

1997 Fowlers Gap Research Report

Metabolic and hormonal relations of arid-zone passerines

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We measured basal metabolic rate of selected old endemic Australian species (e.g., Chestnut-crowned Babblers, White-plumed Honeyeaters, Singing Honeyeaters, Spiny-cheeked Honeyeaters, Variegated Wrens) and Zebra Finches (new endemic). Contrary to the literature, we found no evidence of reduced metabolic rate in any of the old-endemic species which showed BMR values that were statistically indistinguishable from predictions based on data from north-hemisphere passerines. We also examined reproductive steroid levels in free-living honeyeaters and fairy wrens and found that the wrens tended to have testosterone levels like those found in breeding north-temperate male passerines but that male honeyeaters had relatively low levels of Testosterone (T).

Heart size and mitochondrial density in Red Kangaroos and feral Goats: A comparison of exercise capacities

Investigators: Elizabeth Boliger and Terence Dawson, School of Biological Science, UNSW Sydney 2052.

Kangaroos are able to hop for many kilometres at high speeds, and are thus considered to be highly athletic animals. Their hopping locomotion is unique in its efficiency, and has been well examined. However, the role of aerobic metabolism at high speeds, over 25 km/h has yet to be determined. There are no experimental data on the cardiovascular responses of exercising kangaroos, and the capabilities of their hearts during intense exercise is unknown. This study used wild animals at Fowlers Gap Research Station to compared the size and the aerobic potential of red kangaroo hearts (*Macropus rufus*) with that of the hearts of a similarly sized placental, the feral goat (*Capra hircus*).

Red kangaroos were found to have a heart to body mass ratio 165% greater than that of feral goats, and 30 % larger than expected for marsupials of their size. Overall, kangaroo hearts were found to have superior aerobic potential to goat hearts, with a 70 % greater total mitochondrial volume. The results suggest that red kangaroos have hearts capable of high cardiac outputs during exercise, thus being able to deliver large amounts of blood and oxygen per unit time to the working muscles. The implication of these data is that, at times, the muscles of red kangaroos have a much higher maximum oxygen demand than those of goats. The athletic ability of kangaroos therefore relies on both an energetically efficient locomotion and a relatively high aerobic capacity.

An evaluation of the controls on hillslope sediment transport in a small Australian arid zone catchment: a case study from Homestead Creek catchment, western New South Wales, Australia

Investigators: Kate J. Brown, Department of Geography and Environmental Science, Monash University, Clayton VIC 3168

Thesis Abstract:

This thesis reports on a study of hillslope sediment transport in a small Australian arid zone catchment. Primary data were derived from a network of 56 slope wash troughs, representing one of the most extensive field sampling programmes that has yet been employed in dryland geomorphic research. Supplementary data were obtained using networks of erosion pins and analysis of the radio-isotope caesium-137.

Trap masses and textural characteristics of trough sediments were recorded at intervals during a five year study period. To explore the controls on hillslope sediment transport in the landscape, sediment trap masses and textural characteristics were related to a suite of landscape features measured for the area contributing sediment to each trough. Relationships between landscape features and sediment transport were assessed using bivariate correlation, multiple regression analysis and principal components analysis. Results demonstrate a complex and variable role for the individual landscape features. The statistical analyses demonstrate that the order in which variables enter predictive regression equations varies with rain event size and landscape context. In addition, more landscape features contribute to the explanation of variance during small rain events than during large rain events. In large events, it is inferred that increasing volumes of overland flow diminish the importance of some surface properties. It is also demonstrated that sediment contributing areas are dynamic, and that as a consequence sediment collection is best done with unbounded sediment collection traps rather than bordered runoff plots.

The findings of the study indicate that the control of an individual landscape feature on hillslope sediment transport is not as straight forward as first anticipated, and that the influence varies according to the experimental technique used, the size of the storm, the local gradient, and the way that the trapped sediment is examined (for example, the sediment trap mass or particle size).

A major contribution of this study is that it provides one of the most comprehensive demonstrations of the inter-linkages that exist between landscape features in complex natural environments, and highlights the need to adopt multivariate statistical techniques to explore the control of site characteristics on sediment transport.

