Scanning and Tail-flicking in the Australian Dusky Moorhen (*Gallinula tenebrosa*)

DAVID A. RYAN, KYLIE M. BAWDEN, KATHRYN T. BERMINGHAM, AND
MARK A. ELGAR
Department of Zoology, University of Melbourne, Parkville, Victoria 3052, Australia

The Dusky Moorhen (*Gallinula tenebrosa*), which is common in swamps and waterways, feeds on seeds and the tips of grasses and shrubs (Marchant and Higgins 1993). During the breeding season, adult male and female Dusky Moorhens are colorful, with bright orange frontal shields. The color of the shield of females and younger males fades to black or greenish brown in autumn and winter (Eskell and Garnett 1979). Juveniles have a black shield and beak with a greenish-yellow tip and olive-green legs. Both adult and juvenile Dusky Moorhens possess white undertail coverts. Like many other members of the Rallidae, Dusky Moorhens foraging on the ground flick their tails vertically, revealing their conspicuous undertail coverts (e.g. Garnett 1978, 1980, Woodland et al. 1980; but see Ridpath 1972). The function of this behavior is poorly understood (see Craig 1982, Alvarez 1993).

There are several possible explanations why Dusky Moorhens tail-flick, none of which are mutually exclusive. First, tail-flicking may signal to conspecifics that a predator is present, or it may signal a degree of alertness to a potential predator, thereby discouraging pursuit (see Woodland et al. 1980, Craig 1982, Caro 1986). These ideas can only be tested by examining the behavior of birds in the presence and absence of predators. Second, tail-flicking may be a conspecific signal of an individual's state of vigilance or perception of danger (see Caro 1986). This idea predicts that birds that are more vigilant should also tail-flick more frequently. Finally, tail-flicking may signal the social status of the individual (Craig 1982), in which case tail-flicking rates should covary with the social status of the individual.

We investigated whether tail-flicking in Dusky Moorhen represents a conspecific signal indicating an individual's perception of danger and/or its social status. We assume that scanning behavior is associated with predator detection (see Lima 1990) and that individuals adjust their scanning rates according to their perceived risk of predation (Lima and Dill 1990). Numerous studies show that scanning rates change with group size and the location of individuals within the group (see Elgar 1989), which may reflect differences in the risk of predation (see Lima 1995). Thus, scanning and tail-flicking rates should vary similarly for individuals in both different-sized groups and different locations within a group. Additionally, if tail-flicking signals social status, then individuals of different status should differ in tail-flicking rates.

Methods.—Dusky Moorhens were observed between 1300 and 1700 EST during March 1994 at the Prince's Lawn in the Royal Botanical Gardens, Melbourne, Victoria (37°50'S, 145°E). The lawn is an open, grassy area of about 3 ha, flanked by bushes on three sides and inclining to an ornamental lake towards the eastern edge. At least 25 Dusky Moorhens frequented the general vicinity of the lawn at any time. Pacific Black Ducks (*Anas superciliosa*) also were seen occasionally on the lawn, foraging among groups of Dusky Moorhens.

The behavior of Dusky Moorhens foraging on the grass was recorded from a garden bench that afforded a view of most of the study site. The presence of observers on the bench apparently did not influence the behavior of the birds. Individual Dusky Moorhens were selected arbitrarily from throughout the study area. We noted the color of the frontal shield of the focal bird and categorized the bird as either alone or in a group. A group was defined as four or more birds within 2 m of each other. Solitary birds were greater than 2 m from any conspecific. We also noted whether individuals were at the edge or center of the group. A bird was defined as being at the edge of a group if there were no other birds within 180° of the perimeter of the group. We did not collect data for birds in pairs or trios because it was not possible to discern whether individuals were at the center or edge of the group. It is probable that some birds were observed more than once; while this is unlikely to introduce any systematic bias into the analysis, it may reduce the statistical power.

The numbers of tail-flicks and proportion of time spent scanning were recorded over a 2-min period, after which another bird was selected. A tail-flick was defined as a single rapid movement of the tail in an upward direction. Birds were recorded as scanning when they lifted up their heads and turned them on a horizontal plane. Observation periods were terminated early if the composition of the group changed, a disturbance caused the birds to run or fly, or the birds were fed by visitors to the gardens; data from terminated observations were discarded.

Data were analyzed using procedures in the package SYSTAT 5.2 for the Apple Macintosh computer (Wilkinson 1992). Tail-flick rates were $\log(x + 1)$ transformed in order to approximate a normal distribution.

