Terrifying tourists and wary wallabies: responses of macropodid species to the presence of humans

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The responses of four species of macropodid to humans at a wildlife sanctuary were investigated experimentally. Bridled Nailtail Wallabies *Onychogalea faenata*, Red-necked Wallabies *Macropus rufogriseus* and Swamp Wallabies *Wallabia bicolor* all spent less time feeding, resting, grooming, interacting and more time looking up or moving in the five minutes after being approached by the researcher. Eastern Grey Kangaroos *M. giganteus*, Red-necked Wallabies and Bridled Nailtail Wallabies fled at shorter distances from an approaching researcher in a vehicle than from a researcher on foot. The proportion of macropodids found in grassland compared with forest was not significantly affected by a recent tour.

To minimize negative impacts of tours on macropodids in the sanctuary, it may be necessary to conduct tours in vehicles rather than on foot.

Key words: Macropodidae, Impacts, Wildlife tourism, Behaviour, Flight distances.

INTRODUCTION

HUMANS are perceived by many animals as predators. It is not surprising that many mammals have been found to flee or interrupt their activities if approached by humans (e.g., Alpine Marmots: Mainini *et al.* 1993; Amur Tigers: Kerley *et al.* 2002; Asian Rhinoceros: Lott *et al.* 1995; Chamois: Gander *et al.* 1997; Polar Bears: Dyck *et al.* 2004; Pygmy Marmosets: de la Torre *et al.* 2000; Woodland Caribou: Duchesne *et al.* 2000; Western Lowland Gorillas and Chimpanzees: Tutin *et al.* 1991). Others change their use of habitat in areas where humans are active (e.g., Brown Bears: Olson *et al.* 1997; Pronghorn: Fairbanks *et al.* 2002; Pyrean Chamois: Pépin *et al.* 1996). Such responses have implications for survival or reproduction by affecting the foraging efficiency, energy use, ability to detect other natural predators, stress-hormone levels, heart rates, social activities and by causing abandonment of young (MacArthur *et al.* 1982; Goodrich *et al.* 1994; de la Torre *et al.* 2000; Phillips *et al.* 2000; Creel *et al.* 2002; Grossberg *et al.* 2003).

Faced with predators, prey sacrifice fitness by spending time vigilant or foregoing opportunities in risky habitats (Brown *et al.* 1999). Prey assess costs, benefits and risks of predation to decide how much time to spend in different behaviours (Lima *et al.* 1990). The extent to which humans affect behaviour is influenced by the distance and mode of approach. Generally, the closer the approach, the greater the change in behaviour (e.g., Lott *et al.* 1995; Johns 1996; Cassini 2001; Papouchis *et al.* 2001). The response of most mammals is generally greatest when humans approach by foot (e.g., McLellan *et al.* 1989; Andersen *et al.* 1996; Papouchis *et al.* 2001; but see Pedevillano *et al.* 1987). Leaving a track frequently traversed by humans tends to elicit a greater response than approaches by humans who remain on such a track (e.g., Mainini *et al.* 1993; Miller *et al.* 2001).

In Australia, wildlife tourism often involves approaching members of the marsupial family Macropodidae (kangaroos and wallabies). Some populations of macropodids subjected to tourism comprise animals that have been reintroduced to redress serious declines across the species' former ranges. It is important that tourism does not arrest population increases in the initial stages of reintroductions or cause decreases in later stages. For animal welfare it is also important to minimize impacts of tourism, even with abundant species.

The response of macropodid species to humans may differ from those of other mammals, especially mammals that have a long history of evolution with humans. It is important to determine how distance and mode of approach affects the response of macropodids and other marsupials, so that the impact of tourism can be minimized.

We investigated the responses of four macropodid species in a semi-captive environment to approaches by humans. We had three aims: 1) to determine if macropodids changed the time they spent in different activities in response to approaches by humans; 2) to identify factors that influence the magnitude of responses (in terms of changes in activity and flight distances); and 3) to determine whether macropodids were displaced to less suitable feeding areas for a significant time in response

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to the presence of humans. This last aim used guided tour groups. The first two aims were addressed by a single researcher undertaking the approach; it was not possible to unobtrusively observe animals immediately after an approach by a tour group.

