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SHORT COMMUNICATION

The effects of flock size and human presence on vigilance and feeding behavior in the Eurasian Coot (*Fulica atra* L.) during breeding season

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Abstract Group size influences individual vigilance in different bird species. Most studies have shown that animals spend more time for feeding and less time on vigilance when in groups. Apart from group size, additional factors, such as group density, age, sex, and season, are considered to influence vigilance behaviors. The aim of the present study was to investigate the effects of flock size and human presence on vigilance and feeding in the Eurasian Coot (*Fulica atra*) during the breeding season. This work was performed in Yorukkirka Lake (Eskisehir, Turkey) from March to August 2005. No correlation was found between flock size and vigilance rates during either human absence or presence. On the other hand, when comparing behavioral differences between human presence and absence, humans appeared to have an important negative effect on vigilance rates, vigilance duration, and feeding behavior, regardless of flock size.

Keywords Eurasian Coot · Feeding behavior · *Fulica atra* · Human effects · Vigilance

Introduction

To scan their environments, birds frequently interrupt feeding and lift their heads (Bednekoff and Lima 2002; Beauchamp 2003; Randler 2005). This behavior is called vigilance. It has been suggested that vigilance and feeding are mutually exclusive and produce trade-off (Lima and Bednekoff 1999; Robinette and James 2001; Randler 2005). However Fernández-Juricic et al. (2008) found that foraging and scanning are not mutually exclusive activities in some species.

Numerous studies have documented an inverse correlation between vigilance and flock size. In larger groups, individuals tend to allocate more time to feeding and less time to vigilance (Lima and Dill 1990; Treves 2000; Randler 2003; Dias 2006; Avilés and Bednekoff 2007; Boukhriss et al. 2007). This inverse correlation is known as the "group size effect" (Robinette and James 2001).

There are three hypotheses explaining the group size effect. The "many eyes" hypothesis suggests that with increasing number of flock members, more eyes are able to detect predators, and thus, individuals can reduce their own vigilance (Pulliam 1973; Randler 2005; Boukhriss et al. 2007). According to the "dilution effect" hypothesis, as group size increases, individuals reduce their vigilance because the individual risk of predation declines (Hamilton 1971). The "scramble competition" hypothesis states that, to compete for a limited amount of scarce resources, individual vigilance decreases in larger groups (Beauchamp 2001, 2003; Boukhriss et al. 2007; Rieucau and Giraldeau 2009).

On the other hand, additional factors may also influence vigilance. These factors include nearest neighbor distance or group density (Pöysä 1994; Proctor et al. 2003; Fernández-Juricic et al. 2007a), age (Boukhriss et al. 2007), sex (Reboreda and Fernandez 1997), ambient temperature (Elgar 1989; Boysen et al. 2001), distance to a refuge (Lima 1987; Elgar 1989; Lazarus and Symonds 1992), visual obstruction (Lima and Zollner 1996), flock geometry (Bekoff 1995; Treves 2000; Dias 2006), the position of an individual within a flock (Treves 2000; Lazarus 2003; Beauchamp 2005; Randler 2005; Dias 2006), human presence (Manor and Saltz 2003), time of day (Elgar 1989; Randler 2005), and season (Tebbich et al. 2004; Pechacek 2006).

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Birds have higher nutritional needs during the breeding season (Ward 1996) due to the metabolic demands of egg production and incubation and subsequent chick rearing. They may increase their feeding and reduce their vigilance to meet these energy demands, as the number of competitors increase (Lima and Dill 1990; Dukas and Kamil 2000; Post and Götmark 2006). While feeding activity increases, it may be easier for predators to detect birds, leading to a higher risk of predation during breeding time.

Although numerous studies show a decrease in individual vigilance when group size increases, no detailed information is available for Eurasian Coot (*Fulica atra* L.) vigilance and response to human disturbance during the breeding season. Randler (2006a) investigated feeding behavior of Eurasian Coots in environments that have different predation risks. However, it was thought that differences in food type (food from water or land) could affect behavior independent of predators.

The Eurasian Coot has a wide distributional range. This monomorphic species is largely gregarious, congregating in flocks (del Hoyo et al. 1996). Although its diet consists primarily of vegetable matter, the Eurasian Coot is omnivorous. Feeding methods include diving for submerged plants and animals, such as algae, aquatic fungi, mollusks, and fish eggs, or surface feeding (del Hoyo et al. 1996; Perrow et al. 1997; Snow and Perrins 1998; Taylor and van Perlo 1998; Randler 2005). The breeding season for this species begins in mid-March. Both sexes incubate eggs for 21–24 days and produce second and sometimes third broods after successfully fledging young.

