MEASURING THE SUCCESS OF WILDLIFE REHABILITATION

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Abstract

Native mammal populations in Southeast Queensland are under threat from habitat loss through land development, dog attacks and motor vehicle accidents. Animals that are not killed from these impacts are sometimes rescued, rehabilitated and later released back into the wild, usually in their area of origin. Although the release of these animals is a relatively common practice, little post release monitoring has been carried out and reported to assess the success of the animals in the wild.

This paper discusses the results of three recent studies which have monitored the movements and health of rehabilitated and translocated koalas (*Phascolarctos cinereus*) and common brushtail possums (*Trichosurus vulpecular*): one conducted by Wildcare Australia in 1995-1996, the other two in collaboration with the University of Queensland. The results indicate that the survival and health of the great majority of the released animals were good and that they were usually able to establish new home ranges during the tracking period. Such findings seem to contradict the results of studies conducted in southern Australia which have monitored the release of translocated possums and gliders, and suggest that there are some key factors which may be critical in determining the success of such releases. These factors include the age of admission and the duration of care, and in particular the selection of the release site. With both koalas and brushtail possums, the release site was found to be critical in determining both the survival and dispersal of the released animals. Consequently, while these studies confirm that the reintroduction of koalas and common brushtail possums may be a viable management strategy, the individual characteristics of the animals themselves and of their release areas must be carefully considered. It is recommended that further research of these key release factors be undertaken and that the work be extended for other species which are commonly released following rehabilitation.

1. Introduction

Every year a large number of native mammals are rescued and rehabilitated for release back into the wild. Whilst there have been considerable advances in the veterinary treatment of wildlife, hitherto little attention has been given to the survival of these animals following their release. This paper briefly describes three radio tracking studies conducted in the Gold Coast region; two followed the movements and survival of released koalas (*Phascolarctos cinereus*), while the third monitored the survival of rehabilitated common brushtail possums (*Trichosurus vulpecular*)

2. The Koala Studies

Perhaps more than any other Australian native animal, koalas have been subjected to numerous translocation programs over the past century. This has largely been because of overpopulation problems in certain areas of Victoria resulting in over browsing and death of trees (Martin and Handasyde, 1999). However, over the years there have also been large numbers of koalas taken in by wildlife carers, shelters and zoological institutions as either sick, injured, orphaned or displaced individuals. Many of these animals have later been rehabilitated and returned to the wild, but to date there have been few post-release monitoring studies aimed at determining the success of this practice (Carrick et al, 1990; Ellis et al, 1990; Sutcliffe, 1997). Two koala radio tracking studies have been conducted recently in the Gold Coast region. The koalas monitored included animals treated for trauma and chlamydial disease, as well as hand reared orphans and animals displaced by land clearing. The first study was conducted in 1995 – 96 by Wildcare Australia and has been reported briefly by Sutcliffe (1997), and the second in 2002 -2004.

2.1 Materials and Methods:

2.1.1 Release Sites:

Two release sites were used in the course of these koala tracking studies: a 6000 hectare site at Kokoda Barracks near Canungra on the Gold Coast City/ Beaudesert Shire border; and an 800 hectare site in the suburb of Coombabah, close to the centre of the Gold Coast City.

Kokoda Barracks
The Kokoda Barracks (Canungra) site comprises approximately 6000 hectares of protected bushland owned by the Australian Army. The vegetation is predominantly open eucalypt forest but also contains complex notophyll vine forest, tall open forest, riparian forest and pockets of rainforest (Driscoll and Plowman 1990). The area is continuous with forested areas of the Gold Coast hinterland and Beaudesert Shire and provides ample opportunity for dispersal, immigration and emigration of most native species occurring in the region. The koala population density appears to be relatively low, based on anecdotal reports and observations during the study.

Coombabah
The Coombabah site is contained within the boundary of the 778 hectare Coombabah Lakelands Conservation Area (CLCA), which is administered by the Gold Coast City Council. Vegetation types include mangrove and saltmarsh communities, *Casuarina*, *Melaleuca* and lowland *Eucalypt* forest and woodland a total of 516 ha of which was considered suitable habitat for koalas (Forestman, 1998).