References

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Morphological and metabolic responses of male White-plumed Honeyeaters to exogenous testosterone

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We captured 24 adult male White-plumed Honeyeaters from areas adjoining Fowler's Gap and evaluated basal metabolic rate (BMR) and morphological features before and 6-weeks after subcutaneously implanting half of them with empty silastic capsules (controls) and the other half with testosterone-filled capsules (T-treated birds). There was no effect of testosterone on BMR, body mass, adrenocortical sensitivity to capture stress, or blood parasite load in these birds. However, T-treated males had significantly higher haematocrits and maintained jet-black bills that typify adult breeding males. In contrast, control males displayed a gradual lightening of the proximal half of their bills, a colour change never seen in free-living adult males at Fowler's Gap, but typical of non-breeding Fuscous Honeyeaters, a congeneric species that breeds seasonally. We conclude that testosterone does not directly increase energy expenditure in male White-plumed Honeyeaters, but the T-induced rise in haematocrit may be beneficial to breeding males in permitting higher aerobic capacity and more rapid recovery following exhaustive activity.

Thermoregulation by kangaroos from mesic and arid habitats: influence of temperature on routes of heat loss in Grey Kangaroos (*Macropus giganteus*) and Red Kangaroos (*Macropus rufus*)

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While basic studies have been made on arid zone kangaroos such as the red kangaroos (*Macropus rufus*) (Dawson 1973), it is surprising that little is known about the environmental physiology of the common mesic species such as the eastern grey kangaroo (*Macropus giganteus*). This species has a fossil history going back more than 5 million years, while the red kangaroo appears to be a newly evolved species with a fossil history restricted to the Pleistocene (Dawson 1995). It has been assumed that many of the thermoregulatory characteristics seen in arid zone species reflect adaptation to such harsh environments. Eastern grey kangaroos have extended their range to the far west reaching Fowler's Gap Research Station in the 1960s or early 1970s, putatively due to the provision of more water sources for domestic sheep. They are reported to drink more frequently than red kangaroos in semi-arid habitats.

Red kangaroos have excellent thermoregulatory abilities, using a sequence of evaporative heat loss mechanisms to cope with external and internally produced heat loads. In regard to the grey kangaroos little has been reported except that they pant and lick. Licking has been suggested to be its major route of evaporative heat loss at high temperatures. In this study we compared the basic thermoregulatory features in the kangaroo species which represent the two major evolutionary lineages of modern kangaroos. We also explored the pattern of responses to high temperature by these kangaroos. There were no major differences between the species but numerous smaller but significant differences were found. The

heavier fur of grey kangaroos meant that heat loss and therefore heat production was lower in the cold than in red kangaroos. This would infer lower food requirements by the grey kangaroo in winter. At high temperatures, an air temperature of 45°C, the red kangaroos appeared to be less stressed as measured by their respiratory evaporative water loss. Panting however, was the major heat loss mechanism of eastern grey kangaroos, but red kangaroos maintained a lower body temperature with significantly less respiratory water loss than seen in the grey kangaroos. This would translate into a lower frequency of drinking as noted by observations in Salon Paddock at Fowlers Gap.

Hydrology and erosion mechanisms in patterned chenopod shrublands

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Rainfall simulation over small experimental runoff plots is being used as the main tool to research aspects of the hydrologic and erosional response of landsurfaces within the patterned chenopod shrublands that are widely developed in the Fowlers Gap district. Various components of these landscapes are being examined separately, including surfaces densely mantled with gibbers, bare shrub interspace locations carrying cyanobacterial crusts, and plots centred on bluebush shrubs. During the rainfall simulation experiments, hydrologic response is assessed from surface runoff rates monitored every 2 minutes; sediment samples are also collected with this frequency. Soil loss is determined from the turbidity of the runoff samples, using a calibrated relationship with sediment mass.

The goal of this work is to build a comprehensive understanding of surface and sub-surface characteristics that influence hydrologic and erosional behaviour. This information will be used in the development and testing of process-based models seeking to account for the behaviour of patterned chenopod shrublands, and to examine the potential impacts of disturbance and environmental change on these landscapes.

