ISRAEL JOURNAL OF ZOOLOGY, Vol. 43, 1997, pp. 79–85

PHYSICAL DISTANCES AMONG INDIVIDUALS IN FLOCKS OF GREATER FLAMINGOES (*PHOENICOPTERUS RUBER*) ARE AFFECTED BY HUMAN DISTURBANCE

REUVEN YOSEF
International Birding Center, P. O. Box 774, Elat 88106, Israel

ABSTRACT

Use of flock members to reduce individual levels of vigilance has been the focus of many studies that have attempted to explain the relationship among vigilance, group size, and distance covered by using foraging or preening as indicators. To avoid the confounding variables associated with foraging and preening, the effects of increasing levels of disturbance on vigilance by measuring distances among individuals (D) in flocks of greater flamingoes was studied. During 61 h, reactions to 112 disturbances were recorded. Undisturbed flamingoes exhibited no relationship between D and flock size. When joggers appeared, birds became alert but continued to feed. D was uninfluenced by flock size when jeeps drove past, but was different in value from that in undisturbed flocks. However, when tours stopped and occupants got out of their vehicles, D was significantly reduced and flock size was positively correlated with flock cohesiveness, i.e., smaller flocks had smaller D values than larger flocks. Flamingoes were terrified of all-terrain vehicles, and in 82% of these encounters, they flew away. In these cases, flock cohesiveness was extremely dense, but flock size did not influence flock reaction. This study shows that flocking species seek protection in numbers, and they leave the area when insufficient conspecifics are present when serious disturbance occurs.

INTRODUCTION

Ever since Pulliam (1973) suggested the "many-eyes" hypothesis, the use of flock members to reduce individual levels of vigilance has been studied by many researchers (e.g., Lazarus and Symonds, 1992; Scheel, 1993; Cresswell, 1994). Most studies focused on group size (Elgar, 1989), flock geometry (Bekoff, 1995), distance to cover (Barnard, 1980; Caraco et al., 1980; Diaz and Asensio, 1991), foraging (Poysa, 1994), and preening (Redpath, 1988; Roberts, 1995) as indicators of vigilance levels.

To date, few of these studies have produced convincing evidence that individuals in groups alter their scanning rates as a direct result of changes in group size, and in most cases confounding variables have not been taken into account (Elgar, 1989). Conspicu-

Accepted October 1996.

ous amongst these variables are those associated with foraging, such as the density of the food resources (Elgar, 1989; Roberts, 1996). Since larger flocks might find better food sources, and animals feeding on better food sources may spend less time indulging in other behavior, such as vigilance, foraging studies may lead to wrong conclusions., Similarly, despite being considered by Redpath (1988) and Roberts (1995) as a more reliable method for evaluating vigilance, preening may also yield mistaken conclusions especially in species engaging in displacement behavior (Krebs and Davies, 1987; Alcock,1989). Preening is part of the ritualized display-sequence in greater flamingoes (Cramp, 1977), and I, thus, consider it a misleading indicator of vigilance.

In this study, I demonstrate real-time decreases in the physical distance among individuals (D) in greater flamingo (*Phoenicopterus ruber*) flocks in response to increasing levels of human disturbance. This measure of flock cohesiveness is assumed to be an indicator of vigilance that is unconfounded by variables associated with foraging.

STUDY AREA AND METHODS

Field work was carried out in December 1994 and January 1995. Greater flamingoes winter regularly in the salt pans that are located to the north of Elat (29°33' N, 34°57' E), Israel. This arid area has an average precipitation of 30 mm, with ten rainy days per year (Ginat, 1993). Annual average temperature is 26 °C (range 10–39 °C). Annual relative humidity is 39%.

The source of these flocks is unknown, however, five flamingoes ringed in the 1970s were recovered in Iran (Shirihai, 1996). Safriel (1968) reported flamingoes only on passage in the Elat region, however, since 1990, flocks ranging from 15–80 birds have been observed regularly in the winter months in the shallow (40–50 mm) salt pans. They feed mainly on brine-shrimp (*Artemia salina*) by sieving, rarely up-ending or treading (Cramp, 1977). No trees or bushes are found on the banks or in the water, resulting in a completely open landscape.

Red wooden stakes were placed 5 m apart across the breadth of the salt pan (85m × 30 m) that the flamingoes frequented most during the two weeks prior to the initiation of the observations. Additional stakes were placed along two banks on the opposite site chosen as the observation point, allowing the drawing of an imaginary grid on the surface of the salt pan. This grid system was drawn on a 1:5,000 relief map of the pan supplied by the Israel Salt Factory. Flamingoes were allowed a week to get used to the stakes prior to data collection. All observations were carried out from within a vehicle and were made from a distance of 40–50 m. Distances between individuals were measured in reference to the stakes. In addition, I used ranging optimeters to verify individual distances (up to 30 m, model 120; up to 180 m, model 620; Ranging Inc.). All distances were rounded off to the nearest meter.