The objectives of this study were twofold: (1) to evaluate the effect of flock size on vigilance and feeding behavior in the water during the breeding season and (2) to test the effect of human presence on feeding and scanning behavior. Human can be potential predator for bird species (Frid and Dill 2002). Plenty of studies showed that human can negatively affect other activities, such as feeding, preening, or nesting (Randler 2006b). Because of human disturbance, birds tend to allocate more time to vigilance and less time to feeding (Hill et al. 1997; Blumstein et al. 2005). The effects of human on birds during the breeding season are particularly important because they could negatively affect breeding success (Fernández-Juricic et al. 2007b). Eurasian Coots are also exposed to illegal hunting in the study area. For these reasons, humans were defined as predators.

Materials and methods

Study area

The study was conducted in Yorukkirka Lake (39°35 N 30° 25 E), which is situated 29 km southwest of Eskişehir, Turkey. The highest point in the study site is 876 m above mean sea level, mean monthly temperatures range from 21.6°C in July to −1.1°C in December, and the mean annual precipitation is 373.8 mm. The lake has an area of 2 km^2 and is surrounded by small freshwater marshes. Only one small stream flows all year. Steppe and forest are the two main habitat types. Vegetation includes *Thymus* sp., *Astragalus* sp., *Verbascum stachydifolium*, *Lathyrus laxiflorus*, *Adonis aestivalis* subsp. *aestivalis*, *Acanthus hirsutus*, *Teucrium polium*, *Salvia* sp. *Allium* sp., *Convolvulus* sp., *Stipa* sp., *Pinus nigra* subsp. *pallasiana*, *Salix alba*, and *Populus alba* (Hüner 2003). The area's main economic activities are agriculture and grazing. Illegal hunting and fishing also occur in the study area.

Data collection

The study was performed from March to August 2005 during the breeding season of the Eurasian Coot. Two days per week were spent collecting data. To avoid time-of-day effects, all observations took place in the morning between 0900 and 1100 hours.

Bird activities were documented using a video recorder (Sony digital 8 video camera×25 zoom) in combination with a telescope (×20–45). All data were transferred to a computer and were analyzed from video recordings by the same person. If group size changed during the observation period, individual's 1-min record was omitted, and a new period was started (Dias 2006).

A total of 142 flocks were sampled. Behavior of focal Eurasian Coots was recorded for 1 min (Randler 2005). For each individual, the following activities were scored: vigilance rate (number of bouts in the minute), vigilance duration, feeding rate on the water surface, diving rate, diving duration, flock size, and the presence or absence of humans. Eurasian Coots were considered vigilant when the head and bill were raised above a horizontal bodyline (Randler 2006a; Dias 2006). Feeding was counted when the head of an individual was below horizontal. Vigilance bout lengths in Eurasian Coots are usually short (Randler 2006a). Duration of vigilance was calculated as the time spent vigilant during the 1 min. Diving was counted every time the whole body was underwater. The mean total time diving per minute was considered diving duration. Flock size was designated according to Randler's method (2004). Briefly, the number of Eurasian Coots within a radius of 30 m was accepted as flock size. Human activities within a 100-m buffer around the lake were noted as a human presence (Ikuta and Blumstein 2003). Fishing and trekking were recorded as human activities. Data were gathered when the number of people around the lake ranged from 1 to 2. Coots, which had maximum amount of visual range to see all humans in the zone, were sampled.

Videotaping was made in a hide and a distance where there was no obvious influence on the birds' behavior. As Eurasian Coots were not marked, there was the possibility of pseudo-replication. However, this appears unlikely because there were several hundreds of birds in the study area. In addition, individuals were followed on the video records.

To evaluate the effects of flock size and human disturbance, other factors that might influence feeding behavior were excluded. It is known that birds located at the edge of the flock are likely to be more vigilant than central ones (Beauchamp 2005; Boukhriss et al. 2007). Therefore, birds sampled from the center of the flock included more than two individuals (Dias 2006).