As a part of this experimental program, the role of surface conditions is being assessed systematically. Particular attention has been paid to the role played by organic litter particles, which cause varying degrees of water impoundment, and have the potential to affect both hydrologic response and splash detachment of sediment particles. Experiments have also focussed on the distinctive hydrologic and erosional behaviour of plots containing shrubs. In particular, the goal has been to separate those effects arising in the plant canopy, such as the interception of raindrop kinetic energy, from those arising in the soil surrounding the shrub, such as organic matter and faunal effects.

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Publications:

Dunkerley D.L. 1997. Banded vegetation: development under uniform rainfall from a simple cellular automaton model. *Plant Ecology* 129: 103-111.

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Energetics and biomechanics of locomotion by red kangaroos (*Macropus rufus*)

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As a red kangaroo hops faster, the rate of oxygen consumption (indicating metabolic energy) remains nearly the same; almost all other animals show proportional increases with speed. This phenomenon has been attributed to exceptional elastic energy storage and recovery via long compliant leg tendons. Compliant tendons may allow muscle fibers to act primarily as economical tension generators. Kangaroo muscles may also be exceptionally efficient. To determine if kangaroos have exceptionally efficient muscles, we measured the metabolic cost of uphill hopping where muscle fibers must perform mechanical work against gravity. We found that uphill hopping was much more expensive than level hopping. The maximal rate of oxygen consumption measured (3 ml O₂ kg⁻¹ s⁻¹) exceeds all but a few vertebrate species. However, efficiency values were normal, ~30%. Biomechanical measurements indicated that the lack of increase in oxygen consumption at faster speeds cannot be explained by an increase in the effective mechanical advantage of the extensor muscles of the ankle joint. Our measurements made in the USA at Harvard University and in Australia at Fowlers Gap Research Station suggest that the preferred speeds of red kangaroos may be determined by the acceptable levels of tendon stress and not energetic cost and that near critical tendon stresses occur at the speeds reported to be their maximum.

Food selection by the Euro (*Macropus robustus erubescens*)

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During a 4 ½ month stay on Fowlers Gap, investigations on the food selection of Euros (*Macropus robustus erubescens*) in different habitats were carried out. Earlier studies showed that some male Euros moved between the flats, slopes and hills whereas others always stayed near to the females in the slopes or hills. These findings posed the question: why do male Euros behave differently and what could be the benefit of the different behaviours? Thus the aim of the present study was to get better knowledge about possible factors influencing the habitat preferences of the Euros. This involved a comparison of the structure and vegetation composition of the different habitats, and of the foraging behaviour of the animals.

During the study period observations were made on seven radio collared male Euros as well as on some male and female Euros without a collar. In general one observation lasted about 40 min and was carried out in the early morning hours or the evening. The social status (alone, with female, in a mating group) was recorded as well as all behaviour including the number of bites on different plant categories. To investigate the density and composition of the

vegetation, plants were classified into different categories and the density was calculated by the 'wandering quarter method'.

The results showed that the habitats - flats, slopes and hills - only differed in the density of the category grass+forb but not in those of Saltbush, Bluebush and Copperburr. The highest density for the category grass+forb was found in the flats, the lowest in the hills. The observations showed that Euros do select their food. Sometimes they ate plants like Lemon scented grass or dried up wood, which are both an unusual foods. Lemon scented grass has a high proportion of ethereal oil and dried up twigs are non-digestible. It seemed that the animals knew about these plants and chose them because of the secondary cell contents or structures. The eating of Lemon scented grass or dried up wooden twigs could therefore be explained by the health supporting character of these plants and the activation of body functions.

The relationship between body size and foraging behaviour was examined by the comparison of male and female Euros in the same habitat. Due to their higher metabolic rate, female Euros had a slightly higher rate of bites/min than males and they ate higher proportions of easily digestible plants like forbs, and sometimes Copperburr. The number of bites/min of male Euros in the hills was a little lower than that of the other habitats there were no significant differences between the three habitats. Also the plants selected by the animals were the same in all three habitats but the proportions differed. In habitats with a high density of grasses male Euros preferred to eat these, but as grass density declined they increased the proportion of Saltbush in their diet. The foraging behaviour of Euros follows the principle of energy maximisers. In areas with a declining grass density it seemed that they adapted their behaviour optimally to their environment. With a low density of grasses on the slopes and hills, large male Euros may have difficulty in fulfilling their high total energetic requirements. The movements of male Euros from these areas to the flats could therefore be explained by the higher grass density and energy supply present in the flats.