METHODS

Study area

The Australian Native Flora and Fauna Sanctuary is a 150 ha area in the southwestern corner of Western Plains Zoo, Dubbo, in Central Western New South Wales, Australia. The majority of the land in the sanctuary was originally used for dairy farming, mixed cropping and orcharding before being used for grazing.

The vegetation of the sanctuary differs between the ridges, drainage lines and grasslands. The ridges (comprising 48% of the study site) are dominated by Mugga Ironbark *Eucalyptus sideroxylon*, White Cypress Pine *Callitris glaucophylla* and Black Cypress Pine *C. endlicher*. In these areas, the shrub layer predominantly comprises Deans Wattle *Acacia deanei*, Boxleaf Wattle *A. buxifolia* and Sword Leafed Wattle *A. gladiiformis*. The herbaceous layer is principally Small Flowered Wallaby Grass *Austrodanthonia setacea*, Corkscrew Grass *Austrostipa scabra* subsp. *falcata* and Foxtail Speargrass *Austrostipa densiflora*.

The drainage lines (comprising less than 1% of the study site) are dominated by Blakely's Red Gum *E. blakelyi*, White Box *E. albens* and Mugga Ironbark with a similar shrub layer. The herbaceous layer is dominated by Tall Sedge *Carex appressa*.

The grasslands (which make up the remaining 51% of the study site) are a mixture of exotic weeds, exotic grasses and native grasses. The few trees and shrubs in these areas are White Box, Mugga Ironbark, Grey Box *E. microcarp* and Deans Wattle (P. Cameron, pers. comm., 3 June 2003). The grassland areas provide most of the food for the macropodids, as the herbaceous layer in the forested areas (the areas dominated by Red Gum and Cypress Pine trees) is extremely sparse.

The sanctuary is undulating to hilly, ranging from 260 m to 340 m above sea level. Underlying geology is rhiolite. Soils range from a shallow lithosol on the steep northerly slopes to deep loams in drainage depressions and gullies.

Temperatures in January can reach 44.2°C. From May to December the temperature regularly falls below freezing. Annual rainfall averages 587 mm (Cameron 1999; Bureau of Meteorology Australia 2001).

This study was conducted between November 2002 and April 2003. At the time the Australian Bureau of Meteorology declared there were serious to severe rainfall deficiencies across most of the state (Bureau of Meteorology Australia 2003). The grassland and herbaceous layers were severely degraded (P. Cameron, pers. comm.).

A 2.7 m high chain-mesh fence, designed to exclude exotic predators, encloses the area. The Red Fox *Vulpes vulpes* and the Cat *Felis catus* have been eradicated (Cameron 1999). Introduced predators, particularly cats and foxes, are now the dominant mammalian predators in mainland Australia and have eliminated many populations of wildlife. Fencing or exotic predator control is essential to successful mammal reintroductions (Short *et al.* 1992). The only native predators in the area are avian: Black-shouldered Kite *Elanus axillaris*, Black Kite *Milvus migrans*, Wedge-tailed Eagle *Aquila audax*, Little Eagle *Hieraaetus morphnoides*, Black Falcon *Falco subniger*, Australian Hobby *Falco longipennis*, Nankeen Kestrel *Falco cenchroides* (A. Thorne, pers. comm.).

Two species, once common to the area but now locally extinct, were reintroduced into the sanctuary between 1996 and 2000: the Bridled Nailtail Wallaby *Onychogalea faenata* and the Brush-tailed Bettong *Bettongia pencillata*. Other large and medium-sized mammals present in the sanctuary are Eastern Grey Kangaroos *Macropus giganteus*, Red-necked Wallabies *M. rufogriseus*, Swamp Wallabies *Wallabia bicolor*, Sugar Gliders *Petaurus breviceps*, Brush-tailed Possums *Trichosurus vulpecula* and Short-beaked Echidnas *Tachyglossus aculeatus*. Introduced European Rabbits *Orytogalus cuniculus* and European Brown Hares *Lepus capensis* are also abundant. Management of the area by zoo staff includes: burning to reduce bushfire risk; provision of supplementary food during severe droughts; culling rabbits; and culling Eastern Grey Kangaroos when numbers become high.

