INDIVIDUAL DISTANCES AMONG GREATER FLAMINGOS AS INDICATORS OF TOURISM PRESSURE

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Abstract.—One of the greatest challenges facing ecologists and conservationists is to ensure the continued coexistence of wildlife with the increasing pressure of human recreation. In birds, the use of flock members to reduce individual levels of vigilance has been the focus of many studies that have tried to explain the relationship among vigilance, group size, and distance to cover by using foraging or preening as indicators of disturbance. To avoid the confounding variables associated with foraging and preening, in this study I observed the effects of increasing levels of human disturbance on vigilance by measuring distances among individuals in flocks of Greater Flamingos (*Phoenicopterus ruber roseus*). Reactions to 112 disturbances were recorded during 61 hr of observation. Undisturbed flamingos exhibited no relationship between individual distance and flock size. When joggers appeared, birds became alert but continued to feed. Individual distance was not influenced by flock size when motor vehicles (jeeps) drove past, but was different in value from that in undisturbed flocks. However, when tour groups stopped and the occupants got out of vehicles, individual distance was significantly reduced and flock size positively influenced flock cohesiveness (i.e., smaller flocks had smaller individual distance values than large flocks). Flamingos appeared to be especially disturbed by all-terrain vehicles (ATVs), and in 82% of the encounters they flew away. In these cases, flock cohesiveness was extremely dense, but flock size did not influence flock reaction. This study demonstrated that flocking species seek protection in numbers, but they leave an area when insufficient conspecifics are present and when serious disturbance occurs.

LAS DISTANCIAS INDIVIDUALES ENTRE FLAMENCOS COMUNES COMO INDICADORES DE LA PRESIÓN DE TURISMO

Resumen.—Uno de los mayores desafíos que enfrentan los ecólogos y conservacionistas es asegurar la coexistencia continuada de la fauna silvestre ante la creciente presión de las actividades humanas de recreación. En aves, el uso de integrantes del grupo para reducir niveles individuales de vigilancia ha sido el tema de varios estudios que tratan de explicar la relación entre vigilancia, tamaño de grupo, y distancia a cobertura mediante el uso de comportamiento de forrajeo y acicalamiento como indicadores de las perturbaciones. Para evitar las variables perturbadoras asociadas al comportamiento de forrajeo y acicalamiento, en este estudio yo observé los efectos del aumento en niveles de perturbación humana sobre vigilancia, utilizando las distancias entre los individuos en grupos de flamenco común (*Phoenicopterus ruber roseus*). Las reacciones a 112 perturbaciones fueron registradas durante 61 horas de observación. Los flamencos que no fueron perturbados no mostraron relación entre distancia individual y tamaño de grupo. Cuando aparecieron personas corriendo, los flamencos se mostraron alertos pero continuaron alimentándose. La distancia individual no fue influenciada por el tamaño del grupo cuando pasaron vehículos motorizados (jeeps), pero fue distinta a aquella en grupos no perturbados. Sin embargo, cuando pararon grupos turísticos y los participantes bajaron del vehículos, la distancia individual fue reducida significativamente y el tamaño del grupo de flamencos fue influenciado positivamente por la cohesión del grupo (por ejemplo, grupos más pequeños tuvieron menor distancia individual que grupos más grandes). Los flamencos parecieron particularmente perturbados por vehículos de todo terreno y en 82% de estos encuentros los flamencos tomaron vuelo. En estos casos, la cohesión del grupo fue extremadamente densa pero el tamaño del grupo no influyó en la reacción del grupo. Este estudio demuestra que especies que forman grupos buscan protección en números pero abandonan un área cuando no hay suficientes conespecíficos presentes y cuando ocurren perturbaciones serias.

Key words.—ecotourism, Eilat, foraging, Greater Flamingo, Israel, *Phoenicopterus ruber roseus*.

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As human recreation in natural areas increases, concern for its possible negative effects is growing more rapidly than our understanding of any negative impacts (e.g., Ingold et al. 1992, Knight and Cole 1995, Knight and Gutzwiller 1995). Human recreational activities negatively affect feeding in waders (Glaser et al. 1998) and reproductive success of seabirds (Anderson and Keith 1980), waterfowl (Titus and Van Druff 1981; Keller 1989, 1991), and raptors (Voous 1977). Hence, among the greatest challenges facing ecologists and conservationists is to ensure the continued coexistence of wildlife with the increasing pressure of human recreation (Addessi 1994, Kinnaird and O'Brien 1996,

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Galicia and Baldassarre 1997, Richardson and Miller 1997) and hunting demands (Fox and Madsen 1997).

Israel is located on the only land bridge between 3 continents, and is thus a junction for birds migrating south from Eurasia to Africa in autumn and north to their breeding grounds in spring (Safriel 1968). Many birds land in the Eilat area to rest before (in autumn) or after (in spring) crossing the deserts (Safriel 1968). The Greater Flamingo (*Phoenicopterus ruber roseus*) is 1 of >200 species that migrate through the region. Flamingos are scarce to uncommon passage migrants, winter visitors, and nonbreeding summer visitors (Shirihai 1996). Staging and overwintering flocks were first observed in the 1980s after the construction of salt pans 20 km to the north of Eilat (Shirihai 1996).

