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The Effects of Provisioning on Behavior of the Allied Rock-Wallaby (Petrogale assimilis)

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The Effects of Provisioning on Behavior of the Allied Rock-Wallaby (*Petrogale assimilis*)

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# Table of Contents

Abstract .......................................................................................................................... 3

1. Introduction .................................................................................................................. 4
   1.1. Background ........................................................................................................... 5
       1.1.1. Macropodoidea ............................................................................................... 5
       1.1.2. Petrogale ......................................................................................................... 5
       1.1.3. Petrogale assimilis ......................................................................................... 6
       1.1.4. Habitat ............................................................................................................. 7
       1.1.5. Physical Characteristics .................................................................................. 8
       1.1.6. Diet .................................................................................................................. 8
       1.1.7. Reproduction and Mating ............................................................................... 9
       1.1.8. Behavior and Home Ranges ........................................................................... 10
       1.1.9. Social Organization, Social Behavior and Agonistic Behavior ....................... 10
   1.2. Provisioning ........................................................................................................... 11
   1.3. Previous Studies on Provisioning Rock-wallabies ................................................. 12

2. Methods ....................................................................................................................... 14
   2.1. Study Site ............................................................................................................. 14
   2.2. Field Work Time Frame ....................................................................................... 15
   2.3. Behavioral Observations and Sampling ................................................................ 16
       2.3.1. Focal Sampling ............................................................................................... 16
       2.3.2. Classification of Behaviors ............................................................................ 17
   2.4. Materials .............................................................................................................. 17

3. Results ........................................................................................................................ 18
   3.1. Aggression ............................................................................................................ 18
   3.2. The Influence of People ...................................................................................... 21
   3.3. Contact Before, During, and After Provisioning .................................................. 24
   3.4. Unprovisioned Colonies ...................................................................................... 26

4. Discussion ................................................................................................................... 27
   General Observations .................................................................................................... 27
   4.1. Aggression of Petrogale assimilis ....................................................................... 28
   4.2. The Influence of People on Petrogale assimilis ..................................................... 30
   4.3. Contact Among the Wallabies Before, During, and After Provisioning ............... 31
   4.4. Unprovisioned Colonies ...................................................................................... 31
   4.5. Provisioning of Petrogale assimilis ..................................................................... 31
   4.6. Provisioning .......................................................................................................... 33
   4.7. Caveats .................................................................................................................. 36
   4.8. Conclusion ............................................................................................................ 37
   4.9. Future Suggestions ............................................................................................... 38

5. Acknowledgements ..................................................................................................... 40

6. References .................................................................................................................... 41

7. Appendices .................................................................................................................. 47
   7.1. Appendix A: Pictures of the Study Site in Arcadia, Magnetic Island ................... 47
   7.2. Appendix B: Time Table of Data Collection ....................................................... 49
   7.3. Appendix C: Scan Data Collection Sheet ............................................................. 51
   7.4. Appendix D: Behavioral Repertoire ...................................................................... 52
   7.5. Appendix E: Definitions of Terms ....................................................................... 54
Abstract

Wildlife provisioning, the feeding of wild animals, is often a component of wildlife tourism in Australia -- tourism provides an important revenue source for the economy and is forecast to continue and grow. Therefore, the study of wildlife provisioning is necessary to understand and minimize its adverse effects.

My study addressed the impacts of provisioning on one particular wild native species group -- a provisioned colony of allied rock-wallabies (*Petrogale assimilis*) on Magnetic Island in northern Queensland, Australia. Twice daily (morning and afternoon) for two weeks, data were collected on the behavior of the individual rock-wallabies before, during, and after tourist provisioning. During each of these 28 site visits, observations of the rock-wallabies’ behavior, human presence, and provisioning were recorded.

The behaviors of the observed provisioned rock-wallaby colony differed dramatically from those observed and reported by others for non-provisioned populations of this species. These other supporting findings are particularly important because my observations were limited by the duration of the study and individual observation.

Only one colony of a limited number of rock-wallabies was involved. My observations of provisioning are in agreement with past observations of provisioned colonies in reporting diurnal activities, high population density, and high levels of aggression and contact between the rock-wallabies both during and after provisioning. Provisioning is thus associated with competition under high animal density in a restricted area. Future controlled studies are needed to confirm cause-effect relationships in the impact of provisioning on rock-wallabies.
1. Introduction

Australia highly values its unique and diverse wildlife and recognizes the importance of maintaining its distinctive biota to promote tourism and retain its economic benefits derived (Rae 2013). Australia has experienced the highest rate of mammal extinctions of any continent in the past 200 years (Short and Smith 1994). To counteract this, various conservation methods need to be utilized and monitored to ensure survival of its endemic species (species unique to Australia). Provisioning (the feeding of wildlife) is a method sometimes used for species conservation, and more frequently used to support wildlife viewing tourism (Orams 2002). While there is evidence that provisioning can benefit species population recovery (Orams 2002), in some cases provisioning has caused dramatic and often negative changes in animal behavior and colony dynamics (Orams 2002; Newsome and Rodger 2008). More research on the effects of provisioning is needed to provide information to reduce further conflicts and propose viable solutions. The objective of the present study is to observe the impacts of provisioning on the behavior of one colony of allied rock-wallabies, Petrogale assimilis. Qualitative and quantitative data are presented in an attempt to show relationships of provisioning on behavior. My study has many limitations that I have noted and are the reasons for my lack of definitive cause-effect conclusions.
1.1. Background

1.1.1. Macropodoidea

The superfamily Macropodoidea was chosen to investigate the impacts of wildlife viewing tourism as it is a group restricted to Australia and therefore an attraction to tourists in Australia. Macropodoidea is comprised of two monophyletic families: potoroidae and macropodidae. Potoroidae include bettongs, potoroos, and rat kangaroos. Macropodidae include kangaroos, wallabies, hare-wallabies, nailtail wallabies, rock-wallabies, swamp wallabies, pademelons, tree kangaroos, and quokka (Hodgson 1998). Members of macropodidae are widespread throughout Australia, New Guinea, and other neighboring islands, with nine genera and more than 37 extant species (Calaby and Richardson 1998). Macropodidae contain the largest of the extant marsupials; with individuals of the largest species weighing up to 85 kg (Strahan 1983). Marsupials have a short gestation period; once young are born they instinctively find their mother’s teat and begin to suckle (Delaney 1993). Parental care is the primary responsibility of the female due to pouch life and lactation. Therefore, maternal body condition is more relevant to child development than paternal body condition (Delaney 1993).

1.1.2. Petrogale

Rock-wallabies belong to the genus Petrogale. The name rock-wallaby is derived from the environment Petrogale inhabits; rock-wallabies are small to medium sized macropods (0.9-12 kg) that inhabit rocky outcrops, cliffs, and boulder piles (Maynes and Sharman 1995). Similar to all other macropods, rock-wallabies use bipedal hopping and balancing as their habitual locomotion. Presently, IUCN recognizes 16 species of rock-wallabies (Winter et al. 2008). The distinct chromosomal diversity of Petrogale has led to a classification of the genus into three major groups: 1) the xanthopus group (the yellow
footed rock-wallabies, *P. xanthopus* and *P. x. celeries*), 2) the *brachyotis* group in the Timorian biogeographic region (*P. brachyotis*, *P. burdigei*, and *P. concinna*), and 3) the *lateralis-penicillata* species group (three taxa of *P. lateralis*, and the remaining taxa from eastern Australia *P. assimils*, *P. godmani*, *P. inornata*, *P. penicillata*, *P. p. herberti* and the Cape York, Mareeba and Mt Claro races). (Eldridge and Close 1992). It is thought that the genus *Petrogale* originated on the western side of Australia, and speciated and dispersed throughout Australia resulting in its widespread distribution today (Briscoe et al. 1982). *Petrogale* is found in all biogeographic zones within mainland Australia, including arid interiors, southern extremities of the Great Dividing Range, and tropical vine forests (Delaney 1993). The largest diversity of the genus is found in the drier areas of the tropics (*P. assimilis*, *P. brachyotis*, *P. burdigei*, *P. concinna*, *P. godmani*, *P. inornata*, and the Mareeba and Mt. Claro subspecies of *P. assimilis* and the Cape York subspecies of *P. godmani*). (Briscoe et al. 1982). Colony size can range from a few individuals to hundreds; colony size is dependent on rocky outcrops and available space and shelter within the rocks (Briscoe et al. 1982).