The sanctuary was closed to the public except for occasional school groups and special interest groups. Plans include holding nocturnal tours in the sanctuary so the public can experience locally extinct fauna in a virtually wild situation (Zoological Parks Board of New South Wales 2002).

Six tracks cross the sanctuary (Fig. 1). They are about 2 m wide, and were used by schools, special interest groups, researchers and zoo staff. The latter groups also often left the tracks. Around 50% of the tracks run through grassland areas and some food was available near the tracks. In forested areas there was more food available near the tracks than under the trees. The zoo staff also placed supplementary food at six locations near the tracks daily.

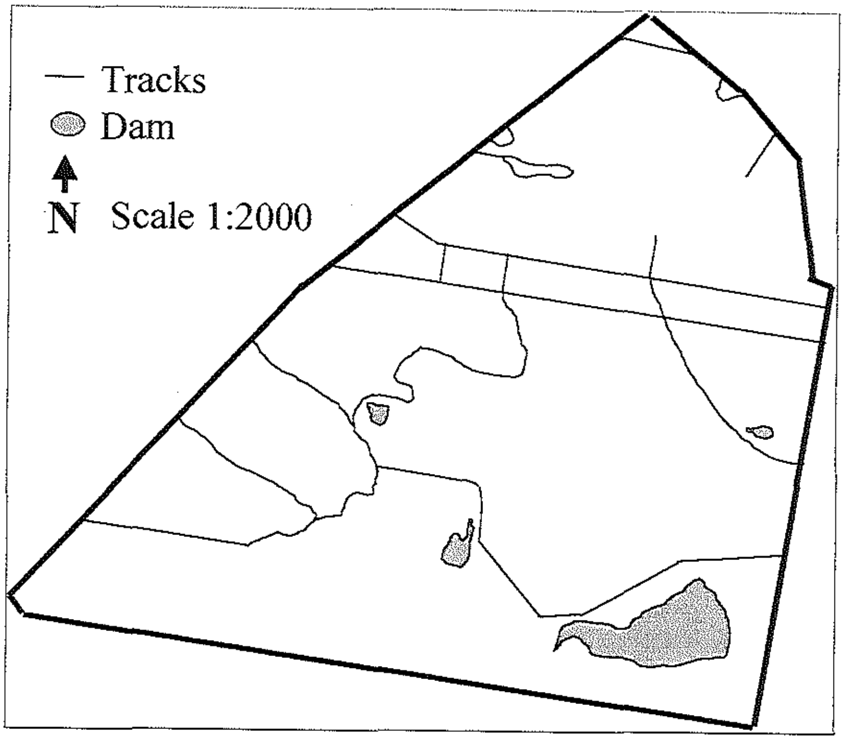

Fig. 1. Tracks within the Australian Native Flora and Fauna Sanctuary, Western Plains Zoo, Dubbo, New South Wales.

Study species

All four macropodid species present in the sanctuary were studied: Eastern Grey Kangaroo, Red-necked Wallaby, Swamp Wallaby and Bridled Nailtail Wallaby. The Brush-tailed Bettong, almost entirely nocturnal, was not studied because it is difficult to observe. Macropodid behaviour is often affected by group size, particularly the number of conspecifics within 10 m (e.g., Blumstein *et al.* 2001; Wahungu *et al.* 2001; Blumstein *et al.* 2003). Therefore, all behavioural data were collected on solitary animals (or mothers with a single young at foot) at least 10 m from the nearest conspecific. Eastern Grey Kangaroos, generally found only in groups, were not included in the analyses of time spent in different activities.

