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COVER: Light morph Booted Eagle (*Hieraaetus pennatus*). Painting by Luis M. Curesma Gallardo.

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LOW PRODUCTIVITY OF BALD EAGLES ON PRINCE OF WALES ISLAND, SOUTHEAST ALASKA

ROBERT G. ANTHONY

U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331-3803 U.S.A.

ABSTRACT.—I investigated reproductive success of Bald Eagles (*Haliaeetus leucocephalus*) on Prince of Wales Island, Alaska from 1991–93. Productivity (0.13 young produced per occupied territory) was the lowest recorded for the species throughout its geographic range. Productivity was not significantly different among different habitats including remote roadless areas vs. roaded and logged areas, which suggested that habitat alterations were not the cause of low productivity. Because nesting densities were high and I observed some effects of proximity of nearest neighbor pairs, I suggest these densities (proximate factor) were affecting productivity through reduced food availability (ultimate factor). However, I could not rule out the effects of environmental contaminants, although this seemed unlikely because of the distance of the island from industrial and agricultural areas. I discuss the various potential causes of this low rate of productivity.

KEY WORDS: *Bald Eagle, Haliaeetus leucocephalus; nearest-neighbor effects; productivity; southeast Alaska.*

Baja productividad de águilas calvas en la isla del Principe de Gales, sureste de Alaska

RESUMEN.—Investigué el éxito reproductivo de las águilas calvas (*Haliaeetus leucocephalus*) en la Isla del Príncipe de Gales, Alaska 1991–93. La productividad (0.13 juveniles producidos por territorio ocupado) fue la mas baja registrada para la especie a lo largo de su rango geográfico. La productividad no fue significativamente diferente entre los diferentes habitats incluyendo áreas remotas y sin carreteras vs. áreas de explotación maderera con carreteras, lo cual sugiere que las alteraciones del habitat no fuera la causa de la baja productividad. Debido a que las densidades de los nidos fueron altas, observe algunos efectos producidos por la proximidad de las parejas vecinas mas cercanas. Sugiero que estas densidades (factor próximo) estaban afectando la productividad reduciendo la disponibilidad de comida (factor último). Sin embargo, no pude medir los efectos de los contaminantes ambientales, aunque posiblemente no hubo debido a la distancia de la isla a las áreas industriales. Discuto las causas potenciales de esta baja tasa de productividad.

[Traducción de César Márquez]

Bald Eagles (*Haliaeetus leucocephalus*) are considered a Sensitive Species in Alaska and are managed under the Bald and Golden Eagle Protection Act (1940) and the Migratory Bird Treaty Act (1918). The most prominent factor for historical population declines in the state was the bounty system which was imposed on the species until 1953; however, populations have increased since mortalities from this system have stopped (Hodges et al. 1979). Southeast Alaska currently has large popu-

lations of breeding and wintering Bald Eagles. Alaska is considered a stronghold (Hodges et al. 1979, Hansen 1987) and provides high quality habitat for the species. However, high densities are not necessarily indicative of high quality habitat (Van Horne 1983) or sufficient demographic performance. Evaluating habitat quality should involve examination of the species' reproductive success and/or survival within the area. Habitat quality may also be influenced by human activities, be-

cause high quality habitats are often avoided because of the presence of humans (McGarigal et al. 1991).

There were several human activities that may have disturbed Bald Eagles on Prince of Wales Island, including road construction, vehicular traffic, helicopter overflights, and habitat alteration in the form of timber harvest. The purpose of this project was to investigate Bald Eagle productivity on the eastern shoreline of Prince of Wales Island, Alaska, and examine both "natural" and human-related factors that may influence productivity. Specifically, I hypothesized that human activities as a result of logging and road construction were having a detrimental effect on Bald Eagle productivity (Anthony and Isaacs 1989, McGarigal et al. 1991). Because of dense breeding populations, I also predicted that nearest-neighbor interactions may affect productivity (Anthony et al. 1994). Hansen (1987) suggested that food availability has an influence on productivity of Bald Eagles in southeast Alaska, so I was aware of this potential effect. However, prey availability is next to impossible to describe for this species because of their diverse diet of fish, birds, and mammals.