**1.1.3. *Petrogale assimilis***

The allied rock-wallaby (*Petrogale assimilis*) is a small macropod (Horsup 1996). *P. assimilis* was first described by E.P. Ramsay in 1877 when he collected a female from Palm Island (Bennett 2011). Ramsay categorized the female as most closely related to *P. penicillata*, the (then named) gray rock-wallaby. Later in the 1900s, the species was regarded as a subspecies of *P. inornata* (the unadorned rock-wallaby); other subspecies in this category are the Mareeba and Mt. Claro rock-wallabies (Eldridge 1997; Bennett 2011). *Petrogale assimilis* is endemic to the wet-dry tropics in Northern Queensland; populations occur from Townsville to the Burdekin River, northwest to Blackbrae’s
National Park and Croydon, and southwest to Hughendon and Mt. Hope. *Petrogale assimilis* can also be found on Magnetic Island and Palm Island, both off the coast of Townsville (Delaney 1993; Eldridge and Close 1995; Bennett 2011, Figure 1.1).

1.1.4. Habitat

Rock-wallabies have one of the most clearly defined habitat requirements of any macropod (Horsup 1996); the name “rock-wallaby” is derived from their rocky habitat of steep rocky slopes, cliffs, gorges and boulder piles (Sharman and Maynes 1983). These areas provide shelter from extreme and harsh environmental conditions (Horsup 1996). Rocks provide caves, crevices, and overhangs for *Petrogale* to take refuge during the day in order to thermoregulate and conserve body water (Horsup 1996). Shelter and reliable food resources are the main factors that limit rock-wallaby distribution (Horsup 1996).
is common for *Petrogale* to live in areas where water is scarce or absent (Horsup 1996).

### 1.1.5. Physical Characteristics

Rock-wallabies are one of the smallest wallabies; their low center of gravity, short feet with wide spread toes, and long tail allow them to balance effectively (Horsup 1996). The fur of *P. assimilis* is similar in appearance to rock types and colors of the environment they inhabit (Horsup 1996) thus providing camouflaging protection. Most rock-wallabies are brown-gray with lighter brown forearms, under parts, hind-legs, and the base of their tail (Eldridge and Close 1995). A dark stripe crosses on a diagonal from both ears over eyes to nose. Nose and eyes are a dark black or brown. The tip of their long tail is black and so are the fingers and toes. On average, males weigh 4.7 kg and females weigh 4.3 kg (Delaney 1993). The claw of the fourth toe is smaller than the rest; this is a trait that sets *Petrogale* apart from all other macropods (Horsup 1996). Their forearms are short and stocky; their claws and tubercle-covered palms are used for efficient grasping of rocks (Horsup 1996).

### 1.1.6. Diet

Wallabies are generalists and feed on forbs, browse, grass and leaves (Horsup 1992; Fennewald 1997). Rock-wallabies have large fore stomachs, allowing them to efficiently digest their fibrous diet (Revetta 2004). Their diet varies seasonally and the food consumed is largely based on availability and seasonal conditions (Horsup 1992). Rock-wallabies adjust the number of hours per day they feed to changes in season and food availability despite increased predation risks related to extended feeding times (Horsup 1992). Forbs (herbaceous flowering plants) are the main food group consumed by rock-wallabies in the wild (Horsup 1992; Schröder 2009). Their diet can also include
fruits, seeds, and leaves, particularly those of *Ficus* trees (Horsup 1992; Eldridge and Close 1995). Rock-wallabies typically begin feeding on herbage in the early evening and forage throughout the night (Eldridge and Close 1995). During the day, they take refuge in shelters and between shaded rocks to prevent overheating from sun exposure (Horsup 1996).

### 1.1.7. Reproduction and Mating

*Petrogale assimilis* are continuous breeders; no specific mating season has been identified; reproduction can occur at any time but appears to be related to rain output (Eldridge and Close 1995). This species is monogamous; Horsup (1996) observed long-lasting pair bonds between individual rock-wallabies. In all studies of this species of *Petrogale*, males have been observed to have continuous breeding capabilities and breed year-round (Tyndale-Biscoe 1989). Females of *P. assimilis* can breed continuously (Tyndale-Biscoe 1989). Continuous breeding is a survival adaptation to the environment of unpredictable resources (Sadlier 1969).

The gestation period of *P. assimilis* is 30-32 days (Eldridge and Close 1995). Joeys remain in the pouch for 6-7 months while they continue their growth (Eldridge and Close 1995). Females sexually mature at 18 months and males sexually mature at 24 months (Eldridge and Close 1995). Females are continuously lactating and can produce two different types of milk for two different offspring going through different developmental stages (Meffert 1996). The life span of *P. assimilis* has been recorded as up to 13 years (Eldridge and Close 1995).
1.1.8. Behavior and Home Ranges

*Petrogale* species can typically be found in spatially isolated colonies, where rocky habitats and ample food sources are available (Horsup 1998). *Petrogale* takes refuge from the sun during the day; they can be seen sunning on open rocks in the early morning and early evening. They typically forage at night. In addition to sunning, their mating and grooming behaviors have been reported to occur primarily during the early morning hours (Eldridge and Close 1992).

In Horsup’s study (1996), adult males had a mean home range (area inhabited over an annual cycle) of 11.9 ha. There is only modest overlap between adult male home ranges. Whenever males are in close proximity with one another and there is the threat or reality of encroachment, displays of aggression are observed. Adult females occupied similar size home ranges (Horsup 1996).

1.1.9. Social Organization, Social Behavior and Agonistic Behavior

Agonistic behaviors are aggressive behaviors exhibited in cases of competition for limited resources, such as food, water, shelter, or mates (Ganslosser 1889; see Appendix D for detailed behavioral repertoire). Females form a stable linear dominance hierarchy, i.e., a colony is dominated by one alpha female (Horsup 1996). Pair bonding is exhibited in colonies, although extra-pair copulations may occur to increase favorable genes in offspring (Horsup 1996). Young males pair with dominant females until a stable pair bond is created with one or more of the dominant females; these bonds can continue for several years (Horsup 1996). Commonly, males mark females by scent and defend them and their rock territories at all times; allogrooming (social grooming) between individuals of this species is frequent and maintains pair bonds (Barker 1990; Horsup 1996).
1.2. Provisioning

Provisioning is the act of providing food typically outside of a species’ regular natural diet by either hand feeding, or providing the food in a habituated manner. Australia is valued for its diverse and unique wildlife that attracts many tourists with the prospect of observing these animals. Feeding animals allows an intimate experience for tourists that gives them a sense of nurturing and connectivity to the animal (Newsome and Rodger 2008). Provisioning can benefit tourists and wildlife; however, if not monitored and managed, provisioning can be detrimental to both the people and the animals.

Habituation, poor nutrition, and aggregation at feeding sites are some of the main concerns resulting from provisioning (Newsome and Rodger 2008). Increased aggression is common among provisioned populations, and is likely the result of dense aggregation (Martin 2007). Although aggregation has been known to reduce predation, it also puts individual animals and people in close contact in a restricted area causing an increased chance of disease transmission (Blumstein 2003). Furthermore, increased aggression can result in injury and in some cases death of either animal or person (Orams 2002).