In contrast with the Kokoda Barracks site, the CLCA is almost completely surrounded by urban development and seems to offer limited opportunities for dispersal of juveniles, emigration and immigration. Koala sightings are common, and there has been a suggestion the area may be at its maximum koala carrying capacity (Phillips, pers. comm.). Despite this, the CLCA is regularly used as a translocation site for koalas displaced by urban development in the northern half of the Gold Coast City.

2.1.2 The Koalas:

a) **The 1995 – 96 study** released 16 radio collared koalas into 6000 hectares of protected bushland at Kokoda Barracks. Six were female (two with pouch young) and 10 were males. The details of these koalas and the reasons for their admission to care are shown in Table 1.

Eight koalas had been brought into care because of traumatic injuries or disease and the remainder were translocated from their original habitat due to land clearing.

Koala ID	*Young*	*Origin*	*Sex*	*Estimated age (yrs)*	*Reason for admission*	*Weight (kg)*
Fuji	No	Gaven	F	2-3	Threatened	5.4
Chester	No	Helensvale	M	5-6	Threatened	7.8
Casper	No	Studio Village	M	2-3	Threatened	6.5
Pania	Yes	Helensvale	F	10-11	Threatened	6.4
Eukiki	No	Gaven	M	2-3	Car hit	6.2
Jemima	Yes	Biggera Waters	F	3-4	Threatened	5.0
Sam	No	Runaway Bay	M	7-8	Car Hit	6.5
Captain Harris	No	Oxenford	M	3-4	Car Hit	7.4
Sweatpea	No	Boonah	F	2-3	Chlamydiosis	4.7
Pete	No	Ashmore	M	3-4	Car Hit	5.5
Tim	No	Banora	M	2-3	Threatened	5.9
Leah	No	Helensvale	F	5	Dog attack	5.4
Kyla	No	Labrador	F	4	Car Hit	4.8
Ernest	No	Ernest	M	2	Threatened	4.3
Max	No	Oxenford	M	5-7	Chlamydiosis	7.3
Jim	No	Runaway Bay	M	2	Threatened	4.5

Table 1: Admission details for koalas in 1995-96 study.

b) **The 2002 – 03 study** utilized both release sites. This was done to allow comparisons to be made between them. Details of the koalas are shown in Table 2.

Name	*Age (at admission)*	*Sex*	*Admission Date*	*Origin*	*Reason for Admission*	*Weight*
Max	11 mths	M	02/12/01	Wildcare	Orphan	800g
Kathy	6 mths	F	02/09/01	Wildcare	Orphan	540g
Sam	14 mths	M	26/08/01	Wildcare	Orphan	1550g
Shine	7 mths	F	03/02/01	Wildcare	Orphan	680g
Hackett	3 yrs	M	15/03/02	Hope Island	Translocated	-
Jedd	1-4 yrs	M	27/03/02	Hope Island	Translocated	4.5kg
Jemima	2-4 yrs	F	05/09/01	Coombabah	Chlamydiosis	5.69kg
Belinda	1-4 yrs	F	04/10/01	Gaven	Chlamydiosis	4.8kg
Jack	15 mth	M	20/01/03	Runaway Bay	Car hit	3.8kg
Baby	7 mth	F	02/01/02	Beechmont	Orphan	550gms
Sally	7.5 mth	F	17/10/01	Canungra	Orphan	612gms

Table 2: Admission details for koalas in the 2002-03- study.

2.1.3 Radiotracking Procedures:

All koalas were examined by a veterinarian prior to release back into the wild, fitted with radio transmitters fixed to collars that contained a 50-60mm elastic insert, and were radio tracked using either a Regal 2000 receiver (Titley Electronics) or a Telonics TR4 receiver (Sirtrack, NZ) fitted with a yagi directional antenna. All koalas released into Kokoda Barracks started from the same release point, whereas koalas released into the CLCA site were released at various points.

