the purpose of mating, must occur. As female mammals are, however, not fertile when pregnant, or in numerous species when lactating,
the total amount of time when the female is receptive to the male may be as little as seven days in the year, even in species without a restricted breeding season. Even in the most sociable of mammals, reproductive behaviour does not, therefore, play a large part in their day-to-day life. This, however, does not make sexual behaviour any less important (Poole, 1985).

Sexual behaviour may consist of any or all of the types of communication described above. For example, relatively solitary females advertise their receptivity by urine or scent marking as they traverse their home range. Males that come across these markings seek out the female. If more than one male finds her, then an agonistic encounter may take place. Sexually aroused male Rufous Hare-wallabies sometimes spray urine when in the presence of a female, whether anoestrus or oestrus (Lundie-Jenkins, 1993) and some female marsupials signal their receptivity by displaying proceptive behaviour such as cease to be aggressive towards the male. This has been seen in various potoroid species (Johnson, 1980; Serena et al., 1996) and *Lagorchestes hirsutus* (Lundie-Jenkins 1993).

### 1.4 Potoroid Behaviour

Potoroid marsupials have been widely studied and it has been shown that they display all of these behavioural types in one form or another. For example, anal scent producing glands have been reported in the Tasmanian Bettong (*Bettongia gaimardi*), which would be used for scent marking (Johnson & Johnson, 1983), and cloacal marking, especially by females,
was observed in *Aepyprymnus rufescens*. Male *Potorous tridactylus* have been observed to select an oestrous female by smelling her external genitalia (Hughes, 1962) while male *Potorous longipes* have been observed to climb over the back of the female leaving a trail of urine from shoulder to rump, after first nosing her head (Coulson, 1989).

Potoroids have also been known to vocalise. When approached by a male, the female *Aepyprymnus rufescens* frequently uttered a low-volume growl, and on approach of oestrous, when the attentions of the male became more persistent, the growl became quite loud. Hissing and foot stamping has also been observed in *Aepyprymnus rufescens* (Johnson, 1980).

Allogrooming, a very important form of tactile communication has also been observed in potoroid marsupials, such as *Potorous longipes*, which have also been observed to huddle (Serena *et al.*, 1996).

*Potorous tridactylus* has been shown to sometimes display quite vicious agonistic behaviour (Colson, 1989; Ganslosser, 1989; Hughes, 1962; Noyes, 1986; Ullmann & Brown, 1983), often for no apparent reason (Noyes, 1986). In some instances, serious injuries had been sustained by animals, although no fighting was observed (Ullmann & Brown, 1983).

Male long-footed potoroos (*Potorous longipes*) have been observed following females (Green & Mitchell, 1997; Serena *et al.*, 1996), often resulting in the male attempting to mount the female. The male sometimes
terminated following behaviour by sniffing the female's cloacal/pouch region and, when following, the male often grabbed at the female's hindquarters in an effort to detain her. Both sexes have been seen to initiate both agonistic and amicable behaviour, with agonistic interactions generally associated with persistent and vigorous following behaviour and multiple mating attempts. These agonistic interactions, observed between a male and a female in an enclosure, have involved one animal scratching or striking the other without knocking it down, one animal striking or pushing the other hard enough to knock it down or one animal attempting to bite the other (Serena et al., 1996).

Female potoroids have sometimes been observed to signal their receptivity by displaying proceptive behaviour. This has been observed in *A. rufescens* (Johnson, 1980), some bettongs and *Potorous tridactylus* (Serena et al., 1996).

Activity patterns in potoroids seem to differ between species. While *Aepyprymnus rufescens* is strongly nocturnal and all species of *Bettongia* are believed to be completely nocturnal, *Potorous tridactylus* has been found to be active quite frequently throughout the day, with "nocturnal" emergence being observed up to one hour before complete darkness, whilst *Potorous longipes* is strictly nocturnal (Seebeck, Bennett & Scotts, 1989).
1.5 Gilbert's Potoroo

1.5.1 The relationships and taxonomy of Potorous Desmarest species

Due to the considerable morphological variation exhibited by potoroos, the taxonomic status of the genus has been reviewed many times (Johnston & Sharman, 1976; Seebeck, 1981; Seebeck & Johnston, 1980). Five species had been named in the genus prior to 1888: *P. tridactylus* (Kerr, 1792); *P. gilbertii* (Gould, 1841); *P. platyops* (Gould, 1844); *P. apicalis* (Gould, 1851); *P. rufus* (Higgins & Petterd, 1884). In 1888, Thomas (cited in Johnston & Sharman, 1976) recognised three species in the genus: *P. tridactylus* from eastern Australia and *P. gilbertii* and *P. platyops* from south-western Australia. Johnston and Sharman (1976, 1977), using univariate and multivariate morphometric analyses for muzzle proportions and body size, and electrophoretic, chromosomal and breeding studies again reviewed the classification (which had been done numerous times over the intervening years) and concluded that there were only two species. They believed that potoroos other than *P. platyops* comprised a single highly variable species, *P. tridactylus*. In 1980, Seebeck and Johnston described a new species, *P. longipes*.

At the time of its rediscovery, Calaby and Richardson (1988) considered Gilbert's Potoroo to be a synonym of the Long-nosed Potoroo, *Potorous tridactylus*, although the Zoological catalogue does not denote subspecies. *P. tridactylus*, which although similar in appearance, is slightly smaller than
P. gilbertii and is found in south-eastern Australia. A study of electrophoretic and DNA sequence data performed since the rediscovery, and designed to determine the phylogenetic relationship between extant potoroos, has indicated that Gilbert's Potoroo should, however, be considered as a separate species, Potorous gilbertii, as originally described by Gould (1841). It was found that the differences between Gilbert's Potoroo and the other two extant potoroo species were of the same magnitude, but larger than those between the known species P. tridactylus and P. longipes. The exact interrelationship between the three species, however, remains unclear (Sinclair & Westerman, 1997).

Courtenay (pers. comm.) has found that examination of cranial morphology also supports this conclusion. The skull of P. gilbertii is smaller than that of P. tridactylus but is relatively broader, noticeably so in the maxillary region (as described by Gould, 1963), the rostrum is very inflated anterior to the incisors and also above the molar row, and the adult pre-molar in P. gilbertii is smaller and flexed in appearance with a shelf like extension on the anterior lingual side. The palate of P. gilbertii is broader but all of the molar teeth are relatively smaller (Courtenay, unpublished data). Due to these differences in genetics and morphology, the author has chosen to use the name Potorous gilbertii.
1.5.2 The history of Gilbert's Potoroo

Gilbert's Potoroo is a small Macropodoid marsupial from the family Potoroidae, which also includes potoroos, rat-kangaroos and bettongs. There is little sexual dimorphism and adults weigh between 900g and 1200g (Sinclair & Courtenay, in press). The species was originally described by Gould (1841) from specimens collected in the King George's Sound (Albany) area by the naturalist John Gilbert (Sinclair, Danks & Wayne, 1996).

Further specimens were collected by George Masters in 1866 and 1869 between King George's Sound and the Salt (Pallinup) River, and a single specimen was collected by William Webb from King George's Sound between 1874 and 1879. Sub-fossil specimens have been collected from cave deposits at numerous sites between Albany and Yanchep, including several caves in the Leeuwin-Naturaliste area, the Margaret River area and at the Yanchep caves site. Of the specimens collected outside the Albany area, only one non-fossil specimen exists. It is an unsexed skull collected from outside Brides Cave, Margaret River, by an unknown collector. However the specimen was part of the Shortridge collection and is now held in the National Museum of Wales (Courtenay, pers. comm.; Sinclair & Courtenay, in press).
Early records indicate that Gilbert's Potoroo has always been restricted to areas of high rainfall in the south-west corner of Western Australia, but was locally abundant in those areas (Calaby, 1971; Sinclair & Courtenay, in press).

Around 1869 a decline in the numbers of Gilbert's Potoroo occurred, and by 1909 they were considered likely to be extinct, with the possibility that, due to their similarity in habitat use and appearance to the Quokka (*Setonix brachyurus*), small existing populations persisted. The initial decline was attributed to wildfire and feral cats and it was predicted that populations may persist only in long-unburnt areas with dense vegetation (Shortridge, 1909, cited in Vetten, 1996). Calaby (1971) and Heinsohn (1968) have suggested that during the 1920s, when foxes became established in the south-west of Western Australia, predation exerted increased pressure on the potoroos, as occurred with many other species.