Structured provisioning services aim to control visitor number, monitor food provided, and educate tourists (Newsome and Rodger 2008). Provisioning can range from small unmonitored areas to large highly monitored areas: from feeding birds in a park to monitored dolphin feeding from afar (Newsome and Rodger 2008). Croft and Leiper (2001) stated that rock-wallabies were a good group for wildlife tourism because they commonly live in appealing landscapes that are visible during cooler times of day and most Australian States have good areas for rock-wallaby viewing. Croft and Leiper (2001) further hypothesized that the relatively large size of rock-wallabies in addition to
their distinctive attributes, compared to the many smaller marsupials, add to the potential for high tourism attraction.

1.3. Previous Studies on Provisioning Rock-wallabies

This section describes previous studies conducted on the effects of provisioning of Petrogale assimilis and Petrogale mareeba. As was the case for my study, none of these studies used a control group.

Wendy Sicard (2004) conducted a study on behavioral differences, specifically aggression, on a provisioned colony of Petrogale mareeba in Granite Gorge and a provisioned colony of Petrogale assimilis on Magnetic Island. At the time of this 2004 study, the Granite Gorge colony had been provisioned for approximately 25 years; Arcadia Beach colony on Magnetic Island had been provisioned for approximately 10 years. Sicard hypothesized that longevity of the provisioning was not the main factor contributing to the level of aggression. Behavioral differences in aggression and foraging habits were reported for the two colonies. On Magnetic Island compared to Granite Gorge, fewer tourists were present, wallabies always outnumbered humans, and greater aggression between wallaby individuals was observed. Conversely, tourists at Granite Gorge outnumbered wallabies, food was abundant and less aggression between wallaby individuals was observed. While in the Granite Gorge colony, wallaby individuals were readily seen on rocks, lounging and foraging at most times regardless of the presence or absence of tourists, wallabies in the Arcadia colony displayed more vigilant behavior in the presence of tourists and a greater dependence on humans. Sicard inferred a greater dependence at the wallabies in the Arcadia colony on provisioning by humans from her observations of wallaby individuals commonly being absent from the rocks when humans were not present, and lingering at night instead of foraging naturally.
Mandy Revetta (2003) conducted research on differences between male and female wallabies in their interactions with tourists and among each other in the provisioned colony at Granite Gorge, as well as the role of dominance in feeding behavior. Revetta examined the impact of outside factors, such as type of food provided by tourists, number of tourists, and their effect on wallaby numbers. Revetta reported that, although male rock-wallabies are typically the dominant and more aggressive sex, both sexes received equal amounts of food. Revetta suggested “pair bonding” as a possible reason, i.e., that females may receive food without protest from other males based on their male partner’s position in the hierarchy. Revetta found that there was no difference in food preference between sexes, but that, overall, males and females both preferred wallaby pellets (oats and mill mixture) and oats. Revetta reported that the number of wallabies present during feedings increased with the number of tourists present. Similar to Sicard’s study, Revetta found that there were more people than wallabies at the feeding sessions at Granite Gorge.

A more recent study by a University of Colorado Boulder, undergraduate, Sukee Bennett (Honors thesis 2011), also monitored the provisioned rock-wallabies on Magnetic Island. At the time of Bennett’s study, local Vern Jack provisioned the colony once a day, five times each week. Bennett’s study reported rock-wallaby abundance, feeding, and behavior among the provisioned colony. Using scan and focal sampling to monitor this colony, Bennett suggested that wallaby aggression levels were higher during provisioning than when wallabies were amidst the rocks during other times. The number of people present was positively correlated with rock-wallaby numbers during feeding sessions but not necessarily with greater numbers of wallabies feeding. Males were observed to show more aggression while feeding than females.
2. Methods

My study was designed to follow-up on the findings of Bennett’s thesis discussed in the previous section. Both studies examined behavioral tendencies in the provisioned colony of *Petrogale assimilis* at Arcadia. And although my study started with a control group, the control group was abandoned after a short while and therefore, both study results are reported without a control group comparison. Due to my study being four years later, two main changes had occurred on the island that makes my study stand apart from Bennett’s. First, Vern Jack was no longer regularly provisioning the colony. Second, wallabies now consistently outnumbered tourists. An additional difference is that the studies took place in different seasons, mine occurring in the beginning of summer.

2.1. Study Site

Data were collected on Magnetic Island, Queensland, Australia (147°00’S, 19°10’E) between November 11th -November 25th, 2013. Magnetic Island is a 52-km² tropical island seven kilometers east of Townsville. A twenty-minute ferry ride is the most common way to get to the island. The island falls within the Great Barrier Reef Marine Park, a World Heritage Site. Magnetic Island is a tourist attraction, due to its beautiful beaches and extraordinary wildlife, such as koalas, birds, and wallabies. Arcadia is a small township on Magnetic Island located 2.3 km from Nelly Bay, where the ferry from Townsville docks. Arcadia is home to a colony of allied rock-wallabies (*Petrogale assimilis*) that have been provisioned by local Vern Jack for over 20 years (Bennett 2011). Rock-wallabies can be found living among rocks and in other habitats throughout Magnetic Island.

The study site is directly on the edge of the ocean and is connected to the
township by an unmarked gravel road across from the Arcadia Hotel. The study site is
350 meters down the road at a cement turnaround surrounded by granite rock piles and
ocean (Bennett 2011). Within the rocks and higher above them are large trees, mostly fig
trees and hoop pines. The study site is divided into two sections, “the rocks,” where
Petrogale assimilis reside and find shade during the day, and the cement turnaround or
“the feeding area” (see Appendix A). The rocks are large granite boulders that cover a
steep hillside. It is unclear how the wallabies are distributed across this area. The feeding
area is where the tourists can walk to, park on, and see or feed Petrogale assimilis.

Hotels on Magnetic Island sell wallaby pellets (similar to horse or llama pellets,
made of barley, wheat, oats, etc.) and promote feeding the provisioned colony of P. assimilis as a tourist attraction. Throughout the day, tourists feed P. assimilis at Arcadia a
range of food items including carrots, wallaby pellets, apples, rice cakes, and rockmelon.

Data were also collected at Bright Point (as a control site), where a colony of
Petrogale assimilis not subjected to provisioning is present. This second site is in Nelly
Bay, facing the ferry port. Here, data were recorded in a similar manner, but there was no
feeding site, only the rocks. Data collection here was discontinued after three days due to
an inability to observe significant numbers of wallabies and the lack in diversity of
behavioral activities. Individuals hid on my arrival, or stared at me during the entire
survey.

2.2. Field Work Time Frame

Tuesday November 5, 2013 was the first day I visited the study site; the day was
used to get familiar with the site and the behavior of Petrogale assimilis. Notes, questions
and concerns were written down to enhance my knowledge of the behavior and site.
Eighteen replicates were conducted on the November 10. Regular replicates began the morning of the November 11 and continued twice a day for two weeks. The last replicate recorded was the evening of November 25. Morning data and afternoon data were recorded to compare behavior at different times of day. Trials were recorded at different times each day due to unscheduled provisioning by tourists. Morning data were recorded between 07:00 and 11:00 hours; afternoon data were recorded between 16:30 and 17:30 hours (see Appendix B). Since provisioning times varied daily, before, during, and after provisioning data were recorded randomly throughout study sessions. During both morning and afternoon surveys, scan and focal sampling were used and recorded onto a data collection sheet (see Appendix C).