After release, each koala was tracked and observed daily for the first 21 days, then no less than 3 times per week for the remainder of the study. Data collected at each observation included spatial position using GPS, date and time, distance and bearing since last fix, tree species height and diameter at breast height (DBH), visible signs of injury, illness, or behavioural abnormality, weather conditions, and other worthy observations.

At the end of the tracking period koalas were caught using traditional methods of tree climbing, pole and flag, and manual capture, or alternatively, using a koala trap. Koalas were given general physical examinations at the time of capture, the radio collars removed, and they were then released at the point of capture.

2.2. Results

2.2.1 Post-release Koala Survival, Fecundity and Health:

a) **In 1995 - 96 study** there were no confirmed koala deaths during the study period. However, one koala's radio transmitter signal failed ("Eukiki") close to the end of the study period, and the radio signals from two young rapidly dispersing males ("Ernest" and "Jim") were lost and not recovered during the period of study. One koala ("Sam") was found at the base of a tree two weeks after release and was returned to care for additional rehabilitation. A further release attempt failed in a similar time period and the koala was re-homed in a captive institution. The definitive reason for his failure to thrive in the wild was not determined, although chronic injuries from motor vehicle trauma may have contributed to a reduced ability to climb and forage.

All of the 13 koalas that were captured for collar removal at the end of the study were in good or excellent body condition. The three remaining koalas, whose signals were lost or failed were unable to be assessed, but were in apparently good health and body condition at their final sighting.

Both of the female koalas with joeys in the '95-'96 study ("Parnia" and "Jemima") had weaned their original joeys, and were supporting new pouch young at the time of collar removal. Of the six female koalas released in the current study, one was supporting an early pouch joey at the time of release, which was subsequently weaned. One koala "Jemima" was euthanased because of reproductive tract disease, and one koala "Baby" was found dead. The remaining females "Belinda", "Shine" and "Sally" had not, at the time of writing, shown evidence of pouch young.

b) **In the 2002 – 03 study,** one young female koala ("Baby"), released at the CLCA site, was found dead three months after release. There had been no apparent illness or injuries up until the time of death. There was no evidence of trauma or predation on examination of the carcase, but a definitive cause of death was not established. One mature female koala "Jemima" that had been treated for chlamydiosis (also released at CLCA) was euthanased shortly after final capture due to complications arising from surgery to remove her diseased

reproductive tract. One koala "Shine" was returned to care for further rehabilitation due to poor body condition at final capture. She had been released 3 months earlier. One month later she was re-released into the project and has remained in good health since.

Of six koalas caught for health and body condition assessment, four had gained weight and either maintained or improved condition score; one koala ("Shine") had lost both weight and body condition, and one koala ("Kathy") with dependent young, had maintained weight but dropped body condition. Two koalas ("Sam" and "Hackett") slipped their radio collars and were lost: they had been radio tracked for 5 months and 6 months respectively. Both were in apparently good health and body condition at their final sighting.

All of the koalas treated for chlamydiosis **in both studies** remained free of active disease for the duration of the tracking period, and were free of clinical signs of active infection at the time of collar removal and release. One koala "Jemima" had reproductive tract cysts that had grown in size during the study. This is not indicative of active infection but is a sequel of scarring and adhesions in the reproductive tract.

2.2.2 Dispersal and Home Range Establishment:

a) **In the 1995 – 96 study** all koalas established stable home ranges with the exception of the two young male koalas ("Jim" and "Ernest") and the koala "Sam" that was removed into captivity. Eight of the sixteen koalas established home ranges within 1 km of the release point, four koalas established home ranges 1-2km from the release point, and one koala ("Casper") established a home range 5-6 km from the release point. The koalas "Jim" and "Ernest" were dispersing away from the release site at the time that radio signals were lost.

b) **In the 2002 – 03 study**, two of three males ("Hackett" and "Jedd") released at the CLCA site failed to establish stable home ranges and were considered to be vulnerable to motor vehicle trauma because they had moved close to busy roads bordering the conservation area. Consequently they were translocated to the Kokoda Barracks site, where "Hackett" established a stable home range within one month. In contrast, "Jedd" continued dispersing for a further 3 months, eventually establishing a stable home range in the neighbouring Numinbah Valley. The young male "Jack" established a stable home range in the Coombabah site close to the release point.

