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Vigilance and Group Size in Emus

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A sufficient food intake and the avoidance of predation are two essential elements for the survival of an individual. As time is a limiting resource, animals must allocate it adequately between feeding and vigilance for predators (Bertram 1978). Group formation is one strategy that animals have developed to facilitate increased feeding time, as individuals can benefit from the vigilance of other group members by reducing their own level of vigilance without increasing their risk of predation. This process has been shown to apply to a large range of birds and mammals (see Elgar 1989 for a review).

Among the large ratites, group size and vigilance were found to be negatively correlated both in Ostriches *Struthio camelus* (Bertram 1980) and Greater Rheas *Rhea americanus* (Martella et al. 1995; Reboresda & Fernandez 1997). In contrast, the relationship between group size and vigilance behaviour in Emus *Dromaius novaehollandiae* has never been examined, despite some studies of their behaviour (e.g. Davies 1963; Davies 1976; Dawson et al 1984; Coddington & Cockburn 1995). This may in part be due to long term studies in Western Australia in which Emus have been viewed as essentially solitary or pair-living and not normally to be found in groups (Marchant & Higgins 1990). However, our observations of free-living Emus in Willandra National Park, New South Wales, suggest that they are found both solitarily and in non-permanent groups of up to 16 individuals in close proximity. Given the lowered vigilance benefit described above for many species, we set out to test the hypothesis that Emus in

larger groups can afford to spend less time vigilant for predators. We also examine whether all emus derive the same benefits from forming groups.

Methods

The study was conducted at the eastern side of Willandra National Park (33°15'S, 145°00'E) in western New South Wales. The park lies on the Lachlan River flood plain and was previously subject to pastoral activity. This semi-arid region is dominated by flat open plains consisting predominantly of grasses and herbs with scattered chenopod bushes and few trees. Other habitats within the park include woodlands that are confined to depressions on the plains and to the margins of temporary and permanent wetlands. The flat terrain and vehicular access on roads and trails made the park a suitable study site for observing Emus.

Emus were observed for three days in mid-April 1997 during their non-breeding season, while alone or in groups on the open plains. Single birds and groups ranging from 2-18 birds were observed and a balanced representation of all possible group sizes was achieved over each of the three days of the study. Whenever Emus reacted to our presence or were disturbed by other occurrences in the study area, observations ceased. Previous season's juveniles were easily identified by their lighter coloured plumage and any groups containing these birds were excluded from the study. Observations were made using either binoculars or telescopes.

Table 1 Behavioural categories recorded.

Behavioural category	Definition
Up	Bird standing up, completely stretching its neck upwards. Most vigilant posture.
Middle	Bird's head and neck not stretched but still held above the level of the body. Lesser vigilant posture.
Down	Bird looking down at vegetation with neck lower than back.
Peck	Head near ground, actively foraging.

When using binoculars up to three birds were observed simultaneously, however only two birds were observed when using telescopes. Individuals were considered as part of a group if they were within 50 m of the nearest conspecific. Individual Emus were observed over a five minute period, with the cumulative time spent in each behavioural category recorded in seconds. The number of times birds performed each activity was also recorded. Among the range of activities recorded, vigilance was divided into two categories, with 'up' being the most vigilant (Table 1).

Statistical analyses were performed using JMP v. 3.0.2. Generalised linear modelling was used to explore factors affecting the categories of vigilance (up and middle). Factors included in the model were group size, time of day (two sessions: early = 0830-1200 h, late = 1600-1800 h) and whether there were other Emus within 200 m of the study group. Three categories of vigilance were used; up, middle, and up plus middle. In all cases, response variables were normally distributed.

For each group under observation, we also calculated the difference between the most vigilant (up plus middle) and least vigilant birds, as this proved the best way to summarise the variation between group members without the problem of pseudoreplication of data. Generalised linear modelling was again employed to test the effects of group size, time of day, and the presence of other Emus within 200m on this value. It should be noted that this final analysis excludes 'groups' of one by necessity.