2.3. Behavioral Observations and Sampling
2.3.1. Focal Sampling

Focal sampling observations made on one individual at a time was used to monitor behaviors and interactions (Altmann 1974). Focal individuals were chosen at random before, during, and after provisioning. Focal sampling was conducted for 10-15 minutes 2-3 times in morning sessions, and 2-3 times in afternoon sessions. The following information was recorded: initial location of the focal individual, number of Petrogale assimilis observable, number of people present, number of people provisioning, what foods were being fed to the rock-wallabies and what quantities, sexes of individuals towards which the focal subject acted aggressively or submissively, natural feeding/foraging, unnatural feeding, contact, and sexual contact, and time of behaviors relative to provisioning (before, during, or after provisioning). Each focal individual was observed for 10 minutes, during which time behaviors were recorded.
2.3.2. Classification of Behaviors

Behaviors were categorized into five groups: aggression, submission, contact, sexual contact, and feeding. Classification of behaviors was adopted from Horsup (1986, 1996) and Hodgson (1998). Aggression was defined as including both active and passive behaviors, e.g., hissing, biting, clawing, jumping on backs, chasing, and stares with perked ears. Submission included behaviors such as moving out of the way for dominant individuals. For all aggressive behaviors, aggressor sex and sex of the individual subjected to the aggression were noted. Contact was defined as including all forms of grooming between individuals, e.g., nose touching and mutual grooming (See Appendix E).

2.4. Materials

The materials used for this study were binoculars, pencils, and data collection sheets (Appendix C). I conducted all statistical analyses using R software (version: R 2.15.2) and ran t-tests, pairwise t-tests, and ANOVA tests.
3. Results

Due to my small sample size, short study duration, observation and tallying by only me, my results need to be read with an awareness of the known caveats that are detailed in the Limitations section of this paper.

3.1. Aggression

Figure 2.b) shows the total observable acts of aggression of Petrogale assimilis as a function of the number of people present (p=3.668e-06; Adjusted R-squared=0.2828; df=62). In contrast, the number of aggressive bouts of *P. assimilis* did not correlate with the number of people feeding (p= 0.1257; Adjusted R-squared= 0.07262; DF=19; Figure 2.a).

![Figure 2.a](image)

Figure 2.a) The relationship between the number of people feeding *Petrogale assimilis* and instances of rock-wallaby aggression observed during the twice daily feedings over 14 days.

![Figure 2.b](image)

Figure 2.b) The relationship between the number of people present on the feeding site and the instances of *Petrogale assimilis* aggression of the rock-wallabies observed during the twice daily feedings over 14 days.

A significant correlation between the observed instances of unnatural feeding/provisioning and instances of aggression (p-value < 0.001; Adjusted R-squared= 0.468; df=59; Figure 3.a) was shown. No correlation between the (rather few) instances
of natural feeding and aggression (p=0.389; Adjusted R-squared= -0.004, df=61; Figure 3.b) was shown. I tried to increase my sample size of wallabies feeding naturally, but, throughout the 14 days, I only observed 26 instances of naturally feeding. This small sample is not comparable to the instances of wallabies feeding unnaturally (344 instances).

![Graph A](image1.png) ![Graph B](image2.png)

Figure 3.a) The relationship between the instances of *Petrogale assimilis* unnaturally feeding and total instances of *Petrogale assimilis* aggression observed during the twice daily feedings over 14 days. Figure 3.b) The relationship between the instances of *Petrogale assimilis* naturally feeding and total instances of *Petrogale assimilis* aggression observed during the twice daily feedings over 14 days.

Figure 4 shows the number of aggressive acts recorded before, during, and after provisioning by four combinations of male and female rock-wallabies pairs. The figure clearly displays a common pattern across all four pairings. Less aggression was seen before provisioning, and aggression rose noticeably during and after provisioning within my limited study. It should, again, be noted that the total number of wallabies (and number of observed behaviors) was much smaller for the scenario before versus during or after provisioning.

There were more male-to-male aggressive instances recorded during provisioning and after provisioning than before provisioning (p=0.037; df=2; F=2.344; Figure 4).
There were more male-female aggressive instances after provisioning than before, (p=0.04), during than after provisioning (p=0.03), and during than before provisioning (p= 2.1e-05; df=61; f= 10.61; Figure 4). More female-female aggressive instances occurred both during and after provisioning than before (p=0.003, p=0.005) but no difference in the levels of aggression between during or after (p=735; f=6.319). There was more female-to-male aggression after provisioning than before, (p= 0.016) and more aggression during provisioning than before (p= 6.2e-05). There was no difference in aggression levels between during and after provisioning (p=.120; Figure 4).

![Figure 4.](image-url)

Figure 4.) The average instances of *Petrogale assimilis* aggression between male-male, male-female, female-female, and female-male observed before, during, and after provisioning during the twice daily observations over 14 days.

A greater number of total male aggressive instances was observed after provisioning than before (p=0.039). More total male aggression was noted during than before provisioning (p= 5.7e-05), but no difference in total male aggression during versus
after provisioning (p=0.054). More total female aggression was noted after provisioning than before (p=0.001), and more total female aggression during provisioning than before provisioning (p=8.9e-06). As shown below, female aggression during and after provisioning (p=0.364; Figure 5) occurred at quite similar levels. The comparison of behaviors during versus after provisioning is more relevant than the comparison of behaviors before versus during/after provisioning, due to the similar numbers of wallabies recorded during versus after provisioning compared with the very low numbers of wallabies and their behaviors observable before provisioning.

![Figure 5](image.png)

Figure 5.) The total male and total female average instances of *Petrogale assimilis* aggression before, during, and after provisioning during the twice daily observations over 14 days.

### 3.2. The Influence of People

The total number of people present correlated with the number of *P. assimilis* on the rocks (p= 0.002; Adjusted R-squared= 0.191; df=62; Figure 6.a). The number of people present correlated with the number of *P. assimilis* in the feeding area (p =8.563e-
Aggression was difficult to observe when wallabies were in the rocks due to poor visibility, and was inferred largely based on their hissing sounds which is a known aggressive behavior.

Figure 6.a) The relationship between the number of people present and the total number of *Petrogale assimilis* on the rocks during the twice daily observations over 14 days.

Figure 6.b) The relationship between the number of people present and the total number of *Petrogale assimilis* in the feeding area during the twice daily observations over 14 days.

The number of people actually feeding *P. assimilis* did not correlate with the number of *P. assimilis* observed on the rocks (p = 0.161; Adjusted R-squared = 0.054, df=19; Figure 7.a) or in the feeding area (p = 0.993; R-squared = -0.053, df=19; Figure 7.b). The wallabies did not distinguish between an individual human’s presence and an individual human feeding.
Figure 7.a) The relationship between the number of people feeding *Petrogale assimilis* and the total number of *Petrogale assimilis* observed on the rocks during the twice daily observations over 14 days. Figure 7.b) The relationship between the number of people feeding *Petrogale assimilis* and the total number of *Petrogale assimilis* observed in the feeding area during the twice daily observations over 14 days.

Figure 8 displays the finding that the number of people feeding the *P. assimilis* did not correlate with the number of *P. assimilis* unnaturally feeding/provisioning (p=0.115; Adjusted R-squared= 0.085; df=18 Figure 8.a). The number of people feeding *P. assimilis* did not correlate with the number of *P. assimilis* naturally feeding (p= 0.916; Adjusted R-squared= -0.052; df=19; Figure 8.b). It should be noted that this comparison is problematic due to the dramatically different sample sizes. I tried to increase my sample size of wallabies naturally feeding, but throughout the 14 days, I only observed 26 instances of naturally feeding. This is not directly comparable to the instances of wallabies feeding unnaturally (344 instances).
Figure 8.a) The number of people feeding *Petrogale assimilis* and the instances of *Petrogale assimilis* naturally feeding during the twice daily observations over 14 days. Figure 8.b) The number of people feeding *Petrogale assimilis* and the instances of *Petrogale assimilis* unnaturally feeding during the twice daily observations over 14 days.

### 3.3. Contact Before, During, and After Provisioning

As shown in Figure 9, more non-sexual contact was observed among *P. assimilis* after provisioning (p = 3.7e-05) and during provisioning (p=0.0001) than before. No difference in the average instances of non-sexual contact during and after provisioning (p=0.646) was observed. More instances of sexual contact during provisioning (p=0.001) and after provisioning (p=0.031) were observed than before. No difference in sexual contact during and after provisioning (p=0.298; Figure 9) was observed.
Figure 9.) The average instances of *Petrogale assimilis* non-sexual contact and sexual contact before, during, and after provisioning during the twice daily observations over 14 days.