The location of each bird was recorded on the grid map. Once mastered, this technique allowed the mapping of up to 40 flamingoes in less than 3 min. Although I did not use marked individuals, the fact that samples were taken over 41 different days scattered throughout December and January, reduces the possibility that the conclusions

are biased by either the sampling of too few individuals or lumped disturbances. Disturbances recorded during this experiment were not initiated by the author.

Flocks were divided into three types: (1) juveniles only, (2) mixed-age groups, and (3) adults only. No differentiation was made among males, females and juveniles, despite known differences in aggressiveness (Schmitz and Baldassarree, 1992).

Disturbances were categorized as: (1) no disturbance (control group), (2) walking or jogging persons, (3) jeep tour in passing, (4) jeep tour with people getting out, and (5) all-terrain vehicles (ATVs).

The duration of the observations ranged from 1-4 h, and ended when no further human activities were expected or the birds flew away. All observations of the control periods were carried out between 0600 to 0730 when no human activity occurred in the vicinity. I considered an individual as alert by the absence of treading of the bottom, a straightened neck with the head held well above the body, and frequent cocking of the head (Schmitz and Baldassarree, 1992).

Statistical analyses were done on the Macintosh version 2 of JMP (1989, SAS Institute Inc). Data are presented as mean ± SD. I chose $p < 0.05$ as the minimum acceptable level of significance.

RESULTS

Of the total 131 flocks observed, 13 (9.9%) were comprised of juveniles only, and 118 (90.1%) flocks were mixed-age groups. No adult-only flocks were observed. Although flocks of juveniles (17.6 ± 5.9, range 9–29) were significantly smaller (Wilcoxon signed-rank test, $p < 0.05$) than mixed flocks (32.3 ± 13.1, 6-61), D in juveniles was not significantly different ($p = 0.24$) from mixed flocks (11.6 ± 10.5 vs 17.4 ± 12.4).

The flamingoes were observed for six hours during the pre-disturbance (control) time period. In 19 flocks observed, there was no significant relationship ($r^2 = 0.02$, $p = 0.52$) between the average D (26.7 m + 6.7) and average flock size (38.3 ± 15.3). However, for all flocks observed during the study, smaller flocks had significantly smaller D values ($p = 0.001$).

In addition, a total of 61 h of observation was carried out during which 112 incidents related to disturbance categories 2 to 5 occurred. Jogging or walking tourists were not a common occurrence, and only 23 such incidents were observed. Flamingoes were observed to raise their heads, move away from the bank on which the movement occurred, and continue feeding. Individual distance (30.6 m ± 9.3) was also not influenced by average flock size (36.0 ± 12.7, $p = 0.81$) and was not significantly different from that of the control flocks ($p = 0.17$).

In the "passing jeep tours" category, I included not only the regular tourist tours that show their customers wildlife while on the move, but also all military vehicles and patrols that drove on the bank but did not stop in the vicinity of the salt pan. In the 36 incidents, D (21.9 ± 5.9) was not influenced by flock size (28.5 ± 12.3, $p = 0.49$), but was statistically different from that in the undisturbed flocks ($p = 0.03$).

In the 42 incidents included in the fourth category, the tour guides stopped the jeep in

the vicinity of the flocks and one or more of the occupants got out. The explanations given to the group were usually loud, and in the case of children's groups, the noise was especially pronounced. The birds reacted by flocking together in the middle of the pan and D (5.14 ± 3.2) was reduced significantly ($p = 0.001$) in comparison to the control group. Flock size positively influenced flock cohesiveness and smaller flocks had on average significantly smaller individual distances ($p = 0.001$). In eight out of 42 cases, when the flocks were small (>15) and comprised of only juvenile flamingoes, the birds flew away.

Although ATVs are forbidden to drive off specifically marked trails, riders were observed on 11 occasions to race along the bank of the salt pans. ATVs are very noisy, fast, and raise a lot of dust. During these disturbances the birds appeared terrified and exhibited agitated behavior—necks stretched upwards with heads cocked from side to side, fast stepping, and giving short "aahonk aahonk" calls (Cramp, 1977). In nine of these instances the flocks flew away. Flock cohesiveness was extremely dense (2.27 ± 1.1), and significantly different from that in the control flocks ($p < 0.005$). During the time period that the ATVs were present, flock size did not influence flock reaction ($p = 0.52$).

DISCUSSION

I observed no aggression among individuals in a flock. This is in contrast to Bildstein et al. (1991) who found in Venezuela, that in mixed flocks, juveniles were often involved in aggression, especially as recipients from neighboring adults, and that aggressive encounters significantly affected the amount of time flamingoes spent filter-feeding. Further, Schmitz and Baldassarre (1992) suggested that under conditions of reduced food abundance, flamingoes may gain more by feeding than by elevating levels of aggression toward conspecifics. At the salt pans in Elat, brine shrimp are the major arthropod food source, and their densities are probably below the threshold level forcing individuals in mixed-age flocks to desist from aggression. This may also explain why they spread out between 20–30 m, when undisturbed, from their neighbors while feeding.