Time spent in different activities in response to observer approach

Observations were made every second day during the study. Observations began before sunrise, as soon as there was sufficient light to observe macropods without a spotlight, and concluded one hour later. During this time the macropods were mainly foraging. The researcher walked or drove at one kilometre per hour along the track in a southward direction where possible, starting from a pre-determined randomly assigned location until the first animal was sighted. Four different treatments were used:

1. *No approach*: the researcher hid at least 300 m from the animal with the animal apparently unaware of their presence;
2. *On-track approach*: the researcher walked towards the animal along the track;
3. *Off-track approach*: the researcher walked towards the animal off the track but parallel to it;
4. *In car approach*: the researcher drove towards the animal along the track in a large sedan.

For the latter three treatments, the researcher recorded the distance to the animal at the closest approach. The researcher then continued to walk or drive past the animal until it was possible to hide and the animal was apparently unaware of the researcher's presence. In all treatments the researcher then observed the animal through binoculars for five minutes, recording transitions between activities by speaking into a tape recorder. The five-minute period was chosen because a pilot study found most macropodids returned to their pre-approach activity five minutes after an approach. The following activities were recorded:

1. *Feeding*: Head down biting or chewing, or biting and chewing leaves from tree or shrub;
2. *Resting*: Head down stationary, or lying on side;
3. *Grooming*: Licking parts of body or rubbing parts of body with paw;

4. *Interacting with conspecifics*: Attention focused on another animal, approaching another animal, touching another animal or chasing another animal;
5. *Moving*: Moving in any direction, not including moving with head down biting and chewing; and
6. *Looking up*: Head raised, forepaws off ground, not including feeding from trees or shrubs.

We categorized the first four activities as primarily "maintenance activities", i.e., activities required to meet energy demands, maintain health and maintain social organization.

The percentage of the five-minute period the animal spent in each different activity was calculated. The observer then moved to the next randomly assigned location. Methods described above were then repeated until the one-hour period ended.

Flight distances in response to observer approach

The same methods were used as for the time spent in different activities, with the following differences: 1) only three treatments were used: on-track approach, off-track approach and in car approach; and 2) the animal was approached until it fled, and the flight distance (distance from the researcher to the animal when it fled) was recorded.

Observations were conducted on the same days as for the time spent in different activities; the data collected depended on whether the animals remained or fled, so flight distance observations were only made for individuals that fled.

Movements between habitats in response to experimental tours

Experimental tours were conducted in the sanctuary that began at dusk and concluded an hour later. Tour guests comprised visitors staying in local motels and caravan parks, as well as interested locals. Tour group sizes varied between three to 17 people.

Data collection began one and a half hours after dusk, half an hour after the tour was finished, and concluded two hours later. The half-hour time interval was chosen to determine if macropodids that fled were displaced to less suitable feeding areas for a substantial period. Where the forests and grasslands met four sites were selected for observation. Two sites hosted tours (experimental sites) and two were used as control sites. At each site three transects were constructed, each running 120 m into the forested areas and into the grassland areas. The sites and transects were randomly allocated on each day of the study.

Transects were walked with a spotlight with 15 mins spent in the forest and 15 mins in the grassland. The number of individuals of the four macropodid species seen in grassland and forest were counted and the percentage of macropodids seen in grassland determined. The grassland areas provide most of the food for macropodids; the forest areas are less suitable for feeding.

Data was collected for two weeks prior to the commencement of tours. Tours were then run every second day for a month. Data was collected every day and continued for two weeks after the tours ended. This allowed data to be collected at the following times and sites:

1. *pre, control*: prior to the commencement of tours in the control sites;
2. *tour day, control*: on a day on which a tour was run in the control sites
3. *no tour day, control*: on an alternate day to the days on which tours were run in the control sites;
4. *post, control*: after tours were completed in the control sites;
5. *pre, tour*: prior to the commencement of tours in the experimental sites;
6. *tour day, tour*: on a day on which a tour was run in the experimental sites;
7. *no tour day, control:* on an alternate day to the days on which tours were run in the experimental sites; and
8. *post, control*: after tours were completed in the experimental sites.