As seen in Figure 10 below, there was a correlation between the number of *P. assimilis* unnaturally feeding and the instances of non-sexual contact (*p* = 9.158e-05; Multiple R-squared= 0.230; df=59; Figure 10.a). Similarly, there was a correlation between the number of *P. assimilis* naturally feeding and the instances of non-sexual contact (*p*=0.018; Multiple R-squared= 0.089; df=51; Figure 10.b).

Figure 10.a) The instances of *Petrogale assimilis* contact and the instances of *Petrogale assimilis* unnaturally feeding during the twice daily observations over 14 days.

Figure10.b) The instances of *Petrogale assimilis* contact and the instances of *Petrogale assimilis* naturally feeding during the twice daily observations over 14 days.
3.4. Un provisioned Colonies

*Petrogale assimilis* were observed in lower numbers in the un provisioned colony of Bright Point than the provisioned colony in Arcadia. The provisioned rock-wallabies were considerably approachable, whereas the individual rock-wallabies in the Bright Point colony were timid and darted into the rocks at first sight of my presence. In some cases, a few rock-wallabies stopped and stared at me curiously before running into the rocks. I assume this behavior suggests that they consider humans to be a threat. During the eight trials done at Bright Point, only one instance of aggression and three instances of non-sexual contact were observed. These observations suggested that differences in behaviors in the presence of people exist between an un provisioned and provisioned rock-wallaby colony.

<table>
<thead>
<tr>
<th>Number of Observations</th>
<th>Rock-wallabies on the Rocks</th>
<th>Rock-wallabies Naturally Feeding</th>
<th>Non-sexual Contact</th>
<th>Sexual Contact</th>
<th>Total Aggressive Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
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<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 11 presents the number of observations at Bright Point, the site where no provisioning was occurring and no people were present.
4. Discussion

General Observations

Before provisioning occurred, I typically observed few to no wallabies present in the feeding area. The absence of large numbers is understandable considering that these animals are nocturnal and take refuge in the shade during the day. I always tried to observe the wallabies within the rocks to gain a valid count of the colony and all rock-wallaby behaviors. Unfortunately, due to the obstructed view of areas among the rocks, I was unable to observe these secluded areas, where the majority of wallabies were likely present. Therefore throughout this study, I observed considerably more individual wallabies when they were on the feeding site during and after provisioning than prior.

I am aware that my statistical analyses of the wallaby behaviors before versus during/after provisioning are compromised by the different numbers of animals observable, and is further discussed in the Limitations section. However, the suggestions of my analyses are supported by other research.

I report another presumably seriously negative consequence of provisioning not yet been mentioned -- severe accumulation of feces. Among the rocks surrounding the feeding area where the Arcadia wallaby colony lives, the ground is covered with feces. Unless corrective steps are taken, one can assume that this unsanitary condition will only worsen. Previous studies of Petrogale assimilis found that wallabies live monogamously in isolated colonies, rarely coming in contact with other pairs (Horsup 1996). Their natural home ranges are large, 9-11 ha and all this land is used for foraging. An unintended consequence of provisioning in the Arcadia colony is the abundant source of food in a small geographic area. Individual wallabies have no reason to forage over large distances and thus spend their days close by. This pattern has led to increased density in
the provisioning location. Living in their feces is not only unnatural behavior, but it is unhealthy and presumably results in diseases, blindness, and infection (Holsback et al. 2008).

4.1. Aggression of Petrogale assimilis

Provisioning wild animals can create competition and aggression among individual members of the species by supplying sometimes large quantities of food in a restricted area (Orams 2002). High levels of aggression, apparently associated with provisioning, were observed repeatedly in the Arcadia colony of Petrogale assimilis. My observations showed that the Arcadia wallabies tended to use hissing as a frequent form of aggressive behavior. In fact, the observed wallabies hissed more frequently than they exhibited other more physical aggressive behaviors such as punching, lunging, or kicking. Hissing occurred both independent of the other behaviors as well as in conjunction with other forms of aggressive behaviors. During and after provisioning, hissing was heard frequently whereas before provisioning, hissing was rarely heard coming from in the rocky area. These anecdotal observations corroborate previous research, and my assumption that there was less aggression among individual wallabies while in the rocks due to the silence.

Based on my observations of the 14-day period, while instances of P. assimilis aggression increased with an increased number of people present in the feeding area, no relationship was observed between the actual number of people feeding and total aggression of P. assimilis. This suggests that P. assimilis associated food with people per se but not with the number of individual people feeding. While in the provisioned colony, a high level of aggressive behaviors was seen during and after the actual feeding events,
no relationship was seen between the few observed natural feeding events and aggressive behavior. It is noteworthy that only a limited number of natural feeding events – from a rather limited number of individuals – was observable for the provisioned colony (only 26 times were *P. assimilis* observed naturally feeding), which prevents a rigorous quantitative comparison of aggression levels as a function of feeding mode; one can only say there is an indication that individual wallaby’s behavior was altered by human interaction and provisioning. The fact that only limited numbers of individuals were observable (for both the provisioned colony during times when wallabies did not congregate on the feeding platform and for the non-provisioned colony at large) is consistent with the view that the rock-wallaby, as a species with a relatively large home range, does not naturally congregate and that high levels of aggression are thus not natural for this species. In other words, the behavior of non-provisioned colonies thus presumably consists largely of natural foraging and less aggressive behavior, as individuals rarely come in contact with each other. Overall, my observations during my study and review of the related research indicate that provisioning in this species produces a number of unnatural and undesirable outcomes, including unnatural congregation of large number of individuals and high levels of aggression.

Aggression levels were high during provisioning, compared to before provisioning. All male-male, male-female, female-female, and female-male aggressive interactions were presumably lowest before provisioning. This is because individuals were typically located on or among the rocks before provisioning and not provoked by competition for food resources. Again, few wallabies were visible among the rocks before provisioning; I cannot exclude that more aggression was recorded during and after provisioning because more wallabies were in plain sight. Aggressive interactions
observed were highest during provisioning for all pairings except female-female pairing, which was highest after provisioning, although there was no visible difference in aggression level of wallabies during or after provisioning. Provisioning brings individuals together in close proximity; *P. assimilis* exhibited high levels of aggressive behaviors when seen in close contact with other individuals of their species. Of the four pairing combinations of aggression studied (male-male, male-female, female-female, and female-male), male-male aggression was least frequent and female-male aggression was the most frequent. The increase in rock-wallaby aggression in the presence of people is likely due to the wallabies not distinguishing between people with and without food.

### 4.2. The Influence of People on *Petrogale assimilis*

The number of people present significantly affected the number of *P. assimilis* on the rocks and the number of *P. assimilis* in the feeding area. This further indicates that the presence of people influences the behavior of *P. assimilis*. At times of the day when *P. assimilis* usually take refuge from the heat, the presence of people lured them out into the sun. The number of people feeding had no effect on the number of *P. assimilis* observed on the rocks or in the feeding area. Similarly, the number of people feeding did not relate with the number of *P. assimilis* unnaturally feeding or the number of *P. assimilis* naturally feeding. As stated earlier, it appears from my observations of this colony that the act of people feeding did not influence the behavior of *P. assimilis*, it was the number of people observed by the wallabies.
4.3. Contact Among the Wallabies Before, During, and After Provisioning

My observations suggest that, similar to aggression, non-sexual and sexual contact also differed before and after provisioning, as well as before and during provisioning. Increased *P. assimilis* density leads to more contact, which, in turn may lead to aggression within the observed colony. The difference in non-sexual and sexual contact was not noticeable between during and after provisioning; instances of contact were high and similar in both situations. Both types of contact also increased with instances of unnaturally feeding based on my limited observations of this scenario.