1.5.3 The rediscovery of Gilbert's Potoroo

In late November 1994, a Ph.D. student from the University of Western Australia, Elizabeth Sinclair, was attempting to catch Quokkas in Two Peoples Bay Nature Reserve. By the 29th, 17 traps had been set for six nights without any success. The following morning, however, they found one trap occupied by a small mammal initially believed to be a bandicoot. When they trapped two more of these animals the following night, they realised they were not bandicoots and took them to Department of CALM
staff to have them identified. By a process of elimination, using mammal identification books, the animals were identified as Gilbert’s Potoroos. Comparison with museum specimens and measurements of distinguishing morphological characteristics confirmed that the individuals were indeed, two of the thought to be extinct Gilbert’s Potoroos (Start et al., 1995).

On rediscovery, a captive colony was immediately established. This now consists of 12 individuals, whilst the only currently known wild population of Gilbert’s Potoroo consists of eight individuals (four males and four females), of which seven appear to form a loose aggregation within a fairly limited area, while the other was captured at the original rediscovery site. Two other individuals were previously captured at a further two sites, however, in spite of trapping and hair-tubing of these areas, it is not known whether they are still living (Courtenay, pers. comm.).

Due to their restricted distribution and the extremely low number of known living individuals, Gilbert’s Potoroo is classed as “Critically Endangered” according to the International Union for Conservation of Nature (IUCN) criteria (Sinclair & Courtenay, in press; Vetten, 1996), and as there are only 20 known living individuals, they are most likely Australia’s most critically endangered mammal (Courtenay, pers. comm.).
1.5.4 The recovery process

There are two major components of the recovery process; the captive colony and ecological research. The captive colony was established to provide insurance against catastrophic loss of the wild population (through wildfire, for example), and to provide the basis for an eventual translocation program. It was established on site to protect the animals from risks associated with climate changes, long distance transportation and exposure to unfamiliar pathogens. The captive colony also provides scientists with the means to more easily collect information on the species' biology (Courtenay, pers. comm.).

The founding animals consisted of four individuals - two adult females (each with pouch young), an adult male and a sub-adult male. All animals were from the original rediscovery site. In January 1995, the sub-adult male was released and replaced with a juvenile captured at a second site and in May of the same year, a female and her young-at-heel from a third site were added to the colony. In April 1996, a female with pouch young, also from the second site, joined the colony (Courtenay, pers. comm.).

Three pouch young were lost in the first six months of captivity. This was most likely due to the stresses placed on the mother, in adapting to captivity. Since then, however, one female that was introduced into the captive colony
with a pouch young has raised her young to independence and six young have been conceived, with five raised to permanent pouch exit (four to adulthood) within the colony (Courtenay, pers. comm.).

These conceptions and births have provided scientists with important information on the reproductive biology of this animal. For example, the animals appear to be exercising mate choice, as certain pairings have proven infertile even though both male and female have bred with other partners and thus breeding may in fact be monogamous. The species displays post-partum oestrus and embryonic diapause and they produce only one young at a time. At this stage the pattern of births appears to suggest that although breeding occurs throughout most of the year, most occur during summer and autumn (13 out of 18 young born to both wild and captive females). The gestation period appears to be similar to that observed in *P. tridactylus*, and length of pouch life is believed to be approximately 120 days. A single male of known age bred at 14 months and it would therefore be expected that females would have reached sexual maturity by about 12 months (Sinclair & Courtenay, in press).

Regular handling of the animals has revealed that males often have penises encrusted with sand and a yellow-green mucous-like substance, which seems to be more pronounced in the males housed alone. Penile encrustation has also been observed in wild males, but was not seen to be
as severe as that of the captive males (Courtenay, pers. comm.). A comparison of the behaviour of the male housed alone, with the behaviours of males housed with females may show whether this penile encrustation has a behavioural cause.

Since the rediscovery, ecological research has focused on two main areas: investigating the home range and habitat requirements of the known populations, and searching for more populations (Sinclair & Courtenay, in press).

Radio-tracking of one female and two males was undertaken between May and August, 1995, in the vicinity of the second and third sites mentioned above and although the female did not travel far, both males traversed quite large areas. The data may not, however, be representative of normal foraging behaviour as the males were collared and radio-tracked immediately after the resident female had been removed to the captive colony. It is possible that they may have been searching for the absent female. Radio-tracking has not been done on the more stable population as the radio collars caused severe chafing around the neck, however once a suitable collar design is developed, radio-tracking will recommence (Courtenay, pers. comm.; Manson, 1995).

Using spool-and-line tracking techniques, Vetten (1996) undertook a detailed microhabitat study which examined the habitat use of six potoroos from the stable population mentioned above. This showed that most
individuals displayed some selective behaviour by utilising vegetation types in different proportions to their presence in the habitat. It was also found that approximately 40% of the line length was spent in open vegetation and that a slow rate of movement and foraging behaviour tended to be observed in the open areas. Diggings adjacent to, or under the spool line were also seen to be in open or semi-open areas.

Hair tube surveys have been conducted to locate other potoroo populations outside of Two Peoples Bay, if they exist, and to determine the extent of the population within the nature reserve. Trapping surveys have also been conducted to clarify the status of individuals that have only been trapped once and to locate more animals (Courtenay pers. comm.).

Detailed diet studies have not been conducted, however funding has recently been provided by Worldwide Fund for Nature-Australia, for such a study, as well as for a study on oestrus cycles (Courtenay, pers. comm.).

1.6 Aims of the Project

At this time little is known about *P. gilbertii*, especially in relation to social behaviour and specifically the sexual behaviour of wild or captive individuals. It is, therefore, necessary to conduct a careful study of the animals' activities and interactions, particularly as there is some concern that the present housing arrangements of the captive potoroos may not be conducive to optimal breeding success. The males in the captive colony have been
observed to have encrustation of their genitalia and it is feared that this may adversely affect their breeding success. It is therefore important to observe and compare the behaviour of males housed under different conditions, to see if there is a behavioural cause for this condition and to if so, to determine the extent to which it may affect reproductive success.

The aim of this investigation is to determine the nature of male/female interactions and to provide information on the behaviour of males housed alone, with a view to finding management strategies which will increase the chances of survival and breeding success within the captive colony. The study is also intended to provide baseline data on the general behaviour of Gilbert's Potoroo which would be useful in directing further behavioural studies either in captivity or in the field.

The research is designed to address, though is not confined to, the following questions:

- What is the nature and extent of sexual display, courtship and mating behaviour?
- What is the nature of any associations between different behavioural elements?
- Do males show any behaviour which may adversely affect breeding success?
- Is there any obvious behavioural cause of penile encrustation?
2 MATERIALS AND METHODS

2.1 The Captive Colony

The captive colony is housed in a purpose built facility at Two Peoples Bay Nature Reserve consisting of eight 3 x 10 metre cages radiating off a corridor which is entered via a work room and food preparation area. Between the cages adjacent to one another, there are small doors, which can be removed to allow animals free movement between these cages. Figure 2.1 displays the cage setup. At the time of the study there were 12 animals living in the captive colony. Their birth history is shown in Figure 2.2.

The animals used in the study were in cages 2, 3/4, 5 and 7/8. The animals contained in each of the cages are shown in Table 2.1 and displayed in Figure 2.1.

Table 2.1: Configuration of study animals in their respective cages.

<table>
<thead>
<tr>
<th>CAGE</th>
<th>ANIMALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>male #28</td>
</tr>
<tr>
<td>3/4</td>
<td>male #3, female #10, female #32</td>
</tr>
<tr>
<td>5</td>
<td>male #11, female #18</td>
</tr>
<tr>
<td>7/8</td>
<td>male #7, female #19, female #27</td>
</tr>
</tbody>
</table>
Figure 2.1: Diagram of the captive housing arrangements.
Figure 2.2: Status and known relationships of individuals within the captive colony of Gilbert's Potoroo. Key: Circle = female, Square = male, Dotted square with ? = unknown father of wild born young, Black = wild caught animal (unknown parentage), Grey = wild born animal (one parent known), White = captive born animal (both parents known), Line through = deceased.
The cages contain a 3x3 metre area which is clear of vegetation where the food bowls are placed and where a tap and water bowl are located. This area is protected from the weather by a corrugated iron roof. The other 3x7 metres of cage contains natural vegetation growing in a sandy substrate. The vegetation is structurally similar to that found in the potoroo's natural habitat, however the species composition differs slightly. The cages adjacent to each other (see Figure 2.1) are separated by wire mesh and hardiflex sheeting one metre high.