Three female koalas released at the CLCA site all established stable home ranges within one month of release, although the young female "Baby" subsequently died, and the mature female "Jemima" was euthanased nine months after release because of surgical complications.

Six of seven koalas either initially released at the Kokoda Barracks site, or translocated from the CLCA site ("Hackett" and "Jedd") established stable home ranges within the boundaries of the Kokoda Barracks. As described above the young male koala "Jedd" continued to disperse until settling in his current home range over 10 km from the release point. Of the remaining six, five established home ranges less than 1 km from the release point, and one established a home range 2.3 km away.

The following table (Table 3) summarises the results of home range size estimation and distance of home range from the release point. The first 16 koalas were in the '95-'96 study at Kokoda Barracks, and home range sizes were estimated without the use of computer programs. The home ranges of the remaining koalas, used in the current study, were estimated with the Ranges V software (Natural Environment Research Council, UK) using the minimum convex polygons (95% convex polygon).

Name	*Age at release (yrs)*	*Sex*	*Home range size (ha)*	*Distance from release point (m)*
Fuji	2-3	F	11	855
Chester	5-6	M	13	1864
Casper	2-3	M	27	5300
Parnia	10-11	F	23	346
Eukiki	2-3	M	18	1729
Jemima	3-4	F	11	546
Sam	7-8	M	N/A	N/A
Captain Harris	3-4	M	13	819
Sweatpea	2-3	F	13	1000
Pete	3-4	M	55	546
Tim	2-3	M	10	830
Leah	5	F	18	182
Kyla	4	F	20	582
Ernest	2	M	Not determined	N/A
Max	5-7	M	19	485
Jim	2	M	Not determined	N/A
Max	1.5	M	187	2250
Kathy	2	F	6.13	325
Sam	2	M	30.69	700
Shine	2	F	7	150
Hackett	3 yrs	M	20.16	700
Jedd	1-4 yrs	M	Not determined	11 500
Jemima	2-4 yrs	F	10.76	344
Belinda	1-4 yrs	F	7.19	0
Jack	16	M	Not determined	0
Baby	2	F	Not determined	0
Sally	1.5	F	Not determined	Not determined yet

Table 3. Home range size estimations and distances of home range from the release point for the koalas released in both the 1995 – 96 and 2002 – 03 studies.

2.2.3 Home Range Sizes

a) **In the 1995-'96 study** of koalas released into Kokoda Barracks the average home range size of males was 21.7 ha and for females 16 ha.

b) **In the 2002 – 03 study** the average home range size of males in Kokoda Barracks was 79.28 ha and females 6.56 ha. The average home range size of females in the CLCA site was 8.97 (2 only).

2.3 Discussion

A number of important conclusions may be drawn from the results of these two koala radio tracking studies. The first is that koalas are well able to establish stable home ranges and become reproductively successful following translocation into unfamiliar territory, as long as the habitat provides appropriate food trees. The second is that rehabilitation efforts are not wasted on either orphaned joey koalas or those suffering from trauma or disease, so long as the animals are fit and healthy at the time of release: of five koalas treated for traumatic injuries, four successfully established home ranges following release and were healthy at the time of completion of the study; of four koalas treated for chlamydial disease, none had signs

of active infection over the period of the study. (One required euthanasia because of surgical complications during an attempt to remove a chronically diseased reproductive tract.); of six hand reared orphaned koalas, only one succumbed during the period of the study.

The issue of translocation of koalas (due to land clearing or other threatening processes) is a controversial one: some would argue that remaining habitat is assumed to be at its carrying capacity and that translocation of koalas into that habitat may have detrimental effects on the resident population. However, frequently on the Gold Coast, and in other areas of rapid urban development, the only humane alternative to translocation is euthanasia. In addition, the factors affecting koala population densities in various areas are so poorly understood, such as to make such an assumption invalid. It is therefore ideal to monitor not only individuals that have been translocated or reintroduced, but also to monitor the health, fecundity and population dynamics of resident populations in areas receiving translocated animals.