This study was too short to resolve the question as to which strategy (remaining in the hills or moving between the hills and flats) gives the higher fitness. Further long-term study is required to determine whether is it more efficient to forage optimally in the flats and to move only from time to time to the slopes and hills to compete for mating opportunities, or to stay near to the females and try to get every mating opportunity at the cost of optimal foraging?

The quantitative assessment of Bladder Saltbush (*Atriplex vesicaria*) in rangelands using remotely sensed imagery at Fowlers Gap Station

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Shrub steppes occupy approximately 308,000 km² of the Australian mainland. These communities are generally composed of clumped woody perennial shrubs separated by areas of bare ground. Following rain these bare areas become covered by low annuals, grasses and forbs. The shrublands are highly regarded by the pastoral industry and have been utilised for the grazing of sheep and cattle since the 1850's. Coincident with the initiation of grazing

practices, was large-scale land degradation due primarily to overgrazing. Over time the community structure of the shrublands was changed through the removal of the perennial shrubs by stock, with subsequent erosion and replacement by other species. This mismanagement resulted in a decline in the carrying capacity of the rangelands, as large tracts of once productive shrublands were replaced by unpalatable vegetation and scalded surfaces.

In order to manage the rangelands in a sustainable way it is important to maintain the cover of perennial shrubs, as it is these plants which are primarily responsible for protecting the soil from erosion. Perennial shrubs should be regarded by the land manager as maintainers of landscape stability and secondarily as a forage resource. The most crucial time for the manager is in dry periods when all the preferred forage (forbs and grasses) has been removed leaving only the shrubs to graze. Decisions must be made, based on the state of the shrubs and soil condition, as to when stock should be relocated. This three year project is being undertaken with the aim of providing the land manager with quantitative information concerning rangeland condition with particular emphasis on the perennial shrub component.

Bladder Saltbush (*Atriplex vesicaria*) was selected for this study because of its wide spread distribution and sensitivity to grazing. This species is generally preferred to other perennial shrubs as a source of forage when the more palatable grasses and forbs have been eaten and as such, should be carefully monitored to ensure its persistence during those times in which it is being grazed. Remotely sensed satellite data is particularly suited to this task as it can provide cost effective and continuous information on rangeland condition at the scales required by the pastoral industry. Problems remain however, to relate the spectral reflectance measurements recorded by satellites to quantitative surface variables such as cover and biomass.

This project will attempt to produce a methodology which will allow for the extraction of quantitative surface variables from satellite imagery. This information will be used to construct a rangeland GIS which will aid the land manager in maintaining the stability and therefore, the productivity of the land.

Nest-site spacing and selection, diet and parental care of the Wedge-tailed Eagle (*Aquila audax*) at Fowlers Gap

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We examined nest site spacing and selection, diet and parental care of the Wedge-tailed Eagle during the breeding season (June-November) of 1997. The location of 40 nests was determined using a GPS. The dispersion of these nests was analysed using the method of Hopkins (1954) and the frequency distribution of inter-nest distances was compared to a Poisson distribution. Nest sites were aggregated rather than randomly dispersed across Fowlers Gap suggesting habitat selection. Inter-nest distances between 0-5 km and 17-20 km were significantly over-represented relative to a Poisson distribution. Thus nest-sites are aggregated but each aggregation is some distance from another. A comparison of nest trees to non-nest trees showed that tree and crown heights, and crown sectional area were significantly higher and larger, respectively, in nest trees situated near major tributaries and

creek beds than non-nest trees. In flat and ridge habitats unassociated with creeklines, few differences were found between nest and non-nest trees.