Results and discussion.—A two-way ANOVA, with

TABLE 1. Scanning and tail-flicking rates (per min; $\bar{x} \pm$ SE) of Dusky Moorhens with and without developed frontal shields foraging alone, in groups, and at center or edge of groups.

	n	Flicks		Scans	
A. Frontal shield and group size[a]					
Frontal shield present (adults)					
Solitary	17	23.8	7.1	0.39	0.04
Group	27	6.3	2.4	0.19	0.02
Frontal shield absent (juveniles)					
Solitary	17	43.8	9.4	0.33	0.05
Group	30	9.1	2.2	0.20	0.02
B. Frontal shield and position in group[b]					
Frontal shield present (adults)					
Center	7	2.14	2.14	0.14	0.03
Edge	20	7.75	3.08	0.20	0.02
Frontal shield absent (juveniles)					
Center	9	5.00	1.55	0.16	0.03
Edge	21	10.81	2.97	0.22	0.03

[a] Tail-flicking rates (log transformed): frontal shield, $F_{1,87} = 4.63$, $P = 0.03$; group size, $F_{1,87} = 18.77$, $P < 0.001$; interaction, $F_{1,87} = 0.01$, ns. Scan rates: frontal shield, $F_{1,87} = 0.28$, ns; group size, $F_{1,87} = 26.72$, $P < 0.001$; interaction, $F_{1,87} = 1.11$, ns.

[b] Tail-flicking rates (log transformed): frontal shield, $F_{1,53} = 4.24$, $P < 0.05$; position, $F_{1,53} = 2.13$, ns; interaction, $F_{1,53} = 0.21$, ns. Scan rates: frontal shield, $F_{1,53} = 0.37$, ns; position, $F_{1,53} = 3.11$, $P < 0.08$; interaction, $F_{1,53} = 0.01$, ns.

Fig. 1. Correlation between rate of tail-flicking by Dusky Moorhens in groups of four or more and proportion of time spent vigilant ($r = 0.417$, $P = 0.001$, $n = 57$). Correlation remains significant after removing observation (upper right) of bird that scanned for a long time and tail-flicked very rapidly.

presence of a developed frontal shield as one factor and grouping (solitary or group of four or more) as the other, revealed that solitary individuals spent more time scanning and tail-flicked at higher rates than individuals in groups of four or more (Table 1A). The relationship between scanning rates and grouping is consistent with those of numerous other studies of birds and mammals (Elgar 1989, but see Catterall et al. 1992). Alvarez (1993) also reported a negative correlation between group size and tail-flicking in the European Moorhen (*G. chloropus*). A similar two-way ANOVA, with presence of a developed frontal shield as one factor and position within the group (center or edge) as the other, revealed little evidence of a group location effect on either scanning or tail-flicking rates; there was qualitatively more time spent scanning and higher tail-flicking rates for Dusky Moorhens at the edge of a group, but this pattern was not statistically significant (Table 1B).

In both of the above analyses, the variation in tail-flicking rates was significantly explained by the presence of a developed frontal shield. Dusky Moorhens without shields tail-flicked almost twice as frequently as those with shields, but these differences in tail-flicking rates were not reflected by similar differences in scanning rates (Table 1).

The correlations between tail-flicking and scanning also were influenced by whether the birds were alone or in a group. There was no significant correlation between the time spent scanning and the tail-flicking
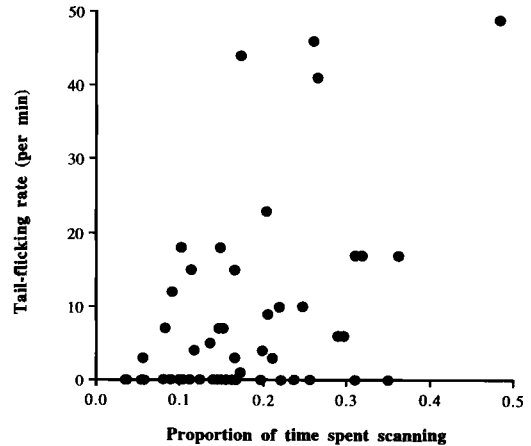
rate for individuals foraging alone ($r = -0.05$, ns, $n = 34$). This result contrasts with the significant positive correlation reported for the solitarily foraging Purple Gallinule (*Porphyrio porphyrio*; Alvarez 1993). However, tail-flicking and scanning were significantly correlated for individuals foraging in groups of four or more (Fig. 1). This correlation was not confounded by group size, because neither tail-flicking nor scanning were significantly correlated with group size for groups of four or more ($r = -0.116$ and -0.022, respectively). Alvarez (1993) also reported a positive, significant correlation between vigilance and tail-flicking among European Moorhens foraging in groups, but the possible confounding effect of group size was not controlled.