Bildstein et al. (1991) also mentioned that the food-intake rate of juveniles was about 82% that of adult flamingoes. Thus, we would expect juveniles to spread out to greater distances from their neighbors while foraging. However, this was not the case, and an alternative explanation may be that their inexperience, and the lack of adults in the flock, limited their distance from their nearest neighbors. The fact that most of the juvenile-only flocks flushed almost immediately upon being disturbed also suggests that they are far more susceptible to disturbance than mixed flocks.

The fact that D was similar in flocks exposed to joggers and strollers and in the control flocks, suggests that human presence in the vicinity did not necessarily disturb the flamingoes while foraging. The decrease in D in flocks disturbed by jeeps and ATVs, however, indicates a negative response to these disturbances.

My results are inconsistent with Cramp's (1977) claim that flamingoes are "highly

intolerant of human disturbance or close approach." It is possible that upon arrival from the breeding grounds the flocks are initially very sensitive to human presence but then get habituated over time to the continued presence of people, and eventually fail to react, as was described for great crested grebes (*Podiceps cristatus*) (Keller, 1989). This habituation process needs to be addressed in future studies.

It is of interest to note that group size did not affect D in the control flocks or when joggers/strollers or vehicles passed by without stopping. However, when vehicles stopped in the vicinity and people got out or made noise, the flamingoes reacted by clustering in the middle of the salt pan, resulting in small values of D. This is in contrast to Conder (1956) who reported that distance to the nearest neighbor did not vary with group size or density. The results of this study indicate that staging birds are susceptible to disturbances, and stresses the need to mitigate human activities.

Numerous studies (e.g., Barnard, 1980; Sullivan, 1984; Elcavage and Caraco, 1983; Diaz and Asensio, 1991) demonstrated a negative relationship between vigilance time and flock size as predicted by Pulliam's (1973) "many-eyes" theory. The fact that smaller flocks had on average smaller D, indicates the existence of a flexible mechanism whereas flock size positively influences flock cohesiveness. In addition, small flocks that were comprised of only juvenile flamingoes tended to fly away as compared to flocks that were either large or had adults present. This suggests that flamingoes may consider a certain threshold number as being the key to "safety in numbers." However, further study of the geometric relationships among flock members is needed to understand the flamingoes' cognitive processes (Bekoff, 1995).

Undisturbed flamingoes probably spread out in order to take better advantage of the low densities of brine shrimp in the salt pans (Schmitz and Baldassarre, 1992), as suggested by the optimal-foraging theory (e.g., Charnov, 1976; Pyke et al., 1977), but when disturbed by either vehicles or ATVs, they flock to the center of the salt pan. Similarly, foraging in the proximity of cover has been widely shown for many species (e.g., Brown, 1988; Brown et al., 1988; Diaz and Asensio, 1991). Hence, the association of flamingoes within the central area of the water body may confer a net advantage if they keep as much open area as possible between themselves and potential predators, at the same time allowing for early detection with enough time for escape.

This study shows that flocking species, like flamingoes, may seek protection in numbers, and if there are insufficient conspecifics, they then leave the area. I also show that physical distance among individuals in free-ranging flocking species can be used as an index of flock and individual vigilance. By measuring D one can index the relative vigilance and agitative state of each individual in the flock, and the overall flock D can also give an indication of the intensity of the disturbance.

The results imply that at present human pressures are intense and that measures to prevent disturbances during foraging periods need to be implemented. Access of tourists or other human-related activities should need to be curtailed to the salt pans during the early morning and late evening hours. However, this is also the optimum time period for the tens of thousands of tourists and birdwatchers that flock to Elat during the migration seasons to observe the birds. In addition, these are also the hours of peak activity of other

waders that also feed in the salt pans. This means that in order to find a compromise between human recreational activities and avian migratory nutritional requirements, alternative solutions need to be examined. Ways in which this problem can be overcome is by limiting access only to those salt pans where the disturbance caused is minimal; or by building hides which will prevent the birds from flushing because of human activity. These hides can also be created by planting local plant species to minimize disturbances to foraging waders and greater flamingoes and by allowing additional species to forage or nest simultaneously.

ACKNOWLEDGMENTS

I thank Mr. Ephraim Gilboa, Manager, Israel Salt Factory, Elat for allowing access to the salt pans and other logistical help. Two anonymous reviewers and the editor improved earlier drafts of this manuscript. Mr. Ernest Brett, WWF Switzerland, WWF International and Studiosus Reisen Munich facilitated this study with their support of IBCE.

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