STUDY AREA

I conducted surveys of Bald Eagles and described productivity on the east side of Prince of Wales Island, Alaska. The coastline in this region is variable. Some areas are very convoluted with many small bays and peninsulas, as well as numerous offshore rocks and islets. Other areas are essentially straight shorelines with few prominent points and steep slopes descending directly to the shoreline. Vegetation consists of forests dominated by Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). The study area consisted of shoreline between Mills Bay on the south and Lake Bay on the north, and small islands near the shoreline also were included in the study. In 1992, I expanded the study area to include Rose, Berry, Round, and the east side of Stevenson Islands (hereafter referred to as islets). Rivers or streams that support runs of salmon (*Oncorhynchus* spp.) within or near this area include Lake Bay, Coffman, Chum, Eagle, Ratz, Little Ratz, Sal, Cobble, Slide Creeks, and the Thorne River.

METHODS

Surveys. Surveys were conducted from April through September 1991–93 by foot, from vehicles, sea (14' Gregor welded and 18' Alumaweld boats), and air (Hughes 500D helicopter). Occupancy and productivity of nests were determined with two aerial surveys each year with four people on board the helicopter. One person recorded data while the others watched for eagles or nests. Locations of all eagles and nests were plotted on U.S. Geological Survey 1:63 360 maps or U.S. Forest Service maps

of the study area. The first survey flight was conducted during the egg laying and incubation periods (7–8 May 1991, 6–7 May 1992, 3 May 1993) to determine occupancy of nesting territories. The second flight was conducted during the late nestling stage (3 and 8 July 1991, 28–30 July 1992, 3–4 August 1993) to determine productivity. In addition, a third survey flight was flown on 15 August 1991 to verify productivity at several nests. I also supplemented aerial surveys at as many nest sites as possible throughout the breeding season using boats or foot travel.

Terminology used in this paper follows that of Postupalsky (1974). A territory was occupied when two adults were observed in association with a nest or when an adult was observed on a nest. If an adult was observed on a nest in incubating posture or with young nestlings, a breeding attempt took place in the territory (Steenhof 1987). A territory was successful if fledglings, or nestlings near fledgling age, were observed. For the purposes of analysis, any occupied site that failed to produce fledglings was considered a failure.

Nearest-Neighbor Interactions. Because breeding populations were dense, I was interested in conspecific nearest-neighbor interactions and its potential influence on Bald Eagle productivity as described for Oregon (Anthony et al. 1994). Accordingly, I determined a Universal Transverse Mercator (UTM) location for each territory for each year. The location of occupied nests, if known, was used for the territory location. If no occupied nest was known for the territory, I used a nest within the area where eagles were frequently observed. If I failed to identify an occupied nest or breeding attempt within the area, I approximated a central point for all eagle observations within the territory during that year. I calculated the distance to the nearest occupied territory using the UTM locations for each territory occupied during a given year. I also calculated the distance to the second nearest territory, which was added to the nearest territory distance to provide the "total neighbor distance." The nearest and total neighbor distances were used to evaluate the potential effect of nearest-neighbors on productivity.

Statistical Analyses. For each year and for all years combined, I calculated three measures of productivity. Breeding success was defined as the percent of occupied sites that produced young, and productivity as the number of young fledged per occupied site. I also calculated the number of young fledged per successful site. Habitats surrounding nests were classified as unroaded and unlogged, roaded but unlogged, unroaded but logged, roaded and logged, and islet nests. Unroaded and unlogged habitats were those that had no roads or past logging history within ~1.6 km of the occupied nest or territory center. In contrast, roaded or logged habitats had roads or past logging history within 1.6 km of the nest or territory center. All logging activities were of the form of clearcut harvests. Chi-square tests or Fisher's exact test were computed to determine if the proportion of successful nests was significantly different among years. Analysis of variance was used to test for differences in the number of young produced per site among years and habitats. I used an alpha of 0.10 to determine significance for all statistical tests, because I wanted to minimize the probability of a Type II statistical error and maximize

Table 1. Occupancy and productivity of Bald Eagle nests on Prince of Wales Island, Alaska, 1991–93.

| | 1991 | 1992 | 1993 | ALL YEARS |
|-------------------------------|----------|----------|----------|-----------|
| Sites surveyed | 109 | 109 | 109 | 327 |
| Occupied ^a | 91 (84%) | 98 (90%) | 78 (72%) | 267 (82%) |
| Breeding attempt ^b | 47 (52%) | 62 (63%) | 41 (53%) | 150 (56%) |
| Successful ^b | 10 (11%) | 10 (10%) | 11 (14%) | 31 (11%) |
| # Young fledged | 11 | 10 | 13 | 34 |
| # Young/occupied site | 0.12 | 0.10 | 0.17 | 0.13 |
| # Young/successful site | 1.10 | 1.00 | 1.18 | 1.10 |

^a Percent is based on number of sites surveyed.