2.2 Video Equipment

Four cages were set up with black and white Sony mini video cameras to monitor simultaneously the behaviours of the occupants in each cage. The camera was mounted using a swiveling mechanism and positioned approximately 30cm above the ground in the corner of cages, south of the cage door, and a light was positioned 90cm above the camera. A Sony quad switcher (model no. YS-Q430P), Sanyo monitor, Sony time-lapse video cassette recorder (model no. SVT-100P) and high quality Akai 240 minute videotapes were used to record the behaviour. The quad switcher enabled all four cages to be viewed simultaneously. The time-lapse video recorder, on the other hand, allowed several filming options. Using a 4 hour video tape, cages could be monitored for 24 hours, 16 hours or 4 hours.
When replayed, the tapes recorded over 24 hours, showed the subjects moving at 8 times their real speed, those recorded over 16 hours showed the animals to be moving at 4 times their real speed, and tapes recorded over four hours, had the subjects moving at their real speed.

2.3 Data Collection

For the study, the cameras were trained on the feeding area of the cage, and therefore, only the one third of the cage containing the camera was visible.

The study was conducted in two parts, a pilot study and the continuous time study. The aims of the pilot study were to determine the times of daily activity, to determine observation intervals, to identify behavioural elements and repertoires and to determine the best methods of recording data, keeping in mind how the data was be analysed. The pilot study was also used to identify the most favourable camera positions and to determine whether the study animals needed to be marked for identification.

To determine times of daily activity, the cages were monitored for 24 hours a day, for one week. The tapes were then analysed to see whether the animals were active during the day and to determine what would be the best time to start filming to ensure that all activity was covered by the time period recorded. It was decided that the cages would be monitored for just over 16 hours continuously per day (4.00pm - 3.20am the next day). Observation intervals were decided upon by recording the times of activity seen over two
days, and then dividing the days into ten minute, fifteen minute, twenty minute, thirty minute and sixty minute intervals and deciding which set of intervals best reflected activity patterns. Thirty minute intervals were decided upon.

The animals could not be identified individually so it was decided that the females would be marked for identification. Chromacryl, a non-toxic, waterproof acrylic paint was trialed, however the animals were able to remove this within two days so it was decided to clip a patch of hair from the potoroo’s body. It was thought that the identification would be easier if the hair was clipped from the forehead. As some cages, however, contained more than one female it was decided that the second female would have hair clipped from the flank instead. When hair was clipped from the forehead, care was taken to leave plenty of hair to protect the eyes of the animal. Females #10, #18 and #19 had hair clipped from their foreheads and females #32 and #27 had hair clipped from their flank regions.

The animals were placed in their respective cages as shown in Table 1 and Figure 2.1 on November 6, 1997 and the study was of three weeks duration from November 10, 1997 to November 30, 1997 with the pilot study preceding this.

The animals were originally in different cages, and were rearranged on 6th November 1997, as previous pairings had proven infertile, and female #10 was again ready to mate after weaning her young (female #32). Placing her
with male #3 and including them in the study ensured that a known breeding pair were observed. Although tapes were filmed from the 6th November, only tapes from 10th November were analysed as it was thought that the data for the first four days may not display normal behavioural patterns, due to the relocation of the animals, and as such these tapes were only used for behavioural descriptions.

As described earlier, adjacent cages had removable doors, and some of these were open during the study. This was the case in cages 3/4 and 7/8 as both sets of cages had three animals in each. As the species is critically endangered, improving reproductive performance is paramount. As sufficient cage space was available, these two groups of animals were each given the run of two cages to minimise the possible risks of stress or aggression, which may have resulted from three animals being housed in one cage. Both groups of three contained one male and two females. This was done in cage 3/4 so as not to prematurely separate juvenile #32 from her mother and in cage 7/8 to see if housing a male, in this case #7, with more than one female improved reproductive success. Male #7 is the only known breeder from one of the founder lineages, making him a preferred breeder, and thus, placing him with two females also maximised the chances of him reproducing.
In the case of filming animals with the run of two cages, two of the feeding bowls were placed in the cage containing the camera to encourage more activity to take place in this cage whilst still making sure all animals had space to eat. This was imperative as male #3 had been observed to chase the juvenile female #32 away from the food bowls.

In the continual study light of invisible wavelengths was used to illuminate the enclosures. Light sources were made by attaching a sheet of purple glass followed by a sheet of red glass over the front of 150 W halogen lights using heat resistant silicon adhesive. Observer activity was restricted to times of subject inactivity, so as to minimise disturbance of the potoroos. The animals were fed nightly at approximately 7.30pm to avoid encouraging them out before dusk, and food bowls were collected the following morning after 10.00am. For two weeks prior to the pilot study the subjects were habituated to the night lights.

On the 15th November 1997, the light globe in cage 2 (containing male #28) blew at 0040 and the cage was in darkness from this time until 0455 the following morning. To enable more comparable graphs to be produced, and statistical analysis to be as accurate as possible, the data for this night for male #28 were extrapolated.
2.4 Annotated/Descriptive Data Collection

2.4.1 The behavioural catalogue

The data were analysed with a view to characterising the behavioural repertoire of the species and distinguishing behaviour most likely to either increase or decrease reproductive success. The behavioural catalogue was based on that developed by Courtenay (1993) and on the works of Ganslosser (1989, 1992) and Coulson (1989) and contains a list of behaviours observed during the study, with descriptions of what exactly occurred and the context they occurred.

Four 3 hour videotapes showing a single cage filmed in real time were viewed and every behavioural element was noted in sequential form. From this, the behavioural catalogue was formulated. The tapes ran from 6.16pm - 9.21pm Sunday 14th September 1997 in cage 7, filming male #3 and female #27, 1.00am - 4.04am Friday 19th September 1997 in cage 3, filming male #6 and female #19, 8.00pm - 11.04pm Friday 19th September 1997 in cage 7, again filming male #3 and female #27 and 6.00pm - 9.24pm Saturday 20th September 1997 in cage 5/6, filming male #7 and females #1 and #18.

The cages, as filmed above, contained different configurations of animals to those shown in Table 2.1 and Figure 2.1 as these tapes were filmed prior to the animals being moved around on 6th November 1997. Tapes filmed at
real-time containing only a single cage were used as the movement of the animals was slower and thus the behaviour of the animals was clearer. The tapes were of different times on different days so as to give a greater cross-section of activity, should an activity be restricted to only certain times of the night. Any additional behaviour observed on any other tape or viewed from the door of the enclosure was also added.

2.4.2 The sequence descriptions

Both the real-time tapes used for the behavioural catalogue and the time-lapse tapes from the continuous study were used to describe the behavioural sequences. Tapes recorded between 8th September 1997 and 15th October 1997 were also used. The behaviours described in the behavioural catalogue were divided into categories. These were determined by comparing the behavioural elements obtained to commonly used categories found in relevant literature and placing these behaviours into those categories. Any element that did not immediately fit into any of these common categories was placed in its own category. Nine different categories were identified. The categories were locomotion, feeding/foraging, social, individual, vigilance, agonistic, marking, sexual and stereotypical.

Locomotion was defined as general movement from one place to another, and excluded following and chasing. Feeding/foraging incorporated sniffing and/or digging or scratching for, and eating of food. Social behaviour was
any behaviour or interaction involving more than one animal, excluding agonistic and sexual interactions. Individual behaviour included the animal sitting still, sniffing an object other than another animal or food, nesting or grooming. Vigilance was any action involving the animal seeming to survey the surrounding area possibly in response to an external stimulus. Agonistic behaviour was any behaviour that was aggressive towards another animal, whether provoked or unprovoked. Marking behaviour was any behaviour that could be intended to leave an indication of the animal’s presence. Sexual behaviour was any male-female interaction where an animal showed sexual interest in another animal. Stereotypical behaviour was a continuously repeated action that seemed to have no obvious purpose.

It was decided that although nesting was included in the category of individual behaviour, it too would be described. Had masturbation been observed, it would have been given its own category.