The results of this study suggest that high densities of resident koalas, such as in the CLCA site, may affect the ability of a translocated koala to settle the area, particularly if it is a male. Whilst this site provides some suitable koala habitat with high densities of food trees, it is a relatively small and isolated habitat fragment with limited opportunities for safe emigration or recruitment. It is therefore susceptible to overpopulation pressure whether from natural increases in the population or by artificial methods such as translocation. Koalas are frequently rescued from the suburbs and roads surrounding the site, and these are often juveniles of dispersal age (18mths – 3 years) (Gail Gipp, Wildcare Australia, pers. comm.). This observation supports the suggestion that the CLCA may be nearing, or even exceeding its natural carrying capacity for koalas.

It is therefore recommended that koala populations at sites such as the CLCA be actively managed on the basis of thorough investigation and monitoring of population health and dynamics. This requires a substantial commitment of money and resources from the relevant authorities, but is the only logical and realistic way of managing the area for conservation of koalas.

In contrast, the Kokoda Barracks site, with its 6000 hectares of native forest, and its contiguity with adjacent woodland and forest in the surrounding district, is a more attractive site for translocation of koalas. It provides ample room for movement of individuals, without the hazards of urbanisation, and ample corridors for emigration and recruitment. Furthermore, its koala population density appears to be lower than CLCA, so agonistic interaction between resident individuals and translocated animals could be presumed to be less frequent. The overlap in home ranges of koalas released at Kokoda Barracks was less than that of those released at Coombabah (in which three translocated koalas and at least one resident all shared a similar home range). In addition, the mortality rate of koalas released into the Kokoda Barracks was low, compared with other studies (Ellis *et al.*, 1990; Lee *et al.*, 1990).

Currently, Queensland Parks and Wildlife Service recommend that koalas requiring translocation due to threatening processes or land clearing be moved to the closest area of substantial bushland. Whilst this recommendation is supported by some basic ecological principles, in practice (particularly in rapidly developing urban regions), it may not provide the most acceptable or humane outcome unless adequate post-release monitoring of translocated individuals is carried out. The results of the current study in respect of CLCA attest to that.

2.4 Conclusions and Recommendations

- Koalas are a relatively robust species with regard to their ability to adapt to translocation.
- Translocation sites need to be chosen carefully with regard to the availability of browse species; density of resident populations; overall size and protection status; and availability of corridors for emigration and recruitment.

- Ideally, translocated koalas should be monitored by radiotelemetry.
- Radio tracking at a frequency of at least 3 times per week for a minimum of 3 months is recommended to ensure adequate monitoring of translocated koalas. Longer studies provide much more data on seasonal variation in behaviour and movement patterns.
- The fecundity, health and population dynamics of resident populations should be established prior to translocation programs, and monitored during and after.
- The use of elastic inserts in the koala collars is recommended to prevent accidental deaths due to entrapment of the collars on vegetation. Accidental deaths by hanging are not unusual in radio collaring studies, although rarely reported.
- The use of a degradable material insert in the collar (such as elastic) is recommended to allow degradation and loss of the collar within 2 years, should the signal fail or the collar be unable to be recovered for other reasons.

3. The Common Brushtail Possum Study

The brushtail possum is one of the most common native mammals being released back to the wild following rehabilitation. However, the long term survival of these animals is largely unknown. Anecdotal evidence from the carers themselves is usually very positive, however, this optimism has not usually supported by the published research. For instance, Augee and Ford (1999) reviewed a number of possum-release studies and concluded that most were terminated by high predation pressures from introduced predators on the released animals. Similar results have been found for rehabilitated, relocated and wild common ringtail possums (Augee *et al.*, 1996; Smith *et al.*, 2003) and relocated common brushtail possums (Pietsch, 1995).

