Establishment, behaviour and ecology of the SA mainland tammar wallaby (*Macropus eugenii eugenii*) following an experimental reintroduction.



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Abstract

The South Australian mainland tammar wallaby (*Macropus eugenii eugenii*) was presumed extinct in the wild from the early 1930's, until a feral population was re-discovered in New Zealand. Eighty-five animals were returned to Australia as part of a repatriation program into their former range. The establishment phase after a reintroduction is a critical time as animals may fail to survive if they cannot find resources and avoid predators in an unfamiliar habitat. To maximise reintroduction and establishment success, reintroductions need to be planned with a good understanding of the animals' ecology and anti-predator strategies. To improve this understanding requires experimental reintroductions and detailed monitoring. This thesis investigates the experimental reintroduction of 46 wallabies into Innes National Park in South Australia and examines the influence of release group familiarity on establishment. Part of this was an investigation of home range, habitat requirements and social behaviours during establishment and seasonally post-establishment. The thesis includes three data chapters which focus on (1) home range and core area, home range stability and degree of overlap with conspecifics; (2) habitat selection at the landscape scale and for day and night use within home range; and (3) factors influencing fine scale habitat use and social grouping behaviours in light of predation risk. In this study, the animals' perceived risk of predation is assumed to be reflected by surrogate measures of risk, such as distance to cover, likelihood of using cover, group size, and distance to nearest neighbour.

Release group familiarity was established by housing animals together in captivity for at least one month prior to release ("familiar" groups), whereas "unfamiliar" release groups comprised animals housed separately but released together. After each reintroduction the first month was considered to be a time of "establishment" in the environment. During the establishment month, home ranges were not randomly located within the landscape, as indicated by the biased occupancy of particular habitat types. Habitat types selected at the landscape scale were similar for familiar and unfamiliar release groups. However, animals released in unfamiliar groups showed a stronger preference for denser high cover habitat during their nocturnal activities within their home range. As tammars use cover to conceal themselves from predators, this result suggests that animals released in unfamiliar groups were more cautious than those released in familiar groups. Indeed at the fine scale, it was also found that animals released in unfamiliar groups were more likely to be found in high cover habitat, and forage closer to cover at night than did those released in pre-established familiar

groups. Using habitat with more caution and capitalising on communal vigilance in an unfamiliar habitat may ultimately improve the likelihood of survivorship and overall reintroduction success.

Comparing habitat decisions and social behaviours during the establishment period to similar times of year post-establishment suggested that animals' naivety about their new environment influenced some decisions they made. While habitat selection at the landscape scale was similar during establishment and at an equivalent time of year post establishment, analyses showed that they preferred to use melaleuca (a high cover habitat) during their nocturnal activities during establishment much more strongly than they did once they had established. Home range and core areas were also significantly smaller during the establishment month than at an equivalent time of year post establishment. This result supports the idea that animals will restrict their movements when they are unfamiliar with the habitat and predation risks. It also suggests that some habitat choices improved once they were familiar with their new environment and presumably predation risks. Their habitat choices reflected better anti-predator behaviour than those made during the establishment period: they were more likely to use high cover habitat, they remained significantly closer to cover while foraging, and group sizes were larger than during establishment.

Seasonal habitat selection at the landscape and home range scales suggested that the five habitat types within the study area provided different fundamental resources for the animals, as they were preferred at different times of year. Some differences in habitat selection were observed between the sexes, and the females were more selective in their diurnal and nocturnal activities. These differences most likely reflected, in part, differences in predator avoidance and reproductive strategies of the sexes, where females' preference at the landscape scale shifted towards high cover habitat during spring, the time of year when pouch young vacate the pouch and start to become independent. While no such selection at the landscape scale was observed for the males, it was also observed that within their daily activities both sexes were more likely to be found in high cover habitat during spring than any other time of the year, perhaps suggesting that as males were following the females. Overall, females generally selected *Eucalyptus diversifolia*, *Acacia anceps* and grassland at the landscape scale, and used *E.diversifolia* for refuge during the day and the other two habitats for foraging at night, whereas males generally preferred *Melaleuca halmaturorum* instead of *E.diversifolia* for diurnal refuge. *Eucalyptus rugosa* was mostly avoided by both sexes.

From month to month, both sexes expanded rather than shifted their home ranges to incorporate new areas, and these new areas were explored with conspecifics (when the amount of new area increased the amount of sharing also increased), highlighting their reliance on communal vigilance when in unfamiliar habitat. More new areas were incorporated into home ranges from July to December than from January to May. Time since release was not influential, which also supported the conclusion that perhaps home ranges moved to follow resources or overlap conspecifics more. Indeed, in one circumstance when neighbouring animals had died, a male wallaby was observed to move four kilometres through unfamiliar habitat and completely shift his home range in search of other residence.