Each time one of these behaviours was observed, it was sequentially recorded using the behavioural elements as contained in the behavioural catalogue and the start and stop times were also noted. The descriptions were formulated from these, using the most common sequences for the particular behaviour type, noting any deviations.
2.5 Statistical (tabulated)/Continuous Data Collection

2.5.1 Behavioural type frequency

Using the time-lapse video recorder and quad switcher, the cages were monitored simultaneously for 16 hours and twenty minutes on 21 nights from Monday 10th November 1997 to Sunday 30th November 1997, starting from 4.00pm. It was decided that although filming began on Thursday 6th November 1997, the first few nights data may not have displayed completely accurate behaviour patterns, as the animals had only just been placed in these cages and this gave them a few nights to settle in.

The behaviour was recorded according to the nine different categories described in the previous section.

Each night was separated into half hour periods, as determined during the pilot study, starting with 1600-1629, and for every animal it was noted how many times, during each period, it performed a sequence from any of the categories. This was done in tabular form using a tallying system. The data were recorded only for the instigator of the activity and if an activity overlapped two time periods it was recorded in both. For example, a male approaching a female and attempting to mate with her would be classed as sexual behaviour by the male only, as he instigated it, and if an animal started grooming at 2229 and was still grooming at 2230, the grooming would be included under both the 2200-2229 and 2230-2259 periods. If the
activity was interrupted, even for a moment, and was then continued, it would be recorded as two instances of the original behaviour and the interrupting behaviour would also be recorded.

This information was tabulated to produce graphs to show the total number of times a particular animal displayed behaviour from any one of the behavioural categories on any particular day.

2.5.2 Activity patterns

Using the same video tapes as recorded for the behavioural type frequency (10th November to 30th November 1997), the times at which each animal began and ceased visible activity was noted for each night. This was compared against the sunset and sunrise times, as provided by the Perth Observatory, and it was noted whether activity began before or after sunset and whether it ceased before or after sunrise. The number of days that an unidentified animal began activity before sunset was recorded for each cage if at least one animal began activity after sunset on that day. The number of days that an unidentified animal ceased activity after sunrise was also recorded for each cage if at least one animal ceased activity before sunrise on that day.
2.6 Statistical Methods for Analysis

2.6.1 Male Vs male

Comparisons between males were performed to see whether the behaviour of the male housed alone differed from the behaviours of the other males, to determine if there may have been any behavioural cause for the penile encrustation, and to see if there were any behavioural differences between the male that successfully mated and the males who were unsuccessful.

For each behavioural category, the total number of times each individual animal performed that activity was recorded for each day. Excepting social, agonistic and sexual behaviour, the totals for all of the days combined, from all four males were placed in numerical order. These were then divided into three groups; low-the bottom third, medium-the middle third and high-the top third of the totals. A contingency table containing the number of times a given male's totals fell into the categories of low, medium and high was then constructed. Chi-square analyses were performed on these data. These comparisons were done to see whether the behaviour of the male housed alone differed from the behaviours of the other males, to determine if there may have been any behavioural cause for the penile encrustation,

For the social, agonistic and sexual behavioural categories the same was done except that only the totals of males #3, #11 and #7 were used as male #28 was housed alone and so could not display these behaviour types.
2.6.2 Male Vs female

For each behavioural category, the total number of times an animal performed that activity was recorded for each day. These totals were averaged separately for males and females, as the numbers of each sex differed, and the averages for all of the days combined were put in numerical order. Once in numerical order, the averages were divided into three groups; low- the bottom third of the averages, medium- the middle third and high- the top third. A contingency table was formed to show the number of times the males and females averages fell into the categories of low, medium and high. A chi-square analysis was performed on this data. As male #28 was housed alone, his results were not included for the categories of social, agonistic and sexual behaviour.

2.6.3 Female Vs female

As the focus was primarily on male reproductive behaviour, a comparison between the behaviour of the females was not undertaken.

2.7 Procedural Limitations

Due to the critically endangered status of the species, the needs of the breeding program, being instigated by the Potoroo Recovery Team, placed a number of limitations on the study. As the number of animals in the colony is so small, and the scientists in charge of the breeding program are trying to
keep more than two separate lineages, to minimise inbreeding in the colony, replication of the groupings was impossible. This need to maximise reproduction of all of the founder lineages also determined which animals were housed together and whether single or double cages were used.

The housing arrangements could also make the results biased as some animals were housed within one cage and some housed within two. Although there were two sets of two cages, each containing three animals, cage 3/4 contained an adult male, an adult female and a juvenile female, whereas cage 7/8 contained an adult male and two adult females.

Another limitation of the study was the area of cage being filmed. In the single cages, this was a third of the cage, however in the sets of two cages, the area being filmed was a sixth of the cage area available for animals to utilise. Much behaviour could have occurred in these unfilmed areas, and some behaviour may only be conducted under dense cover and thus would not have been seen in any case. Another limitation of the study was that minor details of the animals' behaviour or movement could not always be clearly determined depending on their distance from, and body position relative to, the video cameras.

Limitations were placed on the study due to the limited amount of money available, as filming of the behaviour of all animals, in all cages would have required at least two more cameras, another time-lapse video, monitor and quad switcher.
2.8 Ethical Considerations

Research on Gilbert's Potoroo is approved by the Edith Cowan University Animal Experimentation Ethics Committee, protocol number 97-A7 issued to Dr. Jackie Courtenay. The Potoroo Recovery Team requested that such a study be undertaken and the research proposal for the study was approved by them, prior to the commencement of the study. The study was conducted under the licence of Dr. J. Courtenay as a Department of Conservation and Land Management consultant, in accordance with the aims and recommendations of the Potoroo Recovery Team and all handling and clipping was carried out by Dr. Courtenay, or in her absence, under the guidance of Potoroo Recovery Team members, Kelly Gillen and Alan Danks.
3 RESULTS

3.1 Annotated/Descriptive Data

3.1.1 The behavioural catalogue

The following behavioural catalogue contains a list of all elements of behaviour observed during both stages of the study, with descriptions of what they entailed and what context they may be found in. The naming of elements is based on Courtenay (1993), Gansloser (1989, 1992) and Coulson (1989).