It may be concluded from these studies that the number of introduced predators in a release site is likely to be the most important factor determining the survival of released possums. However, it is also true that there may be other aspects of the possums' habitat and behaviour which may influence their post-release survival and which have yet to be fully determined.
For instance, Baker and Gemmel (1999) in their study of translocated common brushtail possums found that it took up to two years for some animals to regain their full reproductive ability. They concluded that possums required considerable time to adapt to apparently small environmental differences in their new habitats.

In addition, most studies of released possums have so far been confined to Victoria and New South Wales; little is known about the behaviour and survival of brushtail possums in Queensland.

This study examined the survival and behaviour of common brushtail possums which had been rescued, rehabilitated and released in southeast Queensland. In particular, it followed their short term survival, their patterns of dispersal, and their preference for and ability to find denning sites.

3.1 Materials and Methods

3.1.1 Release Site:

The study area was approximately 400 ha in size, located in Gold coast region of south east Queensland about 16 to 20 km west of the coastline. The area comprised undulating hills ranging in altitude from approximately 75 m to 500 m., and included mainly privately owned bushland with a small section of government-owned parkland. One major road (Beechmont Road) ran through the centre of the area from north to south. There were three gullies in the study area, which ran from west to east and which carried little water except after heavy rain.

The vegetation was predominantly woodland and open forest, containing mainly White Mahogany, Grey Gum, Queensland White Stringybark and Broad Leafed White Mahogany. The area also included littoral rainforest, subtropical warm temperate rainforest and small patches of open forest complex. .

The area was known to support populations of common brushtail possums as well as other marsupial species, and had been used for years by various wildlife carers as a site in which to release rehabilitated common brushtail possums (E. Hanger & T. Wimberley, pers. comm.).

3.1.2 The Common Brushtail Possums

Thirteen common brushtail possums were released and tracked during this study. These animals were accessed from the locally based wildlife care group, Wildcare, and had originally come into care as either rescued adult or sub-adult possums, or as orphans requiring hand-raising. All of them originated from the local area, within a six km radius of the release site. The details of these possums and the reasons for their admission to care are shown in Table 4.

3.1.2 Radiotracking Procedures:

All possums were examined by a veterinarian prior to release, fitted with radio transmitters fixed to small collars that contained a short elastic insert, and were radio tracked using a Yagi directional antenna supplied by Sirtrack and a communications receiver supplied by Icom (Osaka, Japan).

Only animals which weighed at least 1200g were selected for release. This was to maximize their chances of survival post-release, and to ensure that the radio-collars fitted them appropriately. Once fitted with their radio-collar, each possum was replaced in its rehabilitation cage, where it was kept for up to five weeks to allow it to acclimatise to its radio-collar.

All animals were released at dusk from their rehabilitation cages, using a “soft release” procedure commonly practiced by possum carers (E. Hanger and T. Wimberley, pers. comm.). This consisted of leaving the doors of the rehabilitation cages open, and of providing supplementary food and water for the released animals until they were found to be no longer returning to it.

After release, each possum was tracked and observed daily for the first 21 days, then no less than 3 times per week for up to two months or until the possum was lost due to transmitter failure or removal of the collar. Data collected at each observation included spatial position using GPS, date and time, distance and bearing since last fix, tree species height and diameter at breast height (DBH), visible signs of injury, illness, or behavioural abnormality, weather conditions, and other worthy observations.

At the end of the tracking period each possum was caught using a wire possum trap, examined, its collar removed, and released at the point of capture.

3.2. Results and Discussion

3.2.1 Post-release Possum Survival, Fecundity and Health:

The fate of the thirteen possums released in this study is shown in Table 4.

Two possums (Fletcher and Jane-Doe) were found dead shortly after release, at six days and two days, respectively. Both were found to have been killed by carpet pythons (*Moerlia spilota*) according to the results of postmortem (J. Hanger, pers. comm.). A third possum (Matilda) was also found dead during the tracking session, more than three months after release. Her postmortem revealed the cause of death to have been trauma, probably from a fall (J. McKee, pers. comm.). Despite the presence of foxes (*Vulpes vulpes*), feral cats (*Felis catus*) and feral dogs (*Canis familiaris*) in the study area (E. hanger, pers comm.), no predation by these introduced predators was found during the study.