4.4. Unprovisioned Colonies

The wallabies of the unprovisioned colony at Bright Point acted quite differently than those at Arcadia (Figure 11). During my eight observations, the individual wallabies had two standard reactions: (1) scattered and hid or (2) one or two individuals (seemingly dominant) remained on the rocks and stared at me. I discontinued my observations at Bright Point because of the difficulty observing a sufficient number of the *Petrogale assimilis* at this site. The wallaby behavior that I did observe was dramatically different than that of the wallabies at Arcadia who approached me immediately upon my arrival, as well as during and after provisioning. In sum, over the eight observations with multiple wallabies each time minimal aggression was observed during only one observation period (Figure 11).

4.5. Provisioning of *Petrogale assimilis*

My observations and previous studies have posited that when offered the option
of provisioning, wallabies choose to be unnaturally fed/provisioned rather than to feed naturally on their own. Over the 14-day observation period, I recorded 26 instances of wallabies naturally feeding and 344 instances of wallabies unnaturally feeding. Although *Petrogale assimilis* is listed as “least concern” on the IUCN red list (Winter et al. 2008), there are implications for future threats to the species. Van Der Wal et al. (2012) report that, as part of global warming there has been substantial change in temperature and rainfall over the last 60 years. Delaney (1993) provided a detailed look at the life history and reproductive biology of rock-wallabies. She noted that the presence of feral predators could dramatically affect populations of rock-wallabies. In addition, she reported that the wet-dry tropics of Australia have unpredictable and variable weather conditions; varying temperatures and rainfall creates seasonality. The seasonality of the wet-dry tropics can directly or indirectly affect life history traits such as reproduction and growth. Due to these seasonal changes, individuals maximize energy-intensive activity during periods of maximum resource availability (Bourliere and Hadley 1970). Continuously breeding species have adapted to survive in resource consistent, or resource unpredictable environments (Delaney 1993). The rocky habitat in which *P. assimilis* lives may improve the situation for individuals; rocks retain moisture and increase runoff; this can result in higher moisture levels in soil, improving plant diversity and abundance (Mares and Lacher 1987). However, in times of drought and below average levels of rainfall, rock-wallabies are negatively affected (Delaney 1993).

In a two-year study, Delaney (1993) found that rainfall had a huge impact on the conditions and population of the *Petrogale assimilis* at Black Rock, North-west of Townsville, QLD. The rainfall during both years of the study was below average for Black Rock; however the pattern of rainfall varied in each year resulting in different
effects on *P. assimilis*. Delaney reported that in 1987, the drought caused starvation and anemia in *P. assimilis*. In 1988, a higher proportion of the annual rain fell during the dry seasons resulting in increased plant growth and abundant foraging prospects throughout the year (Horsup and Marsh 1992). As a result, the rock-wallabies maintained a stable weight (Delaney 1993). In essence, the patterns of rainfall during a drought year have large influences on the body condition of rock-wallabies.

Delaney (1993) proposed that large fluctuations (pulsing patterns) in population size are natural for rock-wallabies, but population size should be carefully monitored in the presence of feral predators and unfavorable climatic conditions. In the colony observed on Magnetic Island, there is no pulsing pattern due to provisioning and lack of predators (Delaney 1993). The combination of few feral predators and consistent daily provisioning on Magnetic Island has led to an unnaturally large density of individuals in a small area. The population in Arcadia of *P. assimilis* is significantly larger than populations that receive no provisioning (Bennett 2011). Monitoring of *Petrogale assimilis* on Magnetic Island is important to highlight any downturns in population that might be due to unfavorable climatic conditions. This is particularly important with the predictions of changes in temperature and rainfall for the region (Van Der Wal et al. 2012).

### 4.6. Provisioning

It is argued that wildlife tourism can be a key tool for conservation and can secure the status of a species or habitat (Newsome et al. 2004). In well-managed conservation systems, ecotourism can influence the knowledge, attitude and behavior of tourists (Newsome et al. 2004). To be accredited in Australia as “ecotourism,” the experience
must “foster environmental and cultural understanding, appreciation and conservation” (Ballantyne et al. 2009). Organizations with such accreditation have been known to effectively impact the behavior of both animals and people.

Provisioning has been used to increase the population of critically endangered species; in the case of the Kakapo (*Strigops habroptilus*) supplementary feeding was conducted in a study to increase the population of less than 100 individuals (Clout et al. 2001). The goals of the project were to (i) increase the health of female birds to exceed the nutritional threshold required for successful breeding, (ii) increase the number of eggs laid, and (iii) increase hatchling survival by providing enough fruit for mother and chicks (Clout et al. 2001). This was a successful project that through monitoring and management of provisioning proved to be extremely effective. This protocol is an excellent example of successful provisioning; species were monitored closely and all variables were considered.

Unfortunately, in some situations provisioning can be detrimental to individuals. I believe that this is the case for the Arcadia colony of *Petrogale assimilis* on Magnetic Island. Due to regular and frequent provisioning at Arcadia, the wallaby population has increased dramatically over the years (Bennett 2011). The increased density of a colony creates more opportunities for aggression and, as suggested by my observations, more instances of aggression. Additionally, provisioning creates competition among individuals that also leads to aggression. During provisioning, I observed constant hissing noises, and extremely common aggressive behaviors, assumed impacts of provisioning. Finally, this is a species that normally rests throughout the day and forages at night – provisioning has disrupted the natural activity cycle of these creatures.

Other variables of interest were also studied in regard to related species. Species
can be affected by spatial and temporal variations in habitats that influence social and mating behavior (Goldingay et al. 2001). Food availability can also alter behavior and colony dynamics in a species (Goldingay et al. 2001). When food and resources are widespread, species generally have a larger distribution and larger home ranges (Emlen and Oring 1977; Clutton-Brock 1989). Species reproduction is also reliant on resource availability and distribution (Clutton-Brock and Vincent 1991). In Clutton-Brock and Vincent (1991), mountain brushtail possum, *Trichosurus cunninghami*, females were recorded to have successfully raised young based on limiting resources of space and food availability. The distribution of females strongly determines the distribution of males in a population; for males to be successful in passing on their genes they must mate with as many females as possible (Mitani et al. 1996). In the Arcadia colony of *Petrogale assimilis*, food was readily available at the feeding site. The ample regular food supply provided by people led to an apparent increase in population density, increased species contact, and increased feeding proximity, all resulting in an aggressive colony that is comfortable with human presence.

In their natural habit, *Petrogale assimilis* live and forage in pairs rarely coming into contact with other pairs (Horsup 1996). Rothley and Semeniuk (2008) studied the costs of normally solitary foragers (southern stingrays) in a group provisioned setting. They found increased parasite load, increased competition and aggression, lower body condition, and higher susceptibility to injuries caused by humans. They conclude that the presence of tourists negatively affects long-term fitness and propose long-term management and monitoring of stingray tourism. The researchers posit that less food provisioned would reduce competition and injury. The Arcadia colony is representative of (for the most part) solitary foragers in a provisioned group setting. Provisioning of
naturally social species that live in groups is more favorable and has less implied costs (Rothley and Semeniuk 2008). In a related study, Hill (1999) found that group size and social complexity are also factors that affect the behavior and social structure of species. Hill (1999) also reported that the differences in intensity of aggression in the provisioned and unprovisioned groups were mainly caused by the differences in the concentration of the main food resources (Hill 1999), which is consistent with my observations.