^b Percent is based on number of sites occupied.

power to detect any possible differences (Sokal and Rohlf 1981).

Nested analysis of variance (ANOVA) was used to test for differences in nearest and total neighbor distances using SAS (SAS Institute 1989). For both nearest neighbor distances, I compared active versus inactive nests and successful versus unsuccessful nests within years. Because sample sizes were unequal for many groupings of nest sites, Satterthwaite's approximation to the *F* statistic was used for both tests of activity nested within years (Sokal and Rohlf 1981). The standard simple approximation of the *F* statistic was used for both tests of success nested within years. I transformed both nearest and total neighbor distances using the square root transformation so the frequency distributions were normally distributed. Productivity at territories on the more remote islets was examined, because I hypothesized that these territories may not be influenced by nearest-neighbor interactions. A chi-square test of independence was used to compare breeding success at remote islets with that of nests in the remainder of the study area.

RESULTS

Productivity. I identified 109 breeding territories within the study area and 267 breeding attempts (territory occupancy) during the three years. Of these, 62 (57%) were occupied all three years, 34 (31%) were occupied for two years, and 13 (12%) were occupied in only one year. Ninety-one territories were occupied in 1991, and 47 (52%) breeding attempts were identified. Eleven young fledged from 10 successful nests. I identified 98 occupied territories in 1992, and 62 (63%) of these had breeding pairs. Ten young fledged from 10 successful nests. Seventy-eight territories were occupied in 1993, and 41 (53%) had breeding pairs. Thirteen young fledged from 11 successful nests. Productivity was extremely low for all years. The proportion of nests that were successful was not significantly different among years ($\chi^2 = 0.695$, $df = 2$, $P = 0.7065$) and averaged only 11% (Table 1). The number of young fledged per occupied

site was not significantly different among years ($\chi^2 = 1.286$, $df = 2$, $P = 0.5257$) and averaged only 0.13 (Table 1). For all years, an average of 1.1 young fledged per successful nest (Table 1).

Timing of Nesting Failures. In 1991, 14 of the 29 breeding pairs (48%) failed by the early nestling stage. Of the 12 territories that were still occupied and could be monitored, eight succeeded in fledging young. In 1992, 19 territories failed to produce young, and 12 (63%) were still occupied on 27 May. Of these 12, only three were still occupied on 10 June, and all three were successful in fledging young. Therefore, 47% of failures occurred within the two-week period at the beginning of June, which corresponded with the late incubation period. The cause of nesting failures was not determined because I did not climb nest trees to inspect nests according to Anthony et al. (1994).

Influence of Habitat Condition on Productivity. Because there were no significant differences in productivity among years, data for different years were combined for this analysis. Productivity for the different habitat conditions also was extremely low, but there were significant ($P < 0.05$) differences among the habitat conditions. Productivity of islet territories was significantly higher ($P < 0.05$) than those in unroaded and unlogged, and in roaded and logged territories (Table 2). Overall, productivity of islet nests was the highest of all of the habitat conditions. Productivity of territories in unroaded and unlogged areas was not significantly ($P > 0.05$) higher than that of other habitats. When all territories that were either roaded or logged were combined (Table 2), there was no significant ($P > 0.17$) difference in productivity of this group of territories and that of sites in unroaded and unlogged sites. However, productivity of islet nests was significantly ($P = 0.0031$) higher

Table 2. Productivity of Bald Eagle nest sites on Prince of Wales Island in relation to habitat condition.