The use of other flock members to reduce individual levels of vigilance has been studied by many researchers (Pulliam 1973, 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, however, few 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 considered (Elgar 1989). Conspicuous among these variables are those associated with foraging, such as the density of food resources (Elgar 1989, Roberts 1996). Because larger flocks might find better food sources, and animals feeding on better food sources may spend less time in other behavior such as vigilance, foraging studies may lead to the wrong conclusions. Similarly, despite consideration by Redpath (1988) and Roberts (1995) as a more reliable method for evaluating vigilance, preening also may yield mistaken conclusions, especially in species engaging in displacement behavior (Krebs and Davies 1987, Alcock 1989). Because preening or preening-like behavior is part of the ritualized display sequence in Greater Flamingos (Cramp 1977), it may not be an indicator of vigilance in this group.

In this study, I demonstrate real-time decreases in the physical distance among individuals in Greater Flamingo flocks in response to increasing levels of human recreational disturbance. This measure of average individual distance within flock members is assumed an indicator of vigilance that is unconfounded by variables associated with foraging.

STUDY AREA AND METHODS

Fieldwork was conducted during December 1994 and January 1995. Greater Flamingos winter regularly in salt pans 10 km north of Eilat, Israel (29°33'N, 34°57'E). This arid area has an average precipitation of 30 mm, with 10 rainy days/year (Ginat 1993). Annual average temperature is 26°C (range = 10–39). Annual relative humidity is 39% with no dew recorded.

Although the source of these flocks is unknown, 5 migrant flamingos ringed in Eilat in the 1970s were recovered in Iran (Shirihai 1996). Safriel (1968) reported flamingos only on migration in the Eilat region. Since 1990, however, flocks ranging from 15 to 80 birds have been observed regularly in the winter months in the shallow (40–50 mm) salt pans. The birds 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, which results in a completely open landscape.

I placed red wooden stakes in a grid 5 m apart across the breadth of the salt pan (85 × 30 m) that flamingos frequented most during the 2 weeks prior to initiation of observations. Additional stakes were placed along 2 banks opposite the observation point, which allowed me to draw imaginary grids 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 Israeli Salt Company. Flamingos were allowed 1 week to acclimate to the stakes prior to data collection. I conducted all observations from within a vehicle at a distance of 40–50 m. Distances between individuals were measured in reference to the stakes. In addition, I used ranging optimeters (Model 120 and 620; Forestry Suppliers, Jackson, Mississippi, USA) to verify individual distances (up to 30 m Model 120; up to 180 m Model 620). All distances were rounded to the nearest meter. I recorded the location of each flamingo, and I did not initiate disturbances recorded during this experiment.

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

Disturbances were categorized as follows: (1) no disturbance (control group), (2) pedestrians walking or jogging, (3) jeep or tour vehicle drives past slowly, (4) jeep or tour vehicle stops and passengers get out, and (5) all-terrain vehicle (ATV) tour.

The duration of the observations ranged from 1 to 4 hr and ended when no further human activities were ex-

pected or the birds flew away. All observations of the control periods were conducted between 0600 and 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 Baldassarre 1992).

Statistical analyses were done on the Macintosh Version 2 of JMP (SAS Institute 1989). Data are presented as mean ± standard error, and I chose $P < 0.05$ as the minimum acceptable level of significance.

RESULTS

Of 131 flocks observed, 13 (9.9%) were juveniles-only groups; 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 smaller (Wilcoxon signed-rank test, $P < 0.05$) than mixed flocks (32.3 ± 13.1, range = 6–61), individual distance in all juvenile flocks was not different ($P = 0.24$) from mixed flocks (11.6 ± 10.5 vs. 17.4 ± 12.4).

I observed flamingos for 6 hr during the predisturbance (control) time period. In 19 flocks observed, there was no relationship ($r^2 = 0.02$, $P = 0.52$) between the average individual distance (26.7 ± 6.7 m) and average flock size (38.3 ± 15.3). However, for all flocks observed during the study, smaller flocks had smaller individual distances ($P = 0.001$).

In addition, 61 hr of observation were conducted during which 112 incidents related to disturbance categories 2–5 occurred. Pedestrians jogging or walking were not a common occurrence; only 23 such incidents were observed. In response to pedestrians, Flamingos raised their heads, moved away from the bank on which the movement occurred, and continued feeding. Individual distance (30.6 ± 9.3 m) was not influenced by average flock size (36.0 ± 12.7, $P = 0.81$), and was not different from the control flocks ($P = 0.17$).

In the "moving vehicle" 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, individual distance (21.9 ± 5.9) was not influenced by flock size (28.5 ± 12.3, $P = 0.49$), but was different from that in the undisturbed flocks ($P = 0.03$).