Statistical analyses

Square root arcsin transformations were used for the percentage of time spent in different activities and the percentage of animals found in grassland; percentages form a binomial rather than normal distribution. If the square root of each proportion in a binomial distribution is transformed to its arcsine the resultant data will have an underlying distribution that is nearly normal (Zar 1999). Kruskal-Wallis tests (non-parametric tests used to examine differences between two or more groups) were used to compare the time spent in different activities and the flight distances among different treatments, because the data was not normal. Mann-Whitney U tests (which test if two independent samples come from populations of the same distribution) were used for post-hoc analyses (Coakes and Steed 2001). A one-way analysis of covariance, with distance at closest approach as a covariate, was used to test if distance at closest approach affected the observed significant differences in time spent in different activities between treatments (Coakes and Steed 2001). A one-way analysis of variance (which compares the means of more than two groups or levels of an independent variable) was used to compare the proportion of animals found in grassland with different treatments (Coakes and Steed 2001).

RESULTS

All three macropodid species, for which time spent in different activities was analysed, spent less time in "maintenance activities" (feeding, resting, grooming and interacting with conspecifics) when approached by the researcher than when not approached (Bridled Nailtail Wallabies χ^2 = 10.805, df = 3, sig = 0.013, Fig. 2; Red-necked Wallabies χ^2 = 9.951, df = 3, sig = 0.019, Fig. 2; Swamp Wallabies χ^2 = 13.184, df = 3, sig = 0.004, Fig. 2). When the animals were approached the proportion of time spent in these activities did not differ significantly between different types of approach (car, on- or off-track) or with distance at closest approach.

Three of the macropodid species fled at closer distances to the researcher when approached in a vehicle than when approached on foot (Eastern Grey Kangaroos χ^2 = 11.175, df = 2, sig = 0.004, Fig. 3; Red-necked Wallabies χ^2 = 13.576, df = 2, sig = 0.001, Fig 3; Bridled Nailtail Wallabies χ^2 = 15.460, df = 2, sig = 0.000, Fig 3). Swamp Wallabies showed a similar trend (Fig 3). The flight distances for on-track approaches did not differ significantly from those for off-track approaches for any species.

There were no significant differences in the proportion of macropodids found in grassland on different days or at different sites (Fig 4).

DISCUSSION

All macropods in the sanctuary responded to the approach of humans with a decrease in maintenance activities. They did not differentiate between approaches on or off track, or in a vehicle, or with approach distance. This contrasts with results of studies for other mammals. Marmots *Marmota marmota* and Mule Deer *Odocoileus hemionus* showed greater responses when approached by pedestrians off the track than on the track (Mainini *et al.* 1993; Miller *et al.* 2001). These mammals probably respond less to humans on the track because hikers and pedestrians predictably confine themselves to tracks and the mammals learn that they are not a danger (Mainini *et al.* 1993). The sanctuary macropodids may not have been exposed to humans on a track frequently enough to learn that they are not a danger, or they may not habituate well to humans. One-horned