Compositional analysis of habitat use versus availability indicated that monthly home ranges were selectively positioned in the landscape and were always larger than 4ha. Males' home ranges were larger than females', and males shared more of their home ranges than females did, supporting the usual sex bias observed for polygamous species. Core areas were proportional to the size of the home range, with similar sizes held by males and females and throughout the year. Core size was not influenced by the degree of overlap with conspecifics, with similar amount of core area shared by both sexes year round. The time of year influenced home range size, the smallest were held in winter when food resources were likely to be most abundant, but also when inclement weather was likely to restrict movements, as the animals' ability to detect predators may be hindered due to wet and windy conditions. Living with conspecifics is known to assist predator detection by group vigilance. Indeed, this study found the amount of home range overlap and the time two individuals spend together was positively correlated, and the size of home ranges decreased when more of it was shared with conspecifics, which suggested that sharing of home range was important. The degree which home ranges were shared was observed to be a fairly stable requirement for both sexes and did not change with season or time since release.

Despite previous isolation from predators, the wallabies displayed anti-predator behaviours which incorporated interrelated benefits obtained from group vigilance and using protective cover. Additionally, these behaviours were adjusted according to their familiarity with the habitat. Post-establishment, animals were observed to go further from cover when they were a greater distance from their nearest neighbour but surrounded by larger numbers of conspecifics. Whereas during the establishment period, animals ventured further from cover when they were closer to a nearest neighbour, but group size was not influential. It is known that larger groups of animals have more false alarms to predators, and false alarms result in

the animals' wasting energy in fleeing. If false alarms are more prevalent while occupying unfamiliar habitat with unfamiliar risks, then relying on large numbers of conspecifics while establishing may have been more of a liability than a benefit during the establishment period. However, some anti-predator strategies were commonly used, regardless of familiarity with their habitat. During the establishment month and post-establishment, animals were always more likely to be found in high cover habitat when they were further from their nearest neighbour, or were surrounded by fewer conspecifics. Some strategies and habitat decisions may have reflected differences in reproductive needs. While females, with and without pouch young did not differ in how far they would forage from protective cover, females with pouch young remained closer to their nearest neighbour than those without. This finding perhaps reflected the importance of relying on communal vigilance when their flight time from a predator may be hindered due to increased weight and bulk of a pouch young. These findings supported the theory that group vigilance anti-predator strategies are somewhat innate in the tammars, as having previously been completely isolated from predators their responses could have been lost, and once released there was no opportunity to socially learn the appropriate responses off an established population.

Some habitat and social grouping behaviours were occasionally unexpected but may have been balanced out by other behaviours. This study observed that animals foraged further into the open during winter than at any other time of year, which contradicts findings by other authors where tammars foraged further into the open when the weather was fine. However, I also found that animals remained closer to their nearest neighbour during autumn and winter than at any other time of year. Perhaps foraging further into the open in inclement weather is actually safer if it provides a greater chance to detect and react to an approaching predator. For example, a fox approaching from the scrub edge would not give the wallaby enough time to respond. An additional benefit of foraging further away from cover in larger group sizes, is that animals can flee in different directions confusing the fox, as it would have to make a quick decision and chose one animal to pursue. Animals were furthest from their nearest neighbours in spring which was also somewhat surprising as this is when pouch young vacate the pouch and it was observed that females with pouch young remain closer to their nearest neighbour suggesting they gain some anti-predator benefit from doing so. However, during spring the animals were also more likely to be found in high cover habitat than at any other time of year, so this may have somewhat balanced out the need for a close neighbour.

Overall, this study confirmed that tammars retain anti-predator behaviours despite previous isolation from predators. However, their habitat and social decisions improved with time since release. In this experimental study, animals released in groups with unfamiliar conspecifics appeared to be at an advantage as they displayed habitat use and social groupings which suggested they were using their new habitat with more caution. Therefore, this study recommends releasing groups of unfamiliar conspecifics. Releasing animals at different times of year also had an influence on how they used their habitat. Animals released in spring displayed behaviours suggesting that they were more cautious in avoiding predators: they were more likely to be found in cover, foraged closer to cover, and were in larger group sizes than those animals released in winter. Therefore, it is recommended that animals are released at a time of year where conditions are fine and resources are abundant. Releasing females with pouch young did not appear to hinder the animals after their release (compared to females without pouch young) and could be recommended as young permanently evacuating the pouch in the wild are at a greater advantage than juveniles released from captivity. Results from this experimental study were used to assist ongoing management decisions and were imperative in the planning of subsequent reintroduction events for this species, and can be applied more generally to other species with similar anti-predator strategies.

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Names of my volunteers, and the number of days each of them worked. (DEH) = Department for Environment and Heritage employee, (GreenCorp) = Green Corps trainee, (CVA) = Conservation Volunteers Australia volunteer. * = volunteered on more than one field trip.

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