| HABITAT CONDITION | NO. OCCUPIED SITES | BREEDING SUCCESS (%) | YOUNG FLEDGED/OCCUPIED SITE ^a |
|------------------------------|--------------------|----------------------|--|
| A. Separate analysis: | | | |
| Unroaded, unlogged | 149 | 6 | 0.07 ^a |
| Roaded, unlogged | 5 | 0 | 0.00 ^a |
| Unroaded, logged | 22 | 18 | 0.18 ^a |
| Roaded, logged | 42 | 12 | 0.12 ^a |
| Newly roaded and logged | 36 | 22 | 0.25 |
| Islets (undisturbed) | 13 | 38 | 0.38 |
| B. Combined analysis: | | | |
| Unroaded, unlogged | 149 | 6 | 0.07 ^a |
| Roaded or logged | 105 | 16 | 0.17 ^a |
| Islets (undisturbed) | 13 | 38 | 0.38 |

^a Means with the same superscripts are not significantly ($P > 0.10$) different as determined by analysis of variance and a Bonferoni mean separation test.

Table 3. Mean (\pm SE) nearest and total neighbor distance (m) for all activity categories of Bald Eagle nests on Prince of Wales Island, 1991–93.¹

| CATEGORY | N | NEAREST-NEIGHBOR | TOTAL NEIGHBOR |
|--------------------|-----|-------------------------|-------------------------|
| 1991 | 91 | 1130 (59) | 2992 (135) |
| Unoccupied | 44 | 1172 (75) ^a | 3058 (173) ^a |
| Breeding attempt | 47 | 1090 (92) ^a | 2929 (207) ^a |
| Failed | 81 | 1089 (58) ^b | 2918 (133) ^b |
| Successful | 10 | 1461 (259) ^c | 3584 (586) ^b |
| 1992 | 98 | 1048 (60) | 2764 (127) |
| Unoccupied | 36 | 952 (92) ^a | 2560 (192) ^a |
| Breeding attempt | 62 | 1104 (78) ^a | 2883 (165) ^a |
| Failed | 88 | 1081 (65) ^b | 2810 (137) ^b |
| Successful | 10 | 764 (117) ^c | 2360 (281) ^b |
| 1993 | 78 | 1341 (69) | 3547 (159) |
| Unoccupied | 37 | 1341 (112) ^a | 3467 (245) ^a |
| Breeding attempt | 41 | 1341 (86) ^a | 3618 (208) ^a |
| Failed | 67 | 1310 (77) ^b | 3488 (173) ^b |
| Successful | 11 | 1528 (145) ^c | 3904 (388) ^b |
| All years combined | 267 | 1162 (37) | 3070 (82) |
| Unoccupied | 117 | 1158 (55) ^a | 3034 (121) ^a |
| Breeding attempt | 150 | 1164 (50) ^a | 3098 (112) ^b |
| Failed | 236 | 1148 (39) ^b | 3040 (86) ^c |
| Successful | 31 | 1260 (119) ^c | 3303 (271) ^d |

¹ Means for nests with breeding attempts vs. those without and successful vs. failed comparisons were significantly ($P < 0.10$) different when followed by different letters. All comparisons were made within a column.

than that of territories in unroaded and unlogged areas for the combined analysis.

Nearest-Neighbor Analysis. Nearest-neighbor distances between all territories averaged 1162 m (range = 175–3937) for all years combined (Table 3). There were no significant ($P > 0.10$) differences between nearest-neighbor distances for nests with breeding attempts vs. those without or successful vs. unsuccessful nests for all years combined (Table 3). However, nearest-neighbor distance between nest with breeding attempts vs. those without was significant ($F = 7.50$, $P = 0.0795$) within years after annual variation was removed. This was probably the result of nearest-neighbor distances increasing in 1993 because fewer territories were occupied than in 1991 or 1992. There was no significant ($F = 2.74$, $P = 0.2124$) difference in nearest-neighbor distances between successful and failed nests for all years combined; however, the difference was significant ($F = 2.47$, $P = 0.0627$) for within-year comparisons. In 1991 and 1993, successful nests had larger nearest-neighbor distances than failed nests (Table 3). However, successful nests had smaller nearest-neighbor distances than failed nests in 1992.