<table>
<thead>
<tr>
<th>ABBREV.</th>
<th>ELEMENT</th>
<th>DEFINITION</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Attack</td>
<td>One animal jumping at another from a frontal or lateral position.</td>
<td></td>
</tr>
<tr>
<td>AG</td>
<td>Auto-grooming</td>
<td>Animal grooming parts of its own body, either scratching, nibbling or licking.</td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>Attempted mating</td>
<td>Male animal mounts female, but no intromission occurs.</td>
<td>Often preceded by following.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>AP</td>
<td>Approach</td>
<td>One animal approaching another from any direction.</td>
<td>Connected to sexual, social and agonistic behaviours.</td>
</tr>
<tr>
<td>AV</td>
<td>Avoiding</td>
<td>One animal avoiding contact with another by changing direction or turning away.</td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>Body contact</td>
<td>Two animals sitting or lying in contact with each other.</td>
<td>Flank regions touching. Observed when animals feeding.</td>
</tr>
<tr>
<td>BFE</td>
<td>Bipedal</td>
<td>Animal feeding bipedally, using one or both paws to hold food item.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>feeding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Chase</td>
<td>One animal hopping after another in a fast gait.</td>
<td>Agonistic (generally female chasing male) or sexual (male chasing female) context.</td>
</tr>
<tr>
<td>CF</td>
<td>Cuffing</td>
<td>One animal grabs or hits out at a conspecific with one or both paws.</td>
<td>Agonistic behaviour.</td>
</tr>
<tr>
<td>DA</td>
<td>Dodge away</td>
<td>Animal suddenly changes direction to escape animal chasing it.</td>
<td></td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>DG</td>
<td>Digging</td>
<td>Animal uses front paws to scrape sand away, usually forming an indent in the ground.</td>
<td></td>
</tr>
<tr>
<td>DT</td>
<td>Dart towards</td>
<td>Animal suddenly dashes a short distance toward another animal.</td>
<td>Sometimes resulted in chase. Agonistic behaviour.</td>
</tr>
<tr>
<td>F</td>
<td>Flight</td>
<td>One animal hopping away from conspecific in a very fast gait.</td>
<td>Sexual and agonistic contexts.</td>
</tr>
<tr>
<td>FD</td>
<td>Flatten/flinch down</td>
<td>Animal tenses up and flattens itself against the ground in response to an external stimulus (not due to conspecific).</td>
<td>Probably a fright response.</td>
</tr>
<tr>
<td>FO</td>
<td>Following</td>
<td>One animal follows another in a slow gait.</td>
<td>Sexual behaviour.</td>
</tr>
<tr>
<td>FR</td>
<td>Foraging</td>
<td>Animal moves with slow quadrupedal hop while sniffing the ground.</td>
<td>Feeding behaviour</td>
</tr>
<tr>
<td>G</td>
<td>Gazing</td>
<td>One animal fixing its gaze on another one for a few seconds.</td>
<td></td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
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<td>---------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>HH</td>
<td>Raising hands</td>
<td>Animal raising hands and cuffing or hitting towards an opponent without actually making contact.</td>
<td>Agonistic behaviour, either defensive or aggressive.</td>
</tr>
<tr>
<td>I</td>
<td>Ignoring</td>
<td>One animal ignores another which maybe trying to contact it or else just moving or feeding nearby.</td>
<td>Probably attempt to avoid contact.</td>
</tr>
<tr>
<td>JB</td>
<td>Jump back</td>
<td>Animal jumps backwards.</td>
<td>Could be part of courtship behaviour—male jumps back in response to female pushing or lunging at him.</td>
</tr>
<tr>
<td>LA</td>
<td>Look around</td>
<td>Animal looks around.</td>
<td>Animal just surveying the environment, not in response to conspecific.</td>
</tr>
<tr>
<td>LE</td>
<td>Leaving</td>
<td>Animal breaks off contact by hoping away.</td>
<td>Termination of non-agonistic interactions.</td>
</tr>
<tr>
<td>LC</td>
<td>Laying chin</td>
<td>One animal lays its chin on the back of another.</td>
<td>May be marking behaviour in courtship.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
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<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>LH</td>
<td>Laying hands</td>
<td>One animal gently lays one or both hands onto another one.</td>
<td>No hitting or grabbing. Seen during attempted matings.</td>
</tr>
<tr>
<td>LOC</td>
<td>Locomotion</td>
<td>Any general movement from one place to another, ie SBLOC is slow bipedal locomotion and FQLOC is fast quadrupedal locomotion.</td>
<td>Animal moving around-not as a response to conspecific.</td>
</tr>
<tr>
<td>LP</td>
<td>Leap</td>
<td>Animal leaps over object.</td>
<td>Seen during chases, both agonistic and sexual.</td>
</tr>
<tr>
<td>LU</td>
<td>Look up</td>
<td>Animal raises head, usually from nose to ground position or while feeding.</td>
<td>Sometimes in response to conspecifics.</td>
</tr>
<tr>
<td>MA</td>
<td>Move away</td>
<td>Animal moves away quadrupedally.</td>
<td>Termination of interaction but with no agonistic element.</td>
</tr>
<tr>
<td>MASD</td>
<td>Move away short</td>
<td>Animal moves away quadrupedally a few paces.</td>
<td>Breaking contact, but seemingly almost inviting the other animal to follow and resume contact.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
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<td>----------------------------------</td>
</tr>
<tr>
<td>MF</td>
<td>Manipulation of food</td>
<td>Animal picks up food and moves it around using both paws.</td>
<td>Feeding behaviour.</td>
</tr>
<tr>
<td>MO</td>
<td>Manipulation of objects</td>
<td>Animal biting and pawing at twigs and moving bowl.</td>
<td>Often precedes marking.</td>
</tr>
<tr>
<td>MT</td>
<td>Move towards</td>
<td>An animal moves one or two steps towards an animal which has approached it.</td>
<td>Sometimes followed by</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>naso-nasal sniffing.</td>
</tr>
<tr>
<td>PF</td>
<td>Pass in front</td>
<td>One animal passes by another animal neither seeking nor avoiding contact.</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>Pass behind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>Pushing or hitting with snout</td>
<td>One animal pushing or bumping against another with its snout.</td>
<td>Seen in juvenile when in contact with mother.</td>
</tr>
<tr>
<td>QFE</td>
<td>Quadrupedal feeding</td>
<td>Animal feeding quadrupedally using either a single forepaw to hold food item while bending down to eat, or by using its mouth only.</td>
<td>Animal generally sitting still.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>RBc</td>
<td>Rub branch/bush with chest.</td>
<td>Animal rubs branch on chest or rubs chest on bush.</td>
<td>Marking behaviour.</td>
</tr>
<tr>
<td>RBm</td>
<td>Rub branch/bush with chin.</td>
<td>Animal rubs branch on chin or rubs chin against bush.</td>
<td>Marking behaviour.</td>
</tr>
<tr>
<td>RQ</td>
<td>Resume quadrupedal</td>
<td>Animal drops down to quadrupedal position after feeding or moving bipedally, or after alert posture.</td>
<td></td>
</tr>
<tr>
<td>RU</td>
<td>Raise up</td>
<td>Animal rises into bipedal position.</td>
<td>Usually observed after quadrupedal feeding.</td>
</tr>
<tr>
<td>RUA</td>
<td>Raise up alert</td>
<td>Animal rises up into fully erect or 'alert' posture.</td>
<td></td>
</tr>
<tr>
<td>RUF</td>
<td>Raise up feeding</td>
<td>Animal raises up on hind legs and stretches head to reach food.</td>
<td></td>
</tr>
<tr>
<td>RW</td>
<td>Rump wiggle</td>
<td>Animal moves its hindquarters from side to side.</td>
<td>Sometimes observed when animal being followed.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
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<td>----------------------------------------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>SAP</td>
<td>Snapping</td>
<td>Animal shooting its head towards conspecific as if biting but not making contact.</td>
<td>Agonistic behaviour.</td>
</tr>
<tr>
<td>SB</td>
<td>Sniff bowl</td>
<td>Animal sniffs the edge and inside of the food bowl.</td>
<td></td>
</tr>
<tr>
<td>SBS</td>
<td>Side-by-side</td>
<td>Two animals are in parallel or right angled position to each another.</td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>Sexual checking</td>
<td>One animal sniffs at another's tail or urogenital region.</td>
<td>Sometimes seen before attempted mating.</td>
</tr>
<tr>
<td>SF</td>
<td>Flank sniffing</td>
<td>One animal sniffs at conspecific's flank region.</td>
<td>Social behaviour. May be for identification.</td>
</tr>
<tr>
<td>SG</td>
<td>Sniff ground</td>
<td>Animal places head down and sniffs the ground.</td>
<td>Not foraging.</td>
</tr>
<tr>
<td>SH</td>
<td>Shake head</td>
<td>Animal shakes its head rapidly as if to dislodge something out of its nose or off its whiskers.</td>
<td></td>
</tr>
<tr>
<td>SHB</td>
<td>Stretching head</td>
<td>Animal bends its neck backwards, stretching its muzzle straight into the air.</td>
<td>Sometimes seen when in alert posture.</td>
</tr>
<tr>
<td>ABBREV.</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>SHF</td>
<td>Stretching head forwards</td>
<td>Animal extends its neck forward, the muzzle being stretched slightly upward.</td>
<td>Sometimes seen when in alert posture.</td>
</tr>
<tr>
<td>SLF</td>
<td>Sniffing lips</td>
<td>One animal sniffs the others lips or muzzle while feeding.</td>
<td>Observed in mother-young interaction (by juvenile).</td>
</tr>
<tr>
<td>SNN</td>
<td>Naso-nasal sniffing</td>
<td>One animal sniffs at another’s snout, Usually from a frontal position.</td>
<td></td>
</tr>
<tr>
<td>SQ</td>
<td>Sit quadrupedally</td>
<td>Animal sits in quadrupedal posture.</td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>Sniffing air</td>
<td>Animal tests the air by sniffing around. The muzzle is raised slightly up and down and moved from side to side slightly.</td>
<td>Vigilance behaviour.</td>
</tr>
<tr>
<td>ST</td>
<td>Sniff towards</td>
<td>One animal stretches its muzzle in the direction of another animal while sniffing the air.</td>
<td>Generally seen in approach situations.</td>
</tr>
<tr>
<td>STF</td>
<td>Startle and flee</td>
<td>An animal suddenly flees in response to some stimulus not due to a conspecific.</td>
<td>Generally quadrupedal locomotion.</td>
</tr>
<tr>
<td>ABBREVIATION</td>
<td>ELEMENT</td>
<td>DEFINITION</td>
<td>REMARKS</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
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<td>---------</td>
</tr>
<tr>
<td>STM</td>
<td>Stay</td>
<td>Animal sits completely still without sniffing or looking around.</td>
<td>Often in response to movement of conspecific nearby.</td>
</tr>
<tr>
<td></td>
<td>motionless</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Turn</td>
<td>Animal changes direction in the course of normal activity.</td>
<td></td>
</tr>
<tr>
<td>TA</td>
<td>Turn away</td>
<td>Animal turns its body away from another animal.</td>
<td>Breaking off contact.</td>
</tr>
<tr>
<td>TF</td>
<td>Tail flick</td>
<td>Animal flicks its tail.</td>
<td></td>
</tr>
<tr>
<td>THA</td>
<td>Turn head away</td>
<td>Animal turns its head away from conspecific.</td>
<td></td>
</tr>
<tr>
<td>THT</td>
<td>Turn head towards</td>
<td>Animal turns its head towards conspecific.</td>
<td></td>
</tr>
<tr>
<td>TL</td>
<td>Tail lashing</td>
<td>Rapid, lateral movement of the animal's tail.</td>
<td>Seen in male when following.</td>
</tr>
<tr>
<td>TT</td>
<td>Turn towards</td>
<td>One animal turns its body to face another one.</td>
<td></td>
</tr>
<tr>
<td>WF</td>
<td>Wipe face</td>
<td>Both forepaws simultaneously raised up to sides of face and brushed forward towards to nose.</td>
<td>Grooming behaviour.</td>
</tr>
</tbody>
</table>
3.1.2 The sequence descriptions