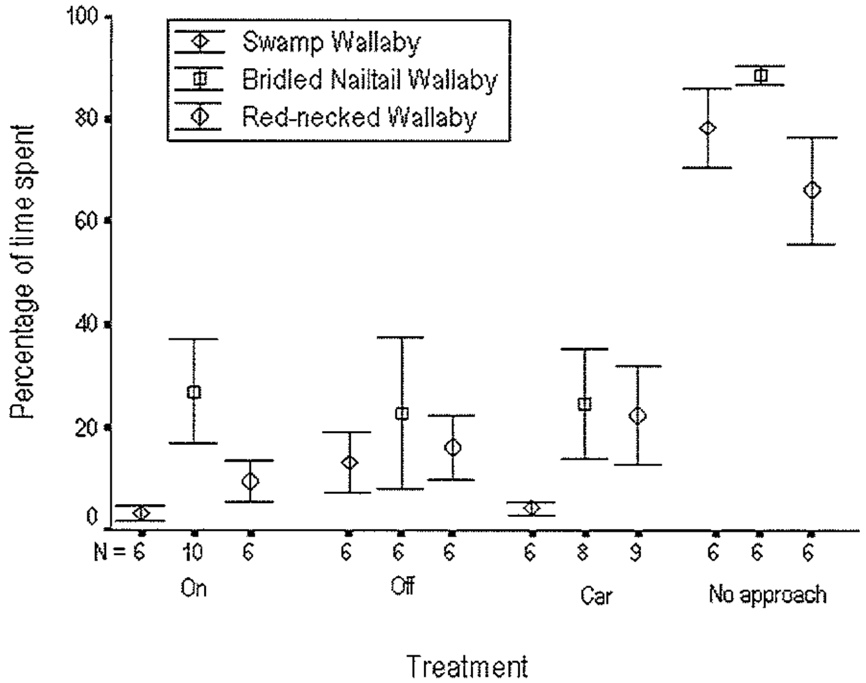

Fig. 2. The percentage of time spent in "maintenance activities" (feeding, resting, grooming and interacting with conspecifics) by a) Bridled Nailtail Wallabies, b) Red-necked Wallabies and c) Swamp Wallabies after different types of approach (mean and standard error).

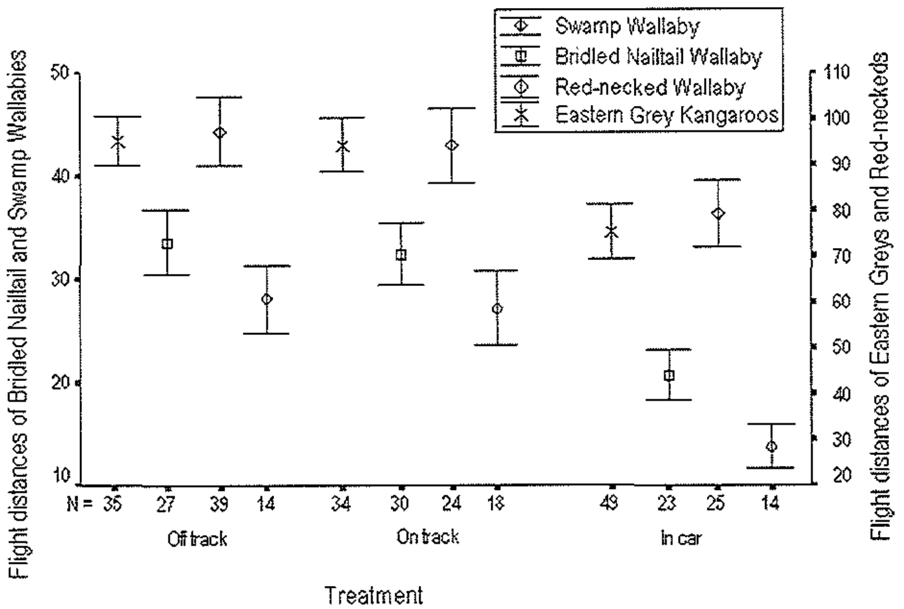

Fig. 3. Flight distances of a) Bridled Nailtail Wallabies, b) Swamp Wallabies, c) Red-necked Wallabies and d) Eastern Grey Kangaroos when approached by different treatments (mean and standard error).