According to Randler (2006a), more space feeding in the water was needed than feeding on land by coots. The nearest neighbor distance of the Eurasian Coot individuals was measured about 1.3 m in the water (Randler 2006a). Individuals were recorded when the nearest neighbor distance was <3 m. The nearest neighbor distance was estimated using the size of the Eurasian Coot (Randler 2004). To account for distance to a refuge, individuals were chosen that were more than ~50 m away from the waterline. Because there is no dimorphism in this species, age and sex effects were not evaluated. Feeding interruptions that were caused by other predators and inter-/intraspecific aggression were discarded (Randler 2006a)

Data analysis

All statistical tests were analyzed using Statistica 7.0 for Windows (StatSoft Inc. 2006). Since data did not satisfy the assumptions of normality, non-parametric tests were used. To compare behavioral differences between human presence and absence, the Mann–Whitney *U* test was performed. For the analysis of group size differences between human presence and absence, Wilcoxon matched pairs test was performed. The Spearman correlation test was used to measure the effects of flock size on vigilance and feeding behavior (Dias 2006; Pechacek 2006) and the correlation between vigilance and feeding rates. Differences were considered significant at <0.05. Data were presented as means±standard deviation (SD).

Results

The behavior of individuals was recorded from 142 different flocks. Flock size varied from 1 to 25 (mean, 8.23±6.09). The mean values for vigilance rate (vigilances/minute), vigilance duration (seconds), feeding rate (feedings/minute), diving rate (dives/minute), and diving duration (seconds) were presented in Table 1.

There was a significant difference in the vigilance rate, vigilance duration, and feeding rate between human absence and presence. However, there was no significant difference between human absence and presence for either diving duration or diving rate (Table 1). Furthermore, there was no differences in group size between human absence and presence, significantly (Z=0.8, p=0.3).

There was no correlation observed between flock size and behavior for either human absence or presence. Spearman correlation test results are shown in Table 2. No significant correlation was found between vigilance and feeding rates (in human absence, r_S=−0.12, p=0.266; in human presence, r_S=0.18, p=0.143).

Discussion

Many studies have suggested that there is a negative relationship between flock size and vigilance (Beauchamp 1998; Treves 2000; Bednekoff and Lima 2005; Dias 2006; Sansom et al. 2008). On the other hand, a number of studies have not observed this group-size effect on scanning behavior (Pöysä 1994; Krams 1998; Slotow and Coumi 2000; Warkentin and Morton 2000; Treves 2003). According to Elgar (1989), inadequate control of possibly confounding variables in field studies results in the failure to detect an inverse correlation. However, it was emphasized that in many carefully controlled studies, group size effect was not observed (Beauchamp 1998; Robinette and James 2001; Dominguez 2002).

Table 1 Mean values of Eurasian Coot vigilance and feeding behaviors and comparison of behaviors with human absence and presence

Results of comparison from Mann–Whitney *U* test

*p<0.05

Behavior	*U*	*Z*	*p* value	Human absence		Human presence	
				N	Mean±SD	*N*	Mean±SD
Vigilance rate (per minute)	1,563	−3.8	0.001*	79	4±1.6	63	5.2±1.6
Vigilance duration (s)	875	−6.6	0.001*	79	14±9.7	63	26.4±10
Feeding rate (per minute)	1,828	2.7	0.006*	79	7.3±5.1	63	4.9±2.6
Diving rate (per minute)	2,338	−0.6	0.536	79	1.4±1	63	1.87±1.8
Diving duration (s)	2,277	0.8	0.385	79	4.9±4.6	63	3.9±3.1

Table 2 Spearman correlation test investigating the correlation between behavior and flock size with human absence or presence

Behavior	Flock size					
	Human absent			Human present		
	N	r_S	*p* value	*N*	r_S	*p* value
Vigilance rate	79	0.008	0.942	63	0.13	0.289
Vigilance duration (s)	79	0.07	0.489	63	−0.09	0.454
Feeding rate	79	−0.09	0.393	63	−0.15	0.217
Diving rate	79	0.02	0.853	63	0.12	0.345
Diving duration (s)	79	0.12	0.260	63	0.02	0.832

Results of this study showed that there was no correlation between vigilance and flock size. In addition, no increase in feeding and diving behavior was observed with increasing group size.

A possible explanation for the lack of flock size effect on vigilance and feeding behavior could be that birds spend more time foraging during the breeding season. This is due to the energetic demands of egg production, egg incubation, and chick rearing (Post and Götmark 2006). To meet nutritional needs, birds may reduce vigilance and increase feeding regardless of flock size.