These findings are very different from the results described in other papers. In particular, the studies for common brushtail possums and common ringtail possums conducted by Pietsch (1995) and Augee et al (1996), respectively, showed high rates of predation by introduced predators, such as foxes and feral cats.

Name	*Sex*	*Weight at Collaring (g)*	*Age*	*Reason for admission*	*Period in care (weeks)*	*Release Season**	*Fate*
Fletcher	M	1225	Orphan	Orphan	?	breeding season	*Found dead on day 6 (by Python)*
Bruce	M	1330	Adult	Threatened	?	breeding season	*Lost contact after day 23*
Natasha	F	1441	Adult	Threatened	*30*	breeding season	*Lost contact after day 17*
Christina	F	1480	Adult	threatened	*5*	breeding season	*Lost contact after day 16*
Jane-Doe	F	1596	Orphan	Orphan	*21*	breeding season	*Found dead on day 4 (by Python)*
Pumpkin	F	2029	Orphan	Orphan	*30*	breeding season	*Brought back to care on day 37*
Lin	F	2093	Adult	Car Hit	*13*	breeding season	*Lost contact after day 37*
Geoffrey	M	1237	Orphan	Orphan	?	non-breeding season	*Released permanently on day 104*
Jonny	M	1257	Orphan	Orphan	*13*	non-breeding season	*Lost contact after day 27*
Lucy	F	1410	Orphan	Orphan	*21*	non-breeding season	*Brought back to care on day 41*
Matilda	F	1517	Adult	Dermatitis	*19*	non-breeding season	*Found dead on day 99 (by trauma)*
Susie	F	1707	Adult	Dermatitis	*11*	non-breeding season	*Released permanently on day 82*
Oscar	M	2390	Orphan	Orphan	*4*	non-breeding season	*Released permanently on day 105*

Table 4: Admission details and fate of the common brushtail possums in this study.

The reasons for these differences are difficult to determine. It may be that although present, the density of introduced predators in the Gold coast hinterland is quite low, or it may be that the habitat itself, being thick scrub with many mature and substantial trees, meant that the possums spent less time on the ground and so were more able to avoid predation from ground dwelling predators. Pietsch (1995) suggested that one of the reasons for the high mortality by introduced predators in his study was because the translocated possums spent abnormally long periods of time on the ground.

The average survival period for all possums released during this study was unable to be calculated from the data collected. The average tracking period of all 13 released possums was 42.8 days, however this figure includes those animals with which contact was lost or where tracking had to stop. If these possums are excluded from the calculations, the known survival period was 66.2 days. Similarly, three possums were released without radio-collars at the end of the tracking period; thus their true survival periods were also not known.

In addition, although the number of animals released in this study was fairly small, the survival data for these 13 possums does suggest some interesting trends. These include:

- Possums that were adult when brought into care tended to survive longer than the hand-reared ones.
- Possums released during the non-breeding season tended to survive longer than those released during the breeding season.
- Large possums tended to survive longer than lighter ones.
- Little difference was observed between the survival of male and female possums in this project.

3.2.2 Possum Release Behaviour and Dispersal

The results from this project also indicate that the pattern of dispersal following release was affected by the rehabilitation procedure and the length of time that the animal had spent in care. In particular, hand-reared possums dispersed more slowly and less far than adult rehabilitated animals.

There were seven hand-reared possums released in the present study. Two were killed within one week which prevented their dispersal from being observed. However of the other five, four remained within the release area and close to human settlement.

Moreover, two of these hand-reared possums showed a marked reluctance to disperse further after release. During the night, they occasionally approached humans and even intruded into their houses. They answered to human calls, approached and climbed up on humans. These highly "humanised" behaviours may indicate inappropriate hand-rearing procedures, and certainly such behaviours are likely to be incompatible with successful rehabilitation to the wild. One of these two possums was brought back into care on two occasions due to injuries from fights with other possums within the area. Fights can usually be avoided by "escape" behaviour or "avoidance" behaviour (Spurr & Jolly, 1999), and rarely cause serious injuries if proper dominant-subordinate behaviours are displayed (Spurr & Jolly, 1999). However, in this case, the hand-reared possum may not have developed appropriate dominant-subordinate behaviour and so may not have been able to deal with another wild possum near its release site.