Results

Factors affecting vigilance

Contrary to expectation, none of the categories of vigilance were affected by group size (Up Time, $F_{1,133} =$

0.47; Up Number, $F_{1,133} = 1.06$; Middle Time, $F_{1,133} = 0.44$; Middle Number, $F_{1,133} = 1.22$; Up plus Middle Time, $F_{1,133} = 0.03$; Up plus Middle Number, $F_{1,133} = 1.61$; $P > 0.05$, $n = 133$ for all tests, Fig. 1).

The presence of other emus within 200 m of the study group had no effect on any of the categories of vigilance (Up Time, $F_{1,133} = 2.25$; Up Number, $F_{1,133} = 0.47$; Middle Time, $F_{1,133} = 0.28$; Middle Number, $F_{1,133} = 0.69$; Up plus Middle Time, $F_{1,133} = 1.49$; Up plus Middle Number, $F_{1,133} = 0.52$; $P > 0.05$, $n = 133$ in all cases).

In the absence of any other significant effects, the analysis was reduced to a 2-tailed t -test of the effect of time of day on vigilance. This showed a significant difference in total time spent vigilant in the two discrete observation sessions. The average number of seconds spent vigilant per five minutes in the early session was 140.64 ± 9.57 s.e. ($n = 81$), compared to 107.48 ± 11.95 S.E ($n = 52$) in the late session, ($t_{1,131} = 2.17$, $P = 0.03$).

Variation between individuals

We found that our new variable 'difference between individuals' was not normally distributed. To overcome this problem we log-transformed (using natural logarithms) both this variable and group size. We also removed three outliers. There was no effect of time of day or other birds within 200m on $\ln(\text{difference})$, (Time of day $F_{1,45} = 0.75$, $P > 0.05$; within 200 m $F_{1,45} = 1.35$,

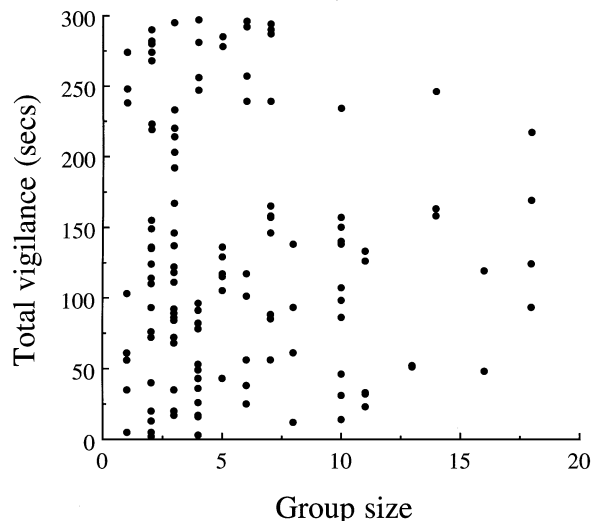


Figure 1 Total seconds spent vigilant (up plus middle categories) per 300 second observation period against group size.

$P > 0.05$, $n = 45$). The final analysis showed that $\ln(\text{difference})$ decreased as $\ln(\text{group size})$ increased ($F_{1,45} = 4.87$, $P > 0.03$, $n = 45$, Fig. 2), showing that the behaviour of individuals was more similar in larger groups.

Discussion

In contrast to the personal observations of S.J.J.F. Davies (presented by Marchant & Higgins 1990) that Emus are not very gregarious, we found distinct groups of various sizes roaming freely on the open plains of Willandra National Park. This is similar to the situation at Fowlers Gap, New South Wales, where Dawson et al. (1984) reported that Emus often occurred in groups of up to nine individuals. At Willandra the Emus were not constrained for space (e.g. they were in equal numbers both inside and outside the park), nor were they congregating at water, food or roadsides. Because there was no obvious reason for their group formation, we set out to assess the 'many eyes' hypothesis (Lima 1995) shown to apply to many species. In his review of vigilance studies, Elgar (1989) found that 52 studies of birds and mammals reported a negative correlation between vigilance and group size. Among the ratites, such a relationship has been demonstrated in both Ostriches (Bertram 1980) and Rheas (Martella et al. 1995). In contrast, the results of the present study show that over-

all vigilance was unaffected by group size in Emus, although we have uncovered the unexpected possibility that only some individuals benefit from forming groups.