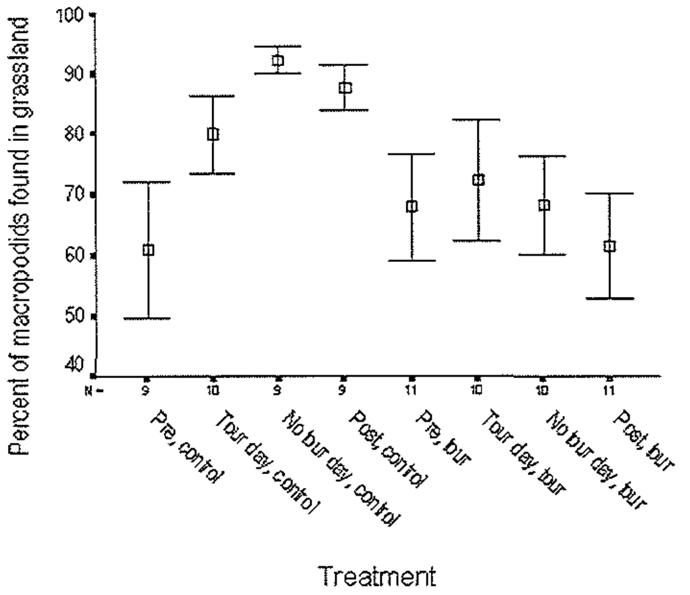

Fig. 4. Percentage of macropodids found in grassland after different treatments (mean and standard error). (Pre, control = prior to the commencement of tours in the control sites; Tour day, control = on a day on which a tour was run in the control sites; No tour day, control = on an alternate day to the days on which tours were run in the control sites; Post, control = after tours were completed in the control sites; Pre, tour = prior to the commencement of tours in the experimental sites; Tour day, tour = on a day on which a tour was run in the experimental sites; No tour day, control = on an alternate day to the days on which tours were run in the experimental sites; and Post, control = after tours were completed in the experimental sites).

Rhinoceros *Rhinoceros unicornis* appeared to habituate easily to humans. Sambar Deer *Cervus unicolor*, living in the same area, did not appear to habituate at all (Cosgriff *et al.* 1999; Curry *et al.* 2001).

Macropodid species can become habituated to humans (e.g., kangaroos and Quokkas: Green *et al.* 2001). With frequent tours in the sanctuary macropodids may respond less when approached on the track than off. The macropodids may also have learnt that humans off track are no danger, but because zoo staff cull macropodids regularly (P. Cameron, pers. comm.) this seems less likely although not impossible. Svalbard Reindeer *Rangifer tarandus platyrhyncus* in areas with hunting were as easily habituated to human activity as in areas without hunting (Coleman *et al.* 2001).

The lack of an effect due to the distance of the approach differs from studies on White-tailed Deer *Odocoileus viginianus*, Californian Bighorn Sheep *Ovis canadensis californiana*, Harbour seals *Phoca vitulina*, Common Chimpanzees *Pan troglodytes*, Mountain Gorillas *Gorilla gorilla beringei*, Asian Rhinoceros *Rhinoceros unicornis*, Moose *Alces alces*, Eastern Chimpanzees *Pan troglodytes schweinfurthi*, South American Fur Seals *Arctocephalus australis* and Desert Bighorn Sheep *Ovis canadensis nelsoni*, which all showed greater responses to close approaches than to approaches at a greater distance (Eckstein *et al.* 1979; Hicks *et al.* 1979; Allen *et al.* 1984; Tutin *et al.* 1991; Lott *et al.* 1995; Andersen *et al.* 1996; Johns 1996; Cassini 2001; Papouchis *et al.* 2001). Approach distances may have had little affect because the macropodids were disturbed by even the most distant approaches. Alternatively, approach distances may have made little difference because the macropodids had habituated to humans and were no longer frightened by close approaches.

The macropodids' greater flight distances when approached on foot than in a car is comparable to the response of Grizzly Bears *Ursus arctos horribilis*, Elk *Cervus canadensis*, White-tailed Deer, Desert Bighorn Sheep and Moose, which are all more likely to flee from pedestrians or skiers than motorized vehicles (Schultz *et al.* 1978; McLellan *et al.* 1989; Eckstein *et al.* 1979; Andersen *et al.* 1996; Papouchis *et al.* 2001). This suggests people on foot or skis represent a greater perceived danger than do vehicles. Moose would rarely, if ever, have bad experiences with mechanical transports. Snowscooters in the area are highly controlled and hunting is only conducted on foot (Andersen *et al.* 1996). They may have learnt that humans are a danger but mechanical transports are not. Mountain Goats *Oreamnos americanus* crossing a highway underpass, however, were more likely to flee because of vehicles on the highway than pedestrians on the highway (Pedevillano *et al.* 1987), possibly reflecting a greater learned danger from vehicles. Although the macropodids responded similarly to most other mammals, their response is surprising because culling is normally from vehicles (P. Cameron, pers. comm.). Perhaps the greater response to humans on foot may occur because pedestrians are recognizable as mammals or even predators. Captive-reared Rufous Hare-wallabies (*Lagorchestes hirsutus*) showed more caution towards models of cats and foxes than towards a strange box, even though they had never been exposed to predators (McLean *et al.* 1994; McLean *et al.* 1996). A final possible explanation for the macropodids responding less to vehicles than people on foot may be that they notice vehicles from greater distances so were not surprised by them. Desert Bighorn Sheep were believed to respond more to hikers because on average they noticed the vehicles and mountain bikers from twice the distance they noticed hikers (Papouchis *et al.* 2001).