The results of our study are difficult to interpret within the context of a single function of tail-flicking. The similar patterns of variation in the time spent scanning and tail-flicking rate support the idea that tail-flicking in Dusky Moorhens provides a signal about an individual's state of alertness or perception of danger. Perhaps Dusky Moorhens spend more time scanning when alone than when in groups because they perceive a higher risk of predation (see also Alvarez 1993), and they must tail-flick more frequently because the intended recipient, by definition, is not nearby. The positive correlation between scanning and tail-flicking rates for individuals in groups of four or more may reflect natural variations in the perceived risk of predation, with the birds adjusting their behavior accordingly. In contrast, solitary birds may invest so much time tail-flicking and scanning that it is not possible for them to vary it consistently with any additional changes in the perceived risk of pre-

dation. Finally, although individuals at the edge of the group spent qualitatively more time scanning and tail-flicking than those at the center, these differences were not significant. While there may have been insufficient power in this statistical analysis, it is also possible that the birds at the edge of a group did not perceive any additional risk of predation.

The difference in tail-flicking rates of Dusky Moorhens with and without frontal shields suggests that tail-flicking may also represent a signal to conspecifics about social status (see Craig 1982). Dusky Moorhens without developed frontal shields may be of lower social status and indicate this by tail-flicking at higher rates. Additionally, scanning in Dusky Moorhens may allow individuals to monitor other members of the group, as well as any external dangers. Thus, individuals in groups that have higher tail-flicking rates also spend more time observing the behavior of others in the group.

Combined, these data suggest that tail-flicking in Dusky Moorhens represents both an interspecific signal of alertness and an intraspecific signal of social status. In the former case, tail-flicking may be a more reliable signal than scanning because the conspicuous undertail coverts, which are flashed during the tail-flick, may be more visible over relatively long distances. Resolving the function of tail-flicking clearly requires comparisons of both scanning and tail-flicking rates of individually identified birds of known social status.

LITERATURE CITED

ALVAREZ, F. 1993. Alertness signalling in two rail species. Anim. Behav. 46:1229-1231.

CARO, T. M. 1986. The functions of stotting in Thom-son's gazelles: Some tests of the predictions. Anim. Behav. 34:663-684.

CATTERALL, C. P., M. A. ELGAR, AND J. KIKKAWA. 1992. Vigilance does not covary with group size in an island population of Silvereyes *Zosterops lateralis*. Behav. Ecol. 3:207-210.

CRAIG, J. L. 1982. On the evidence of a pursuit deterrent function of alarm signals of swamp hens. Am. Nat. 119:753-755.

ELGAR, M. A. 1989. Predator vigilance and group size in mammals and birds: A critical review of the empirical evidence. Biol. Rev. 64:13-33.

ESKELL, R., AND S. T. GARNETT. 1979. Notes on the colours of the legs, wings and flanks of the Dusky Moorhen *Gallinula tenebrosa*. Emu 79:143-146.

GARNETT, S. T. 1978. Behaviour patterns of the Dusky Moorhen *Gallinula tenebrosa*. Aust. Wild. Res. 5:363-384.

GARNETT, S. T. 1980. The social organisation of the Dusky Moorhen. Aust. Wild. Res. 7:103-112.

LIMA, S. L. 1990. The influence of models on the interpretation of vigilance. Pages 246-267 *in* Interpretation and explanation in the study of animal behavior. Vol. 2, Explanation, evolution and adaptation (M. Berkoff and D. Jamieson, Eds.). Westview Press, Boulder, Colorado.

LIMA, S. L. 1995. Back to the basics of anti-predatory vigilance: The group size effect. Anim. Behav. 49: 11-20.

LIMA, S. L., AND L. M. DILL. 1990. Behavioral decisions made under the risk of predation: A review and prospectus. Can. J. Zool. 68:619-640.

MARCHANT, S., AND P. J. HIGGINS (Eds.). 1993. Handbook of Australian, New Zealand and Antarctic birds. Vol. 2, Raptors to lapwings. Oxford Univ. Press, Melbourne.

RIDPATH, M. G. 1972. The Tasmanian Native Hen *Tribonyx martierii*: I. Patterns of behaviour. CSIRO Wildl. Res. 17:1-51.

WILKINSON, L. 1992. SYSTAT: Statistics, version 5.2 edition. SYSTAT Inc., Evanston, Illinois.

WOODLAND, D. J., Z. JAAFAR, AND M. KNIGHT. 1980. The pursuit deterrent function of alarm signals. Am. Nat. 115:748-753.