The following behavioural descriptions were formulated by dividing all of the behavioural elements shown above into categories and then the most common sequences for each category were described, with any deviations being noted.

3.1.2.1 Locomotion

General locomotion in *Potorous gilbertii* is a slow quadrupedal hop, where both front paws are simultaneously brought forward and placed on the ground and the hind feet are simultaneously brought forward beneath the body. The tail is held erect, and slightly raised, behind the body. When startled, the speed of the hop is greatly increased and in some cases, especially when an animal is clasping food, a rapid bipedal hop is utilised. During exploratory behaviour by the juvenile female #32, the front paws were seen to have been put down alternately and as she moved forward slowly, she continued to put her paws down alternately. It was not seen whether she moved her hind paws alternately or simultaneously.

3.1.2.2 Feeding/Foraging behaviour

Foraging involved the animal sniffing the ground whilst slowly moving, using a slow quadrupedal hop. The ground was occasionally scratched at and alternate paws were used for this. Feeding involved the animal sniffing the
bowl and selecting an item of food. This was either picked up with the front paws or by the mouth. Food was generally held with both hands, but one hand was occasionally used. A bipedal stance was usually used when feeding and the food was turned and manipulated by the paws. Food was generally brought up to the mouth and the head lowered slightly. Some feeding on foliage was also observed. This involved the animal sniffing at the plant and reaching up and grasping a branch with its paw. The animal appeared to chew or pull off a portion with its teeth and eat it. On one occasion, male #3 was seen to deliberately throw a piece of food. There did not seem to be any reason for this behaviour.

3.1.2.3 Social behaviour

Social behaviour was mostly confined to animals feeding together, but not strictly interacting other than by looking at each other. Some naso-nasal sniffing, however, was seen. Juvenile female #32 was also seen to approach her mother (#10) and nudge the food out of her paws. The young then proceeded to pick up the food and eat it. The mother simply moved to the bowl and took another piece of food.

3.1.2.4 Individual behaviour

This often involved an animal sitting, apparently idle, and was commonly observed before sunset and after sunrise, where the animal was crouched under a bush. Individual behaviour also included sniffing of objects and
manipulation of objects being sniffed. For example, a female was seen sniffing a bush that a male had been observed marking. Grooming was also included in this category. This commonly involved the animal bringing both front paws up to its face and dragging them simultaneously down over the cheeks to the muzzle. The paws were sometimes brought back up the face. Grooming with the hind feet was also observed, where the hind foot was brought up to the flank and brought down with rapid movements and the syndactylous toes of the hindfoot were flexed outwards.

3.1.2.5 Vigilance

This was most often seen whilst the animals were feeding. It sometimes involved the animal looking around and surveying its surroundings, whether in a bipedal stance or a quadrupedal one, but most often it involved the animal sitting erect, with its back stretched and its chin pointing up whilst it sniffed the air.

3.1.2.6 Agonistic behaviour

This was most often observed when a male was attempting to mount a seemingly unreceptive female. In this case the female would turn rapidly and pounce at the male, usually raising hands. There was often no contact, however in some cases the male retaliated by lunging back or chasing the female.
Other agonistic encounters involved the aggressor darting towards another animal for no apparent reason. In one case an animal was seen to leap over a food bowl to charge at another animal, whilst in another an animal leapt over the food bowls to escape an aggressor that was chasing it. During the pilot study a fight was observed, which mainly involved the animals lunging at each other, with some contact being made with the paws. No animal was, however, physically injured.

3.1.2.7 Marking

Marking behaviour was mainly observed in males and generally involved either a branch being pulled down and the chin or chest rubbed against it, or the animal approaching a tree or bush and rubbing its chin or chest against it. On one occasion a male was seen to drag his chin down the back of a female. Animals were also observed to drag themselves along the ground, using their front paws, with their legs extended behind them, on a few occasions.

3.1.2.8 Sexual behaviour

A third of the sexual behaviour was following or chasing by the male that did not lead to an attempted mating, while the other two thirds were attempted matings. Following was classed as sexual when one animal was following the other at a distance of no more than 1.5 body lengths. The mating attempts lasted from less than one second to five seconds, with generally one to two thrusts per second. The attempted matings involved the male
approaching the female, sometimes after following her and generally from behind, very occasionally sniffing her rump, raising up on his hind legs and laying his hands gently on her back. He then proceeded to thrust his pelvis towards her. The female most often terminated the attempt by moving half to one metre away. No completed matings were observed. The female never raised her rump and the male was never seen to be in a position where his penis could enter the female.

3.1.2.9 Stereotypical behaviour

Stereotypical behaviour involved the animal continually running or pacing across the door of the cage (males #3, #7 and #28 and female #27) or down the wall adjacent to another cage (male #11 and female #32). This ranged from 4 seconds to 47 seconds. Breaks between episodes sometimes lasted as little as one second.

3.1.2.10 Nesting/burrowing

Animals were observed to burrow through the Allocasuarina needles placed in the cages for nesting. It was not, however, seen whether this was facilitated by the front paws or whether the animal pushed through with its muzzle.
3.2 Statistical (Tabulated)/Continuous Data

The total number of times each animal displayed a particular behaviour type was recorded for each day of the continual study. These data were used to form graphs for each animal, displaying their behaviour patterns over the duration of the study.

3.2.1 Behavioural type frequency

3.2.1.1 Cage 2 - male #28

Figure 3.1 shows that on all days locomotion was the most commonly seen behaviour displayed by male #28, followed by feeding/foraging, vigilance, then individual behaviour. No sexual, agonistic or social behaviour was possible, as this male was housed alone. No marking behaviour was seen. The amount of locomotion over the duration of the experiment fluctuated quite dramatically. It was however, highest in the first few days. Male #28 displayed very little stereotypical behaviour with the only observed occasions being once on the 15th and twice on the 16th November 1997.
Figure 3.1: Total number of times male #28 displays any of the behavioural types on any given date.


3.2.1.2  Cage 3/4 · male #3

It is shown by Figure 3.2 that male #3 displayed very little agonistic behaviour and even less marking behaviour. Locomotion was the most common behaviour displayed. It followed a steady pattern initially but increased dramatically on the 15th November and from then on it fluctuated greatly. Feeding and vigilance seemed to follow a pattern similar to one another. Stereotypical behaviour was comparatively low until the 15th November where it was seen to increase dramatically and then decrease the following night after which it stayed low with some fluctuations in number. Social and sexual behaviour also appeared to increase on this night, however not to the extent of the stereotypical behaviour.

3.2.1.3  Cage 3/4 · female #10

From Figure 3.3 it can be seen that for Female #10, locomotion was generally the most commonly observed behaviour of each night. This was followed by feeding then vigilance. On the 15th November, social behaviour seemed to increase quite considerably and agonistic behaviour increased very slightly around the 15th and 16th November, however individual behaviour did not seem to follow any pattern and seemed to fluctuate. Female #10 did not initiate any sexual behaviour and no marking or stereotypical behaviour was seen.
Figure 3.2: Total number of times male #3 displays any of the behavioural types on any given date.
Figure 3.3: Total number of times female #10 displays any of the behavioural types on any given date.
3.2.1.4  Cage 3/4 - female #32

Figure 3.4 shows that locomotion was also the most common behaviour displayed by female #32 and it seemed to display a cyclic pattern. Feeding/foraging behaviour was the second most displayed behaviour on each of the days followed by vigilance and these both seemed to follow the same pattern. The numbers of social interactions over the duration of the study did not seem to display any pattern and marking, sexual and agonistic behaviour were not observed at all. It was to be expected that the latter two would not be observed as this animal is a juvenile. A very small amount of stereotypical behaviour was observed in this individual on the first night of the study.