Time-lapse video recording was used to observe behaviour and diet at nests during incubation and rearing of chicks. The frequency and composition of prey items brought to the nest was recorded from mid-September to early October at two nests, one with a single chick and one with two chicks. The density of lambs, young-at-foot (Yaf) macropods and rabbits was estimated for areas around the nests. Rabbits were the most common prey item, followed by bearded dragons. Only 5.7% of the prey were Yaf and none were lambs even though lamb density was twice that of Yaf. Bearded dragons seem to be staple for feeding chicks and rabbits were a prominent diet item in spite of reduced abundance from RCD. The frequency, duration and temporal variation of several parental behaviours were recorded from both nests. Parental behaviour decreased as the chicks matured, expect that arrival at the nest with food increased with demand from the growing chicks. The pair with two chicks invested less time in preening and brooding than the pair with one chick. However, the two chicks were reared in a very exposed nest and the inadequate crown cover increased the parents' investment in shading the chicks

The loss of crown cover in many trees (due to drought and perhaps fire) and the need for adequate nest over in arid regions may explain why Wedge-tailed Eagles build several nests in different years. Likewise it may explain the irregularity of nest spacing. Further research is needed on nest site selection in relation to prey availability. The novel use of video proved beneficial in gaining a more comprehensive record of behaviour across time compared to direct observation. Furthermore, diet was better characterised than analyses of prey remains at nest since some items were carried away. However, care must be taken in setting up and maintaining video equipment if inadvertent failure of the clutch to hatch is to be avoided.

Re-introduction of hand-reared Red kangaroos (*Macropus rufus*)

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Re-introduction of endangered species into the wild is an attractive conservation tool. In Australia, many wildlife welfare organisations rescue and release injured and orphaned native species. These therefore provide models for captive release programs even though many of the species, such as the Red Kangaroo, are common in the wild. Thus we investigated the feeding ecology and behaviour of re-introduced and free-ranging wild Red Kangaroos in a short 4-month study at Fowlers Gap. One prospective release candidate, a female, provided detailed information on its foraging behaviour on natural pasture.

Individuals for release were held in a large 4-ha enclosure providing a period of acclimatisation and familiarity with natural pasture before being turned loose. This is a so-called 'soft release' technique, which contrasts with 'hard release' where the captive-reared individual has no period of familiarisation. The value of soft release to future survival in the wild has not been studied in Red Kangaroos and so the study was guided by the need to gather information relevant to this question. We therefore studied foraging behaviour, group size,

mobility and vigilance of wild, re-introduced and captive individuals. We also mapped plant distribution and density using the Wandering Quarter method (Catana 1963). The quality of plants was determined as the product of greenness and height or diameter.

Free-ranging wild and re-introduced kangaroos foraged in areas of similar plant composition and quality. The re-introduced females were most often alone or with their young-at-foot whereas wild females were in a median group size of four. However, females with young-at-foot are often distant from other individuals in red kangaroo populations. Furthermore group size varied with grass density and patch size. Thus re-introduced females may not integrate into the wild population but this needs much further study. Both re-introduced and wild subjects spent the same amount of time feeding around dawn and dusk and did not differ in other aspects of their time/activity budgets except that the re-introduced individuals sniffed and were more vigilant than their wild counterparts. Differences in vigilance could be explained by smaller group sizes in the re-introduced individuals.

Hand-reared Red Kangaroos which are liberated back into the wild through a 'soft-release' program seem to adapt to their new conditions. They forage in similar quality areas and with similar efficiencies to their wild counterparts. However, long-term studies are required to determine whether survival equates to reproductive success comparable to their mother-reared peers. Observations on the female (and others) in the enclosure suggest she is an inattentive mother and here offspring would be at considerable risk outside the protection of a fence.

The Sociogenetic organisation of *Rhytidoponera* sp. 12 (Formicidae: Ponerinae)

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Rhytidoponera sp. 12 is a queenless ponerine ant species commonly found in the semi-arid zones of Australia. Within individual *R. sp. 12* colonies there existed multiple workers that were mated (Crozier et al. 1984) known as gamergates (Peeters and Crewe 1984). Based on allozyme studies of the average worker relatedness in the population, cohabiting gamergates were inferred to be either weakly related or unrelated (Crozier et al. 1984). Furthermore, limited information was available regarding the mating behaviour and colony founding strategy of *R. sp. 12* due to the remoteness of their habitats. Recently microsatellite markers were developed for *R. sp. 12* (W. T. Tay unpublished thesis) and could be used to provide essential genetic information leading to a better understanding of *R. sp. 12* sociogenetic organisation.