In the 42 incidents included in the four category, tour guides stopped their jeeps near flocks and ≥1 of the occupants got out. The tour leader's narrative was often loud, and in the case of groups with children, the noise was especially pronounced. The birds reacted by flocking together in the middle of the pan, and individual distance (5.14 ± 3.2) was reduced in comparison to the control group ($P = 0.001$). Flock size positively influenced flock cohesiveness ($r^2 = 0.428$, $P = 0.0001$), and smaller flocks had on average significantly smaller individual distances (37.9 ± 3.8 vs. 39.6 ± 9.0, $P = 0.01$). When the flocks were small (>15) and composed of only juvenile flamingos, the birds flew away in 8 of 42 cases.

Although ATVs are not allowed 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, flamingos appeared highly disturbed and exhibited agitated behavior such as necks stretched upwards with heads cocked from side-to-side, fast-stepping, and giving short "aahonk aahonk" calls (Cramp 1977). Flock flew away during 9 of these disturbance instances. Interbird distance was extremely dense (2.27 ± 1.1m) and was different from that in the control flocks ($P < 0.005$). During the time period that ATVs were present, flock size did not influence flock reaction ($P = 0.52$).

DISCUSSION

I observed no aggression among individuals in a flock, which contrasts to Bildstein et al. (1991) who studied Caribbean Flamingos (*P. ruber ruber*) in Venezuela. Bildstein et al. (1991) noted that juveniles were often involved in aggression in mixed flocks, especially as recipients from neighboring adults, and that aggressive encounters significantly affected the amount of time flamingos spent filter-feeding. Further, Schmitz and Baldassarre (1992) suggested that under conditions of reduced food abundance, Caribbean Flamingos in Mexico may gain more by feeding than by elevating levels of aggression to-

ward 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 low density of brine shrimp may also explain why flamingos spread out between 20–30 m from their neighbors while feeding when undisturbed. Because most of the juvenile-only flocks flushed almost immediately upon being disturbed, these individuals also may be far more susceptible to disturbance than mixed flocks.

The fact that individual distance was similar in flocks exposed to joggers and strollers and in the control flocks suggests human presence in the vicinity did not necessarily disturb foraging flamingos. The decrease in individual distance in flocks disturbed by jeeps and ATVs suggests a negative response to these disturbances.

results are inconsistent with Cramp's (19) claim that flamingos 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, as was described for Great Crested Grebes (*Podiceps cristatus*) in Switzerland (Keller 1989). This habituation process needs future studies because, in contrast, Stalmaster and Newman (1978) found that although Bald Eagles (*Haliaeetus leucocephalus*) in the United States did not react significantly to a single direct disturbance, repeated disturbances sometimes caused abandonment of nests.

Interestingly, group size did not affect individual distance in the control flocks or when joggers, strollers, or vehicles passed without stopping. However, when vehicles stopped in the vicinity and people got out or made noise, flamingos reacted by clumping in the middle of the salt pan, which resulted in small values of individual distance. Hence, results of this study indicate that staging birds are susceptible to disturbances, and that human disturbance activities must be mitigated.

Numerous studies (e.g., Barnard 1980, Elcavage and Caraco 1983, Sullivan 1984, 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 individual distance indicates the existence of a flexible mechanism wherein flock size positively influences individual distances (i.e., flamingos in larger flocks forage at greater individual distances). In addition, small flocks composed of only juvenile flamingos tended to fly away as compared to flocks that were either large or had adults present. This escape strategy suggests that flamingos 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 cognitive processes in flamingos (Bekoff 1995).

Flamingos not being disturbed by humans may spread out 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). When disturbed by either vehicles or ATVs, however, 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 flamingos with 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 wherein this position may allow for early detection and thus time to escape.

These data show that flocking species like flamingos may seek protection in numbers, but if there are insufficient conspecifics, they leave the area. Also, physical distance among individuals in free-ranging flocking species can be used as an index of flock and individual vigilance. By measuring individual distance, one can index the relative vigilance and agitative state of each individual in the flock, and the overall flock individual distance can provide an indication of the intensity of the disturbance.

My results suggest that reducing disturbances during foraging periods would bene-

fit flamingos. I recommend that tourist access or other human-related activities be curtailed at the salt pans during the early morning and late evening (e.g., Sadoul et al. 1998), which are peak foraging times for the Greater Flamingos at Eilat. Further, because of the heat stress during the afternoon hours, early morning and late afternoon are optimal times for visits by tourists and bird-watchers that flock to Eilat during the migration seasons.

Overall, compromises between human recreational activities and avian migratory nutritional requirements include either limiting access only to those salt pans where the disturbance caused is minimal, or building hides that will prevent the birds from flushing because of human activity (e.g., Postovit and Postovit 1987, Knight and Temple 1995). These hides also can be created by planting local plant species (e.g., seablite [*Suaeda monoica*]) to minimize disturbance to foraging waders and Greater Flamingos, and to allow additional species to forage or nest.

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