3.2.1.5  Cage 5 - male #11

Locomotion, feeding and vigilance by male #11 seem to follow the same pattern as shown by Figure 3.5, with locomotion being the most commonly observed behaviour of any night followed generally by feeding then vigilance. There was quite a high amount of sexual behaviour throughout the duration of the study and this was relatively constant throughout. Some stereotypical, marking and social behaviour was noted, however there did not seem to be any obvious relationship between these. No agonistic behaviour was observed.
Figure 3.4: Total number of times female #32 displays any of the behavioural types on any given day.
Figure 3.5: Total number of times male #11 displays any of the behavioural types on any given date.
3.2.1.6 Cage 5 - female #18

Figure 3.6 shows that female #18 also displayed locomotion most frequently on each night of the study, followed by feeding and vigilance. The highest numbers of all three of the behaviours were recorded on the 14th November. The number of times individual behaviour and social behaviour were displayed fluctuated throughout the study, but were relatively low. Agonistic behaviour was rarely seen and sexual behaviour was not observed at all. Marking behaviour was seen only on one night, the 27th November 1997. In this, she was seen to rub her chest against a bush.

3.2.1.7 Cage 7/8 - male #7

Male #7 also showed locomotion most commonly throughout the study, followed by feeding/foraging and then vigilance, as displayed by Figure 3.7. Figure 3.7 also shows that on the first night, locomotion, feeding, vigilance, individual, sexual and social behaviour were all relatively high compared to the rest of the study. Most of these behaviours decreased over the following two nights and then increased again. Sexual behaviour was frequent throughout the study although it fluctuated markedly. For the first part of the continuous study, his mating attempts were restricted to female #19. By the end of the study, however, he did not seem to prefer one female over the other, and attempted to mate with both females quite regularly.
Figure 3.6: Total number of times female #18 displays any of the behavioural types on any given day.
Figure 3.7: Total number of times male #7 displays any of the behavioural types on any given date.
3.2.1.8 Cage 7/8 - female #19

Figure 3.8 shows that although female #19 displayed locomotion most often on each of the nights of the study, followed by feeding and vigilance, on the first night of the study the totals are generally much higher than for the rest of the study. No stereotypical or marking behaviour was observed and very little agonistic behaviour was seen. One episode of sexual behaviour was seen on the first night of the study, where the female sniffed the male’s rump and then followed him.

3.2.1.9 Cage 7/8 - female #27

Female #27 displayed a high level of agonistic behaviour on the first night of the study, however over the rest of the study, very little was displayed (Figure 3.9). Locomotion was again the most frequent form of behaviour seen over the study, followed by feeding and vigilance. Figure 3.9 also shows that no marking or sexual behaviour was shown by this individual and that only a very small amount of stereotypical behaviour was seen. On the 24th November, locomotion, feeding, vigilance, social and individual behaviours all seemed to show a corresponding increase in frequency.
Figure 3.8: Total number of times female #19 displays any of the behavioural types on any given date.
Figure 3.9: Total number of times female #27 displays any of the behavioural types on any given date.
3.2.2 Activity patterns

In cage 2, male #28 was active before sunset every day of the study (total = 21 days) and active after sunrise on 10 days. In cage 3, male #3 was active before sunset on at least 8 days, female #10 on a minimum of 5 days and female #32 on at least 2 days. On 20 days, however, unidentified animals were active before sunset. Male #3 was active after sunrise on at least 2 days, female #10 on at least 5 days and female #32 on a minimum of 7 days with unidentified animals active after sunrise on 15 days. In cage 5, male #11 was active before sunset on 20 days and female #18 on the same 20 days. At least one of these animals was, however active before sunset on the 21st day, though it was not able to be identified. Male #11 was active after sunrise on 8 days and female #18 was also active after sunrise on the same 8 days. In cage 7, male #7 was active before sunset on 17 days, female #19 on 13 days and female #27 on 13 days also. Male #7 was definitely active after sunrise on 3 days, female #19 on at least 6 days while female #27 was not identified as being active after sunrise on any day, however unidentified animals were active after sunrise on 10 days.
3.3 Results of Statistical Analyses

3.3.1 Male Vs male

There were statistically significant differences in locomotion, with #28 displaying the highest frequency of locomotion and #3 displaying the lowest (P=0.000), feeding- #28 the highest and #3 the lowest (P=0.000) and individual behaviour- #7 the highest and #11 the lowest frequency of individual behaviour (P=0.006) between the four males. There was, however, no significant difference in vigilance (P=0.525) between the four males. Between the three males housed with females, there were statistically significant differences in both social (P=0.028) and sexual behaviour (P=0.000), with #11 having the highest frequency of both social and sexual behaviour, whilst #7 had the lowest frequency of social and #3 had the lowest frequency of sexual behaviour. For marking and stereotypical behaviour between all four males and for agonistic behaviour between the males housed with females, some expected frequencies were zero, therefore chi-square analyses could not be performed on these portions of data.
3.3.2 Male Vs female

Males showed significantly higher frequencies of locomotion (P=0.000) and feeding/foraging (P=0.007) than did females. There was, however, no significant difference in individual behaviour (P=0.319). Males displayed significantly more vigilance (P=0.000), marking (P=0.031) and stereotypical behaviour (P=0.000) and they were also more social (P=0.019) and sexual (P=0.000), whereas females displayed significantly more agonistic behaviour (P=0.004).

4 DISCUSSION

The behavioural repertoire of *Potorous gilbertii* is, as a whole, very similar to that of other potoroid and small macropodid marsupials, as described by Courtenay (1993), Ganslosser (1992) and Coulson (1989). Depending on the animal’s distance from, and its body position in relation to, the video camera, minor details of its behaviour or movement could not always, however, be clearly determined.

Sexual following and mating attempts closely resemble those of *Potorous longipes*, where the male follows the female for some distance before mounting her from behind and often thrusting his pelvis. The mating attempt is often terminated by the female moving away, with the male following her (Serena et al., 1996). Savage agonistic behaviour such as that described by Hughes (1962), Johnson (1980) and Noyes (1986) where an animal has
sometimes inflicted grievous wounds to a conspecific, was however, notably absent throughout this study of *P. gilbertii*. This may have been due to there being no contact between males, where severe fighting has most often been noted (Hughes, 1962). The agonistic behaviour that was seen did not, however, seem to have any elements of viciousness, even though males were often very persistent in their mating attempts with an unreceptive female. There were no unexplained injuries sustained by any animals at any time over the duration of the study, as seen by Ullmann & Brown (1983), and it may therefore be postulated that *Potorous gilbertii* may have a different social organisation to, or be more tolerant of conspecifics than, other potoroid marsupials. Gilbert's Potoroo is believed to form loose aggregates, and it has been found through trapping and spooling that male and female home ranges overlap at least partially, and that several males and females utilise the same areas (Vetten, 1996). This is in contrast to the results of radiotracking of *Potorous tridactylus* by Long (1997) that found that there were low levels of intrasexual overlap of home ranges and that male home ranges may partially overlap those of several females. This evidence may support the theory that *P. gilbertii* are more tolerant of conspecifics and thus have greater interaction within populations.

Locomotion in *P. gilbertii* seems to be very similar to that of *Aepyprymnus rufescens*, where both front paws are moved forward simultaneously, followed by the hind feet (Johnson, 1980), however *P. gilbertii* rarely used a slow bipedal hop for normal locomotion, using instead, a slow quadrupedal hop for general locomotion. When startled, Gilbert's Potoroo was
sometimes observed to kick the ground before fleeing, a commonly noted trait of macropodoids (Coulson, 1989; Croft, 1981; Johnson, 1980). A cloud of dust was often kicked up when the animal fled (pers. obs.).

It is not known whether alarm vocalisations were emitted during the study as there was no facility for audio recording in this study. A bird-like “chirruping” call has, however, been heard being emitted by a young that was separated from its mother (pers. obs.) and also by an adult male when he was captured. This is believed to be some sort of alarm or distress call (Courtenay, pers. comm.)