To further understand how coexisting gamergates were related, five *R. sp. 12* colonies with known intracolony worker relatedness (W. T. Tay unpublished data) located in the Conservation Paddock were excavated. Intracolony gamergate relatedness was estimated directly from gamergates that have been identified and confirmed by dissection (ie, gamergates have sperm-filled spermathecae). The sperm samples collected from these gamergates' spermathecae provided opportunities to estimate the mating frequencies of

both gamergates and their mating partners. Our results from mating behaviour study, gamergate and male mate relatedness analyses suggested the following life-history traits in *R. sp. 12*:

Workers mated near the colony entrance or within the colony.

Newly mated workers were accepted back into their parental colonies.

The male mating-partners originated from neighbouring colonies and were probably attracted to receptive workers through the workers releasing male-attracting pheromones.

Establishment of new colonies (established with the help from a group of unmated workers) probably involved individual gamergates and/or groups of related or full sister gamergates.

Gamergates and males generally mated only once although low frequencies of multiple mating were detected in both males and gamergates.

Within individual colonies cohabiting (sister) gamergates sometimes mated with the same males leading to highly related worker offspring.

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Flight behaviour and cooperation of female kangaroos with their young-at-foot: A comparison between species

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Four species of free-ranging female kangaroos with young-at-foot were observed and their alarm and flight behaviour was compared. The species were the Red Kangaroo (*Macropus rufus*), the Western Grey Kangaroo (*M. fuliginosus*), the Eastern Grey Kangaroo (*M. giganteus*) and the Euro (*M. robustus erubescens*). Since young-at-foot live under a great risk of predation and are still dependent on milk provision by their mothers, it is important for their survival to stay in close proximity to their mothers. So in dangerous situations mother and young have to cooperate in a way, that the young will not get lost. Until this study was conducted, it was unsure, if the species observed behaved in a different way concerning the mother-young cooperation during alarm and flight behaviour.

The aim of this study was, to find out:

how mother and young cooperate during alarm and flight behaviour, which kind of anti-predator behaviour is shown by the different species, and whether there are distinctions between the species.

During the observations AT approached the animals by foot and noted their responses to her as a model-predator. Different activities, which possibly give insight into the cooperation behaviour, were recorded and assessed. Relatively few observations were obtained for the Eastern Grey Kangaroos and the Euros, and so it was only possible to compare the Red Kangaroos with the Western Grey Kangaroos in detail.

Mothers of Red and Western Grey Kangaroos looked first at the observer, started flight first, determined the direction of flight and showed flight intention movements more often than their young. In the other two species these differences between mother and young-at-foot were, with one exception, not found. The reason may be partly the low numbers of observations in Eastern Grey Kangaroos and Euros. Euro mothers started like Red and Western Grey Kangaroos more often for flight than their young. In all of the four species, neither the mother nor the young hopped more often in front of the other one or followed it, respectively. Comparisons between the species only revealed a distinction in the intention movement of Western Grey and Red Kangaroos. In all other activities the mother-young cooperation was not different between the species.

While investigating the anti-predator behaviour, alert distances, flight distances, flight length, flight duration, flight speed, habitat type at the end of flight and the distances between kangaroos and observer before and after flight were recorded. The species' reaction varied in the alert distance and the choice of the habitat type at the end of their flight. Red Kangaroos and Western Grey Kangaroos were already alert at greater distances than the Eastern Grey Kangaroos. Red kangaroos chose open areas to end the flight, whereas Western Grey Kangaroos hid for the most part in high thickets at the end of their flight.

How far the differences in some behaviours between Eastern Grey Kangaroos and the other kangaroo species are related to different habitats or in species-specific behaviour, could not be clarified due to the lack of more observations on Eastern Grey Kangaroos in our study. As there were only few differences found in the behaviour of Red Kangaroos and Western Grey Kangaroos, mothers with young-at-foot of these two species probably do not have fundamentally different anti-predator strategies.