The second explanation for the lack of flock size effect can be unlimited food supply. According to the "scramble competition" hypothesis, increased competition in large groups may result in decreasing individual vigilance in limited food supply (Beauchamp 2003; Fernández-Juricic et al. 2004; Sansom et al. 2008). However, it has been suggested that group size effect hypothesis fails to consider conditions of unlimited food supply (Lima et al. 1999; Beauchamp 2007). Food density was not measured in the study area. However, the study was carried out from March to August. Many of the plants and animals included in the diet of Eurasian Coots appear during this period. It is thought that these conditions supply a greater quantity of food. Because of decreased scramble competition, the flock size effect on congregating feeding and vigilance behavior should not be expected. Besides, contrary to other studies where flocks included up to hundreds of individuals (Barbosa 2002; Boukhriss et al. 2007), flock size varied from 1 to 25 in the study area. Individuals in smaller group may not need to compete for resources. Especially in breeding season, small flock size may be optimal to meet energy demand, not only in human absence but also human presence. Thus, the explanation of the similar flock size in human absences and presences could be that to get nutritional needs may be more important than predation risk especially in breeding season.

Dilution and many eyes are also useful hypotheses to explain group size effect on vigilance. According to these hypotheses, per-individual vigilance decreases with increasing number of flock members because of availability of predator with more eyes (Pulliam 1973; Randler 2005; Boukhriss et al. 2007) and dilution of predation risk (Hamilton 1971). On the other hand, the number of individuals of larger group may also be an important factor. The lack of group size effect on feeding behavior can be associated with small flock size. In the study area, the number of individuals in larger groups may be not sufficient to detect easier the predator or to dilute predation risk.

An alternative explanation could be that foraging strategy affects the relationship between group size and feeding behavior. Some bird species, such as Lapwing (*Vanellus vanellus*), can gather information about its predators when searching for prey. Thus, flock size effect cannot be observed in bird species with this strategy (Barbosa 2002). Although the detection of predators when head is down may not be as effective as when head is up (Lima and Bednekoff 1999), some species with large visual field can scan for predators while their heads are down. There is no correlation between vigilance and flock size for these species (Guillemain et al. 2001; Fernández-Juricic et al. 2008). It is unclear how visual information is obtained in Eurasian Coots. However, foraging strategy may make it easier for them to detect predators, especially terrestrial predators as human.

Results of this study demonstrate that there is no significant correlation between feeding and vigilance rate. This may have provided support for explanation of feeding strategy or large visual field. Due to detection of predator while foraging, vigilance and feeding behavior may not be mutually exclusive.

Human effects on feeding and vigilance behavior were clearly detected in this study. Eurasian Coots showed higher vigilance and lower feeding levels in the presence of humans than absence. Observational and experimental studies have shown that most wild animals increase their vigilance in the presence of a predator (Pöysä 1987; Randler 2006a). Although animals can habituate to humans if there is no persecution (Knight et al. 1987), human disturbance can negatively affect animal behavior in different ways (Valcarcel and Fernández-Juricic 2009). It is known that birds usually increase the time devoted to

vigilance and diminish feeding rates, upon encountering human (Hill et al. 1997; Fernández-Juricic and Tellería 2000; Fernández-Juricic et al. 2004; Blumstein et al. 2005).

Statistical analysis showed that human presence did not have a notable effect on diving rate and diving duration. According to van den Hout (2006), water is a dangerous environment for Eurasian Coot because of the aquatic predators. However, there is no aquatic predator in the study area. Therefore, diving can be also a method to escape from the human for Eurasian Coots.

From the obtained results, it could be concluded that Eurasian Coots were affected by human presence as a predator. To detect predators' effect on the Eurasian Coots population, detailed studies should be performed with the other aerial and terrestrial predators and/or outside of the breeding season. Our results suggest that the proportion of time spent for feeding is necessary in this population during the breeding season and is not influenced by group size. Nevertheless, future field studies should be focused to conduct outside of the breeding season under conditions of limited food resources and in larger groups to ensure a lack of group size effects on feeding in breeding season. Furthermore, experimental studies should be conducted to demonstrate the detection of predators when heads are down and foraging strategy effects on the feeding behavior of Eurasian Coots.

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