4.7. Caveats

Several caveats need to be repeated and clearly summarized here to ensure an accurate interpretation of my study’s data and provide some cautions and recommendations for future studies. Below are the four main caveats. First, my sample size was relatively small and the behavior of only one provisioned colony was observed. Second, the habitat of the rock-wallaby colony made observation of both the provisioned and non-provisioned colonies extremely difficult. Therefore, the third caveat is the lack of a comparable control group of wallabies, as originally proposed in my study design. Fourth is related to data collection. All data were based on observations, collected over a fourteen-day period at a specific location, at one point of time, and collected only by me. I established standard observation and recording protocols but I know that some interactions and solo behaviors of the wallabies were missed. Individuals of Petrogale assimilis were very fast and sometimes during scan sampling I was not quick enough to record all the interactions at the same time. I might have recorded them as unknown aggression or missed some quiet contact interactions. In addition, I was unable to confidently identify wallabies from each other; and therefore decided to measure instances of contact, feeding, and aggression and not the number of wallabies. I also
operated with the assumption that if there were more than four wallabies on the rocks or in the feeding area, I recorded they had been fed and referred to the trial as after provisioning.

In summary, observations are consistent with the results of previous studies that lend credibility to my findings (Section 1.3.). However, due to the data limitations and other shortcomings present throughout this study, the results need to be read with caution and clearly future researchers need to try to replicate this study before any definitive conclusions can be drawn.

4.8. Conclusion

Australia benefits economically and culturally from the unique wildlife existing on its continent. Conservation efforts for biodiversity require ongoing monitoring of species’ population health. It is important to use conservation methods that do not harm wildlife or people. Provisioning is a method used for wildlife-tourism and in some cases conservation. Provisioning can be beneficial to humans and animals and, therefore, should be managed and closely monitored at all times. By closely observing a provisioned colony of allied rock-wallabies, \( (Petrogale\ assimilis) \), on Magnetic Island during the two-week period I observed that the presence of people apparently profoundly influences the behavior of \( Petrogale\ assimilis \). Aggression, no-sexual contact, sexual contact, and unnatural feeding were all seen at high levels in the presence of humans at the feeding site. Comparisons of the behavior of \( P.\ assimilis \) before, during, and after provisioning suggested differences in behavior.

The colony of \( P.\ assimilis \) is not endangered; yet, I raise the warning that continued frequent uncontrolled provisioning causing increased competition and
aggression in the colony can lead to a dwindling population. This study is consistent with others showing that provisioning and human interactions can have negative impacts on wildlife. Increased aggression can result in injuries and in some cases death. Injuries can lead to infections or diseases. Additionally, energy expenditure in species is a finite resource, aggression uses energy that could otherwise be spent on foraging, reproducing or resting. On the other hand provisioning, if well-monitored, has the potential to be beneficial, as shown for the Kakapo. Due to the data limitations and other shortcomings present throughout this study, the results need to be read with caution and clearly future researchers need to modify and improve study methods before any definitive conclusions can be drawn.

4.9. Future Suggestions

Future research would greatly benefit from an improved study design. Future designs need to address the caveats noted above. More specifically, at least two observers and a strict data collection protocol are recommended. Data collection would ideally take place for 2-3 weeks during each season of the year in more than one geographical site. Observation devices would be installed among the rocks and at the provisioning sites to capture the wallabies’ behavior at all times (including prior to provisioning for the provisioned colony and overall for the non-provisioned colony). Using these cameras would increase the validity and reliability of data collected -- how many tourists were feeding the wallabies, how many wallabies and their behaviors, as well as what they were feeding and their aggressive patterns. Establishing a means to capture the number of tourists each day would ensure a reliable count of the individuals around the site. A log of tourists would address the shortcoming that, due to the heat, I could not stay in the area.
for the majority of the day and, therefore, had no way of knowing how many tourists were passing through the area. Another possibility for long-term study is tagging the wallabies. Looking into the abundance of the population would be useful for measuring and assessing the effects of provisioning. I was unable to accurately estimate the total number of individuals in the Arcadia colony because there were more than 30 unmarked animals, and they all looked similar to me. Use of tagging would be critical in gathering this information.

A more elaborate and costly data collection method would be analysis of the stomach content and fecal matter. To my knowledge, these types of analyses have not been done and would provide a means to scientifically capture data about their diet. For example, data would be gleaned about the types and amount of food in their diet from the wild and from their provisioning intake, as well as season variation. These findings could have implications for future vegetation planning on the island.
5. Acknowledgements

I am so grateful for all the support that I received throughout the duration of my study, starting with my primary advisor in Australia, April Reside who coached me through my research and was always there to help me overcome challenges. I want to give a special thanks to Dr. Covert for agreeing to be my advisor and working with me side-by-side throughout the writing process. I want to give a big thank-you to Dr. Demmig-Adams for preparing me in every way possible and going out of her way to ensure my success. And last but definitely not least, I express my appreciation to Dr. Buchwald for inspiring me to pursue a career in animal behavior and being a valued committee member.
6. References


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7. Appendices

7.1. Appendix A: Pictures of the Study Site in Arcadia, Magnetic Island

Figure A.1 shows the study site in Arcadia, Magnetic Island.

Figure A.2 shows the road meeting the cement turnaround (the feeding area). It also shows the rocks in which *Petrogale assimilis* live.
Figure A.3 shows a rock cave within the “rock zone.” This is an example of where *Petrogale assimilis* hides from the sun to avoid the heat.

Figure A.4 shows a tourist provisioning the rock-wallabies at Arcadia.
### 7.2. Appendix B: Time Table of Data Collection

**Scan sampling timetable**

<table>
<thead>
<tr>
<th>Location</th>
<th>Time</th>
<th>Weather</th>
<th>Date</th>
<th>Time</th>
<th>Weather</th>
</tr>
</thead>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>sun</td>
<td>18-Nov</td>
<td>8:55-9:10</td>
<td>sun</td>
</tr>
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<td>rain to sun</td>
<td>18-Nov</td>
<td>5:00-5:20</td>
<td>rain</td>
</tr>
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<td>9:15-9:35am</td>
<td>sun</td>
<td>18-Nov</td>
<td>5:50-6:10pm</td>
<td>after rain</td>
</tr>
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<td>19-Nov</td>
<td>8:45-9:00</td>
<td>rain</td>
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<td>19-Nov</td>
<td>9:00-9:15</td>
<td>after rain</td>
</tr>
<tr>
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<td>10:00-10:20am</td>
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<td>19-Nov</td>
<td>9:15-9:30</td>
<td>after rain</td>
</tr>
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<td>19-Nov</td>
<td>9:30-9:50</td>
<td>after rain</td>
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<td>24-Nov</td>
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<td>24-Nov</td>
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<td>24-Nov</td>
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<tr>
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<tr>
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<td>25-Nov</td>
<td>6:45-7:00</td>
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<td>15-Nov</td>
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<td>25-Nov</td>
<td>7:00-7:15</td>
<td>cloudy</td>
</tr>
<tr>
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<td>7:30-7:45</td>
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<td>18-Nov</td>
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**Bright Point**

<table>
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<tbody>
<tr>
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<td>sun</td>
</tr>
<tr>
<td>11-Nov</td>
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</tr>
<tr>
<td>11-Nov</td>
<td>8:10-8:30am</td>
</tr>
<tr>
<td>12-Nov</td>
<td>7:50- 8:10am</td>
</tr>
<tr>
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<td>8:10-8:30am</td>
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<td>8:30-8:50am</td>
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**Bright Point boardwalk**

<table>
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<tr>
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<tbody>
<tr>
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**Focal time table**