The only factor found to affect overall vigilance was the time of day, with Emus in all group sizes spending more time vigilant early in the day. A possible explanation for this is that Emus prefer to feed more later in the day and thus have less time for vigilance. This appears unlikely as Dawson et al. (1984) showed that Emus devote a large proportion of their time to active feeding early in the day. In smaller birds, individuals often need to increase their rate of energy intake in preparation for nightfall (McNamara & Houston 1986) but this is also unlikely to be true for Emus because of their very large body size. Emus are predominantly herbivorous, feeding on seeds, fruits and flowers of small shrubs, and young growth and flowers of grasses, but will also feed on grasshoppers and beetles when in abundance (Davies 1978). Thus, the only food that might vary over the course of a day is insects which may have periods of increased activity. In general, our study only attempted to control for time of day as it relates to vigilance and group size. Given that Dawson et al. (1984) have shown that patterns of behaviour in Emus vary on an hourly basis, it is possible that we have missed some important aspect of the time of day-vigilance interaction.

That overall vigilance was not affected by group size in the present study may reflect one or all of three possibilities. (1) Although the groups seemed close-knit, individuals may not be actively seeking each other out. They may, for example, be congregating at the best foraging sites. There was no obvious sign that food was clumped in this fashion but we cannot rule out this possibility. (2) The benefit they seek may not be a reduction of time spent vigilant. They may for example be attracted to birds of the opposite sex (e.g. many males following a female). (3) The absence of a substantive threat of predation on Emus in the study area may have reduced the need for higher levels of vigilance for individuals or small groups. Although the site was previously inhabited by Aborigines and Dingoes *Canis lupus dingo*, these sources of predation are no longer present. The only potential predators observed during the study were Feral Cats *Felis catus* and Foxes *Vulpes vulpes*. However, because of their size, the threat they pose is probably confined to juvenile Emus. In the absence of any threat from predators, the perceived level of risk

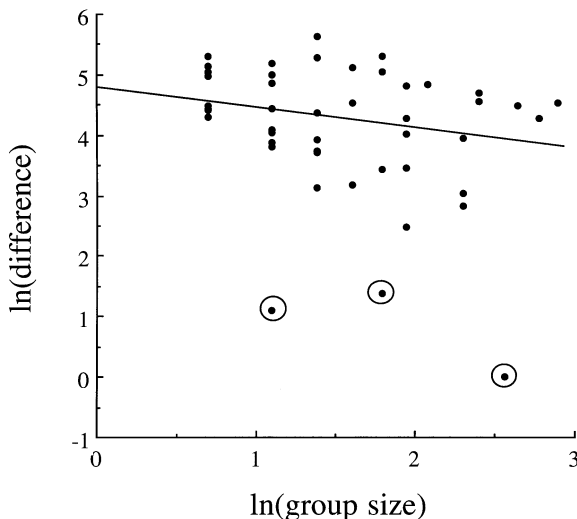


Figure 2 Natural log of the difference between the most vigilant and least vigilant Emus against the natural log of group size. Three outliers (circled) were excluded from the regression. Regression equation: $\ln(\text{difference}) = -0.4 \ln(\text{group size}) + 4.9$.

may have declined in the population with the passing of time (Roberts 1996).

Although we cannot rule out these possibilities our data support a fourth explanation for the lack of any overall reduction of vigilance with group size; that only some individuals obtain benefits from grouping. Studies done on a variety of birds have shown that factors such as sex and age have a bearing on individual vigilance (Bertram 1980; Beveridge & Deag 1987; Heinsohn 1987; Sullivan 1988). Our results include the intriguing finding that individuals differed greatly in their levels of vigilance in small groups, but that vigilance was more evenly shared in large groups (Fig. 2). One possibility is that only those individuals in small groups which spend large proportions of their time vigilant benefit by joining larger groups. It is very likely that these different behaviour types represent different age or sex classes of Emus, but unfortunately we did not have this information available. For example, young inexperienced Emus may benefit more from grouping with older individuals. In contrast, if adults have to compensate for the lack of vigilance of juveniles (e.g. Heinsohn 1987) then these individuals may benefit most. Alternatively, male Ostriches have been shown to allocate more time to vigilance than females (Bertram 1980), with a similar effect possible in Emus. We suggest that further investigation to determine the age and sex composition of groups, and which individuals benefit from grouping, would be very rewarding.

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