Four out of the six adult rehabilitated possums made long distance dispersals soon after release. All but one left their release cages on the first night, and none returned to their cages or to their release sites once they had dispersed.

3.2.3 Den Selection

Common brushtail possums have been found to use a range of natural denning sites including tree hollows, hollow logs, termite mounds, other animals' burrows and nests, and rock cavities (Pietsch, 1995; Smith, 1995; Strahan, 2000; Kerle, 2001). They have also been found using non-natural denning sites when these are available, particularly in urban areas, such in the roof and wall cavities of buildings, and sheds (Pietsch, 1995; Smith, 1995; Strahan, 2000; Kerle, 2001).

In this study, the released possums were observed to use natural denning sites for 73 % of the time, and non-natural denning sites for 27 %. Such a result may seem to be quite appropriate for the areas into which they were released, being composed of natural bushland and forest with some human habitation through it. However, a closer examination of the data suggests some significant trends in the selection of these dens by different possums:

- There was a marked difference between the den sites used by rehabilitated adult and hand-reared possums. Six of the 13 released possums used non-natural denning sites more than 90 % of their total denning, and all six were hand-reared animals. Alternatively, the only occasions on which adult rehabilitated possum used non-natural denning sites were at the release cages during the first few days after release. None returned to these denning sites once they had dispersed away from the area. Furthermore, while 11 % of total den selection for these adult possums was categorised as "not available", all locations were natural denning sites as no non-natural den sites were present in those areas. Therefore, it can he concluded that all the adult rehabilitated possums selected natural denning sites for every tracking day once they had left their release cages.

- Possums released during the non-breeding season used more natural denning sites and less non-natural denning sites than animals released during the breeding season. The reasons for this result are not clear from this study. Unlike some species which become more aggressive in conspecific interactions during their breeding season (Walraven, 1994), common brushtail possums show more hostile conspecific interactions during their non-breeding season (Day *et al.*, 2000). Therefore, the possums might have been using natural dens during the non-breeding season as part of an attempt to establish territories at this time.

- A clear difference in den selection between possums of different body weights was found: the lighter possums were more likely to choose the non-natural dens. . Such a result is likely to be due to a combination of two factors.

  Firstly, the age of the possum at release (the lighter the body weight, the younger the possums). In common brushtail possums older and heavier animals are more dominant to younger and lighter ones (Winter, 1976; Oldman, 1986). Thus, lighter possums might be submissive in the release area and be forced to choose non-preferred non-natural denning sites rather than natural denning sites.

  Secondly, the experiences of the possum prior to release. Hand-reared animals are unlikely to have had experience of selecting and using natural dens, and may in fact show a greater tendency to being humanised with consequent inappropriate behaviours such as preferring unnatural environments and food (Smith, 1995).

  However, these two factors illustrate a quandary in the way that orphaned animals should be hand-reared. On the one hand they should be released as soon as possible to minimise the negative effects of an extended hand-rearing process (Smith, 1995). On the other hand, keeping hand-reared possums until they are, for example over 1500 g, which is the recommended body weight for release of hand-reared common brushtail possums

(White, 1998), may also result in release failure due to the development of inappropriate behaviours due to humanization.
- Natural den use and non-natural den use for male and female released possums showed little difference.

3.3 Conclusions and Recommendations

The results of this study suggest that rehabilitated common brushtail possums can be released successfully, but that this success is likely to be determined by a number of factors. These include:
- The release site must be carefully chosen to ensure that there are sufficient trees and bushes to allow the possums to find suitable dens and to remain above ground and so avoid introduced predators.
- The period of rehabilitation should be kept as short as possible and possums should be released back to the wild as soon as they are ready.
- However, it is also important that possums are not released when they are too small. Body weight is also an important factor in determining their survival.
- Consequently, it is also recommended that further research be conducted to establish appropriate body weights for possum release.

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