<table>
<thead>
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<th>Sex</th>
<th>Size</th>
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<tbody>
<tr>
<td>12-Nov</td>
<td>11:00-11:15am</td>
<td>sun</td>
<td>m</td>
<td>m</td>
</tr>
<tr>
<td>13-Nov</td>
<td>8:20-8:40am</td>
<td>cloudy</td>
<td>male</td>
<td></td>
</tr>
<tr>
<td>12-Nov</td>
<td>8:40am-9:00am</td>
<td>cloudy</td>
<td>female with joey</td>
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</tr>
</tbody>
</table>
14-Nov 10:05-10:20am  sun  m  l
14-Nov 5:50-5:55pm  sun down  f  l
14-Nov 5:55-6:05PM  sun down  f  s
14-Nov 6:05-6:20PM  sun down  m  m
15-Nov 8:00-8:10am  sun  m  m
15-Nov 5:50-6:05pm  sun down  f  m
15-Nov 6:05-6:15pm  sun down  m  l
15-Nov 6:15-6:30pm  sun down  f  s-m w. joey
15-Nov 6:30-6:40pm  sun down  m  m
16-Nov 8:45-8:50am  sun  f  m-l
16-Nov 8:50-9:00am  sun  m  m
16-Nov 9:00-9:15am  sun  m  l
16-Nov 9:15-9:30am  sun  m  l
17-Nov 9:05-9:15am  sun  m  m
17-Nov 9:15-9:40am  sun  m  l
17-Nov 4:45-5:00pm  rain  m  m-l
17-Nov 5:00-5:08pm  rain  f  s
17-Nov 5:09-5:20PM  rain  f  l
18-Nov 9:15-9:30AM  cloud-sun  f  s
18-Nov 5:20-5:35pm  after rain  f  m
18-Nov 5:35-5:42pm  after rain  m  l
18-Nov 5:42-5:48pm  after rain  f  l with joey
20-Nov 8:00-8:15am  cloud  m  l
20-Nov 8:15-8:23am  cloud  f  s
20-Nov 5:00-5:10pm  sun  f  xl
20-Nov 5:10-5:20pm  sun  f  l with joey
20-Nov 5:20-5:30pm  sun  f  s
20-Nov 5:30-5:40pm  sun  m  m
20-Nov 5:40-5:50pm  sun down  f  m
20-Nov 5:50-5:58pm  sun down  m  l
20-Nov 6:00-6:05pm  sun down  f  l with joey
21-Nov 9:37-9:47am  sun  m  m
21-Nov 5:15-5:27pm  sun down  f  l
21-Nov 5:28-5:38pm  sun down  m  l
22-Nov 5:15-5:25pm  sun  m  l
22-Nov 5:25-5:35pm  sun  f  l
22-Nov 5:35-5:42pm  sun  f  m with j
22-Nov 5:42-5:52pm  sun  f  l with joey
24-Nov 8:20-8:30AM  sun  f  m with j
24-Nov 8:30-8:35am  sun  f  l with joey
24-Nov 8:35-8:45am  sun  m  l
24-Nov 8:55-9:00am  sun  f  m
24-Nov 9:15-9:25am  sun  m  m
24-Nov 4:45-4:55pm  sun  m  l
24-Nov 4:55-5:05pm  sun  f  l
24-Nov 5:55-6:05pm  sun  f  l
25-Nov 6:45-6:55am  cloud  f  s
25-Nov 4:30-4:35pm  rain  m  l
25-Nov 4:55-5:05pm  rain  m  s-m
25-Nov 5:05-5:10pm  rain  f  l, w joey
7.3. Appendix C: Scan Data Collection Sheet

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
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<td>Value 12</td>
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</table>

...
7.4. Appendix D: Behavioral Repertoire

III. ACTIVE BEHAVIORS

Aggressive

Aggressive Approach- fast and deliberate action by the aggressor towards the Aggressee

Aggressive Stare- aggressor stares in the direction of the aggressee with ears pricked

Aggressive Vocalization- one of the two following sounds is produced by the aggressor (1) cluck/‘tsk’ (2) hiss-growl

Aggressive Chase- aggressor runs after the aggressee foe at least 5 meters

Back Jump- aggressor leaps directly onto the back of the aggressee

Bite- any form of biting by the aggressor

Forepaw Strike- aggressor pushes or claws at aggressee using one or both of its forepaws

Head Thrust- usually only performed by females towards males; head is pushed into males’ pelvic area or thrusted towards the feet

Sparring/Fighting- both individuals perform continuous forepaw strikes, sometimes performed on tip-toes with little contact (sparring) and other times including leaping at one another, biting and raking with hindfeet

Submissive

Retreat- movement away from an individual of less than 5 meters in response to an aggressive behavior

Flight- movement away from an individual of more than 5 meters in response to an aggressive behavior

Submissive Vocalization- a sound produced by a submissive individual in response to an aggressive behavior, usually in the form of a ‘squeak’ or a high pitched ‘chirp’

Stare Avoidance- a deliberate averting of the head and eyes by an individual in response to an aggressive stare
Hop- a high backwards hop by the individual in response to an aggressive behavior (usually a ‘head thrust’)

**Contact**

Allogrooming- one individual grooms another using the ‘tongue and teeth’ method, usually intersexual, between adult females and pouch young/young at foot, or between juveniles

Mutual Allogrooming- two individuals perform allogrooming of each other simultaneously

Mutual Nose Sniff- nose to nose sniffing of two individuals upon approaching one another; may occur during sexual or aggressive encounters or may result in no further interaction

**Sexual**

Sexual Approach- male individual approaches a female before performing other sexual behaviors

Sexual Checking- male sniffs at the female’s cloaca, tail base, and/or pouch

Sexual Follow- male follows the retreating female, in association with other sexual behaviors

Clawing- male claws female usually when she is uncooperative (clawing at the head and shoulders) or when sniffing the cloaca (clawing at tail base) or while clasping (clawing at back)

Clasping- male grips female’s hips or back with forepaws, usually from behind but may be front-on during sexual marking

Copulation- female assumes a crouched quadrupedal stance while the male clasps her between the hips and thighs while thrusting

**Feeding**

Natural Feeding- foraging on naturally occurring vegetation such as grass, forbs, and leaves

Merycism- violent abdominal contractions and a throaty cough, producing food that is chewed and then swallowed to be regurgitated
Unnatural Feeding- foraging on unnatural foods that are provided by humans and are left on rocks as a result of spillages during hand feeding or have been deliberately thrown or placed there; eating toxic plants is also included

Hand Feeding- eating unnatural food directly out of a human hand

Begging- constitutes two types: (1) standing at the feet of humans or hopping from person to person, often on tip-toes and reaching up with forepaws and head (2) staying within a meter of humans who are crouched down but not feeding the wallaby; may include being patted by humans

7.5. Appendix E: Definitions of Terms

After provisioning: People had stopped feeding Petrogale assimilis; or there were more than three Petrogale assimilis in the feeding area.

Aggression: See behavioral appendix

Before provisioning: People have not been feeding Petrogale assimilis recently (if there were no people at the site provisioning and/or there were less than three Petrogale assimilis present.

Contact: See behavioral appendix

During provisioning: At least one person was feeding Petrogale assimilis.

Female to female aggression: Female aggression directed at another female.

Female to male aggression: Female aggression directed at a male.

Highest number in feeding area: The highest number of Petrogale assimilis observed in the feeding area at the one time.

In feeding area: The total number of Petrogale assimilis that were observed on the cement.

Individuals: Petrogale assimilis.

Male to male aggression: Male aggression directed at another male.

Male to female aggression: Male aggression directed at a female.

Naturally feeding: Petrogale assimilis feeding on naturally foods (fig leaves, grasses, shrubs).

On rocks: The total number of Petrogale assimilis observed on/within the rocks.
**People feeding:** People providing *Petrogale assimilis* with food.

**Provisioning:** People feeding or providing *Petrogale assimilis* with food; from hands; placing food on the ground; placing food on rocks.

**Sexual contact:** See behavioral appendix.

**Submission:** See behavioral appendix.

**Total aggression:** The total instances of aggressive interactions.

**Total female aggression:** The total instances of aggressive interactions initiated by females.

**Total male aggression:** The total instances of aggressive interactions initiated by males.

**Total people present:** The total number of people visible in the area.

**Unnaturally feeding:** *Petrogale assimilis* feeding on foods provided by people; *Petrogale assimilis* feeding from hands; *Petrogale assimilis* feeding on remnants of foods provided by people.

**Unknown aggression:** Aggressive interactions of individuals whose sex could not be determined, or aggressive hissing heard but not seen.