The animals showed a high degree of dexterity with their front paws. For example, they were able to pick up a shelled peanut and manipulate it with the paws. Most food was manipulated this way. Feeding in *P. gilbertii* is similar to that of *A. rufescens*, who also hold and manipulate food with their front paws, however merycism, the deliberate dropping of regurgitated food to be re-eaten, was not observed (Johnson, 1980). Regurgitation of food may, however, have taken place.

Grooming in *P. gilbertii* seemed to follow the pattern seen in other potoroids, such as *A. rufescens*, in that they use an upright stance to groom their abdominal region with their front paws, and when using the hindfeet to groom themselves, the forefeet are placed on the ground, and the syndactylous toes are utilised (Johnson, 1980). Allogrooming was, however, not observed. Grooming was occasionally social, where the animal was in
close proximity to another individual, however most social behaviour involved the animals feeding in close proximity. A juvenile was seen to dislodge food from the paws of its mother and no antagonism was shown towards the juvenile by its mother (pers. obs.). This type of mother-young behaviour has been observed in other macropodoids (Croft, 1980).

The animals showed a high degree of vigilance behaviour. This may have been due to the close proximity of other individuals in adjacent cages, or it could be an instinctual survival response to stay aware of its surroundings. As sniffing was almost always involved, it may have been to detect predators, or even to detect oestrous females. The animals were also observed sniffing many items including the doors, plants and even the cameras. This indicates that as in other macropodoids, olfactory cues are important in *P. gilbertii* communication (Croft, 1980; Croft, 1982).

Marking was displayed almost exclusively by males, most commonly by male #3. Due to the low number of total markings this could not, however, be statistically tested. Male #3 was housed with females #10 and #32. It could be expected that a sexually active male would mark his territory (Poole, 1985), and as Figure 2.2 shows, male #3 and female #10 have mated previously, producing three young.

On December 31st 1997, a new young was found in the pouch of female #10. It was judged that the young was only a few days old, but was definitely less than 14 days old. Based on an estimated gestation period of
38 day, like *P. tridactylus* (Serena, *et al*., 1996), it could be estimated that mating took place between the 15th and 19th November 1997. The data collected for male #3 and female #10 shows that on the 15th November 1997, male #3 displayed a high level of activity, especially in relation to stereotypical behaviour, and to a lesser extent, social and sexual behaviour. Female #10 also showed an increase in social behaviour on this night. It therefore seems likely that the successful mating took place on or around the night of 15th November 1997.

The study by Serena *et al.* (1996) found that the number of attempted matings was highest around the time completed copulations were seen. The highest number of attempted matings by male #3, during the study, was recorded on the 15th November 1997, supporting the inference that this was the date that male #3 and female #10 mated. It must, however, be noted that although receptive female potoroids have been seen to display proceptive behaviour (Serena *et al*., 1996), this was not observed, in fact, the oestrus female showed an increase in agonistic behaviour around this time.

The only two days where male #28 was observed to display stereotypical behaviour occurred around the time female #10, who was in the cage adjacent to that of male #28, was thought to be in oestrus. Only three episodes of this behaviour were observed. It must, however, be noted that
on the night when the single episode was observed (15th November 1997),
the globe in male #28's cage blew, leaving the cage in darkness for over
four hours.

Sexual, social, individual, feeding and locomotive behaviour were all shown
to have statistically significant differences between males, however male #3
did not display the highest totals for any of these categories. In fact, male
#3 displayed significantly less sexual behaviour than did the other two males
housed with females. This could be because male #3 and female #10 were
sexually compatible, so repeated, unsuccessful mating attempts were not
necessary. There did not, therefore, seem to be any obvious behavioural
increase that indicated that these two individuals were a sexually compatible
pair. Lack of excessive mating attempts may, however, be of importance.
In comparison with less compatible pairs, these animals displayed a lower
frequency of mating attempts, which may be an important indicator for an
observer when trying to determine compatibility.

Studies on changes in the behaviour of male #3 around the time of female
#10's oestrus may provide further information on the behaviour of a male
with a female he is known to be sexually compatible with, to help identify
compatible pairs, as may comparisons of a female's behaviour towards a
male in response to unsolicited mating attempts or in regards to agonistic
behaviour of females towards males.
Serena et al. (1996) found that both male and female *P. longipes* initiated social and agonistic interactions, and that of the agonistic encounters in which the sex could be determined (seven in total), marginally more were initiated by the male (four as compared to three initiated by the female). However, this study found that most agonistic behaviour in *P. gilbertii* was initiated by the female, and was in response to an unwelcome mating attempt.

As female #32 is a juvenile, sexual behaviour would not be expected. It would also be expected that this individual would not initiate agonistic behaviour, as juveniles are generally more submissive, and that agonistic behaviour might actually be directed towards this individual by both its mother and father (Croft, 1981). Agonistic behaviour towards the juvenile by both adults was observed on numerous occasions during the study, generally during feeding, with the older animal scaring the juvenile away from the food bowls.

The male housed alone (#28) seemed to do significantly more locomotive and feeding behaviour. This could be due to his residing in only one cage or to his having no companion to interact with. It is, however, most likely due to a combination of these factors, as male #11 also had the run of only one cage, and his activity in these two categories was not significantly higher than those of the males with the run of two cages. Male #28 was not seen to display any behaviour or action that was different to the other males that may have caused him to have a greater degree of penile encrustation.
There did not appear to be any obvious patterns or trends in the activities of the animals collectively over the duration of the study, except that locomotion was the most commonly observed behaviour, followed by feeding then vigilance. This is to be expected, as the cameras were trained on the feeding area and the animal must move to the food. As was previously noted, vigilance was most commonly observed while the animal was feeding, therefore it could be expected that vigilance would be the third most commonly observed activity.

In all behaviours where statistically significant differences were noted, except agonistic behaviour, the males displayed the higher levels of activity. In contrast, females displayed significantly more agonistic behaviour. It must again be noted, however, that only a portion of the cage was visible for the study, so statistical differences may not be entirely reliable. Female #10, however, showed consistently more agonistic behaviour, compared to any of the other females, over the duration of the study, including females #19 and #27 who were also housed in a double cage.

Activity patterns of potoroid marsupials vary quite dramatically, from the wholly diurnal *Hypsipyrmnodon moschatus*, to the completely nocturnal *P. longipes*. *P. tridactylus* is at least partly diurnal (Seebeck et al., 1989). The evidence collected during this study seems to indicate that *P. gilbertii* is also partly diurnal, as all animals were active before sunset on at least two nights, with one animal (male #28) active before sunset on all nights of the study, and two animals active before sunset on all but one night. All animals
except female #27 were active at least two mornings after sunrise, and male #28 was active on ten mornings after sunrise. There did not seem to be any pattern to nocturnal activity, except that animals were generally active throughout the night.

During the day, *P. tridactylus* do not construct complex nests, but generally shelter in a shallow squat, excavated under dense shrubs or at the base of a tussock. *P. longipes* shelter in similar type squats (Seebeck *et al.*, 1989). *P. gilbertii* were observed to shelter in similar squats or in hollows dug in the casuarina needles (Figure 4.1). Burrows were, however, also observed in the *Allocasuarina* needles and a burrow was found by the author, at the very back of cage 4, during a routine handling of the animals. It appeared to have been dug by the juvenile female #32 as the opening was only about 80mm in diameter, and she was found inside the burrow. Figure 4.2 shows the general shape of the burrow.

### 4.1 Conclusions

This study has provided important preliminary data on the behaviour of this previously unstudied, critically endangered species. It has shown that there is a high amount of social and low amount of sexual behaviour displayed by a compatible pair, with the female of this pair displaying quite a high amount of agonistic behaviour towards her mate. It also shows that *Potorous gilbertii* may construct burrows or complex nests, a trait not seen in other *Potorous* spp.
Figure 4.1: *Potorous gilbertii* nest in *Allocasuarina* needles
Figure 4.2: *Potorous gilbertii* burrow
It seems that the species may be monogamous, or at least display a degree of mate choice, but further study would need to be made of this. No behavioural cause for penile encrustation was observed and males did not show any behaviour that would seem to adversely affect breeding success.

Future detailed studies of all aspects of the behaviour of Gilbert's Potoroo, including agonistic behaviour and mother-young interactions, need to be undertaken. This study provides a basis for further studies on what is possibly Australia's most critically endangered mammal.
References