Macropodids were not displaced to more closed habitats after tours; any displacement between habitat types in the sanctuary is short term and animals moved back into areas with food after tours had passed. A similar response has been found in Roe Deer *Capreolus capreolus*, which, after being displaced from their home range by hunting or orienteering, typically moved back after nightfall (Jeppesen 1987b). Provided tours are not forcing mammals away from feeding areas for extended periods, impacts from tourism may not significantly affect wildlife survival or reproduction. This does not necessarily mean that tours have no impact. Mammals may remain in an area where their survival or reproduction is reduced because they have no alternative place to go (Gill *et al.* 2001; Frid *et al.* 2002). The sanctuary is only 150 ha, around half of which is cypress pine forest with limited food. The macropodids may be forced to return to the tour areas regardless because there are no other suitable foraging locations.

IMPLICATIONS OF FINDINGS

The techniques for minimizing negative impacts of tourism on wildlife are very much species specific. For some species, impacts of tourism on wildlife can be minimized by ensuring tourists remain on the path, or do not approach too closely, or remain in cars. For other species it may be better to only take tourists on foot. For some species a combinations of techniques may be best for minimizing impacts. For other species none of the techniques may work. Hence, investigation of the impact of different approaches is needed to determine which techniques best minimize impacts upon different species.

The appropriate techniques of minimizing the impact of tourism upon wildlife may even vary between groups of animals from the same species, depending on their previous experiences with humans or habitat characteristics. For example, Fallow Deer *Dama dama* fled more frequently in closed than in open habitats (Recarte *et al.* 1998).

The best techniques for minimizing impacts on wildlife may also change with time as wildlife become habituated to humans or conditions vary. In a resource-rich area the benefit from remaining may outweigh the risk of remaining (Frid *et al.* 2002). White-tailed Deer have lost their natural fear of man when in poor condition (Kabat *et al.* 1953 cited in Eckstein *et al.* 1979; Dahlberg *et al.* 1956 cited in Eckstein *et al.* 1979). During this study New South Wales suffered from serious to severe rainfall deficiency. This may have influenced the wallabies' responses despite the wallabies being supplied with supplementary food. Flight distances and behavioural responses can also differ at different times of the day or different seasons (Jeppesen 1987a; Louis *et al.* 2000; Papouchis *et al.* 2001; Wahungu *et al.* 2001). Hence wildlife behaviour should continue to be observed over time to ensure selected techniques remain appropriate.

To minimize negative impacts of tours on the sanctuary macropodids tours could be conducted only in vehicles, however this may decrease tourist satisfaction. Tours on foot may be more rewarding for tourists (Shackley 1992). Provided displacement caused by tours is short-term managers may elect to conduct all or some tours on foot. Should displacement become significant, managers may need to conduct all tours in vehicles.

Care should be taken in drawing conclusions about impacts of tourist visits on the macropodids. The impact of approaches by humans may not affect their survival or reproduction. Behavioural responses may be unreliable indicators of fitness costs of human approaches (Gill *et al.* 2001). Lactating adult females in Southern Elephant Seal *Mirounga leonina* harems were more alert and called more often when visited by researchers, but these changes did not affect pup weaning mass (Engelhard *et al.* 2002). Nonetheless, it is important to minimize the impact of tourist visits on macropodids until research establishes if behavioural changes are affecting population size, and for animal welfare.

CONCLUSIONS

Approaches by humans may cause macropodids to spend less time in maintenance activities required to meet energy demands, maintain health and maintain social organization, and more time in activities such as vigilance and flight. Running car tours rather than walking tours may reduce negative impacts of tourism on macropodids, but this may not always be successful. The behavioural responses of macropodids to humans may differ between sites and over time.

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