Total neighbor distances averaged 3070 m (range = 355–8567) for all years (Table 3). Total neighbor distance was significantly different between nests with breeding attempts vs. those without ($F = 11.74$, $P = 0.0493$) when data were combined over all years, but activity was not significantly ($F = 0.72$, $P = 0.5399$) different for

Table 4. Productivity of Bald Eagle populations in North America.

| REGION | OCCUPIED SITES | YOUNG FLEDGED/OCCUPIED SITE | YOUNG FLEDGED/SUCCESSFUL SITE | STUDY PERIOD | SOURCE |
|--------------------------------|----------------|-----------------------------|-------------------------------|--------------|----------------------------|
| Colorado, Wyoming | 85 | 1.21 | 1.92 | 1981–89 | Kralovec et al. (1992) |
| Saskatchewan, Canada | 48 | 1.06 | 1.82 | 1984–87 | Dzus and Gerrard (1993) |
| Chesapeake Bay | 1448 | 1.21 | 1.70 | 1981–90 | Buehler et al. (1991) |
| Wisconsin | 1469 | 1.30 | 1.69 | 1983–88 | Kozie and Anderson (1991) |
| Northwest Ontario | 1370 | 0.80 ^a | 1.67 | 1970–80 | Grier (1982) |
| Arizona | 45 | 0.80 | 1.63 | 1975–80 | Grubb et al. (1983) |
| Alaska Peninsula, Alaska | 43 | 0.97 | 1.61 | 1970 | Hehnke (1973) |
| Kodiak Island, Alaska | 312 | 1.00 | 1.59 | 1963–70 | Sprunt et al. (1973) |
| Oregon | 606 | 0.92 | 1.52 | 1979–92 | Isaacs and Anthony (1992) |
| Wisconsin | 492 | 1.00 | 1.52 | 1962–70 | Sprunt et al. (1973) |
| Texas | 193 | 0.98 | 1.50 | 1981–90 | Maybie et al. (1994) |
| Gulkana River, Alaska | 274 | 0.86 | 1.48 | 1989–93 | Steidl et al. (1997) |
| Florida | 592 | 0.73 | 1.46 | 1961–70 | Sprunt et al. (1973) |
| Yukon Territory, Canada | 39 | 1.05 | 1.46 | 1980–82 | Blood and Anweiler (1990) |
| California | 140 | 0.81 | 1.45 | 1970–91 | Jenkins (1992) |
| Yellowstone Nat. Park, Wyoming | 107 | 0.41 | 1.43 | 1972–79 | Alt (1980), Swenson (1975) |
| Amchitka Island, Alaska | 71 | 0.86 | 1.42 | 1972 | Sherrod et al. (1976) |
| Maine | 521 | 0.44 ^a | 1.35 | 1972–78 | Todd (1979) |
| San Juan Islands, Washington | 275 | 0.84 | 1.35 | 1975–80 | Grubb et al. (1983) |
| New Brunswick, Canada | 55 | 0.73 | 1.33 | 1974–80 | Stocek and Pearce (1981) |
| Washington | 866 | 0.87 | 1.32 | 1981–85 | McAllister et al. (1986) |
| Prince of Wales Island, Alaska | 267 | 0.13 | 1.10 | 1991–93 | This study |

^a The population in this study area has been influenced by organochlorine contaminants.

within-year comparisons (Table 3). This result corresponded with the nearest-neighbor analyses and was probably the result of larger total neighbor distances being observed in 1993, because fewer sites were occupied than in 1991 or 1992. Total neighbor distance for all years combined was significant ($F = 6.17$, $P = 0.0864$) when comparing successful vs. unsuccessful nests within years. However, total neighbor distance did not differ according to success within-year ($P = 0.2571$).

I monitored nesting success of Bald Eagles on small islets in 1992 and 1993, because there was usually only one occupied territory per islet. Territories at these islets produced young more often than territories within the remainder of the study area ($\chi^2 = 90.6$, $df = 1$, $P = 0.0019$). Of the 13 occupied territories on islets, 5 (38%) were suc-

cessful in producing at least one young. At “non-islet” territories, only 26 of 252 (10%) occupied territories were successful. Mean nearest-neighbor distance at islet territories was 1369.9 m, as compared to 1151.3 m at “nonislet” territories. Mean total neighbor distance at islet territories was 3521.5 m, compared to 3046.4 m at “nonislet” territories.

DISCUSSION

Productivity of Bald Eagles on Prince of Wales Island, Alaska, was extremely low for all three years and in all habitat conditions. The average number of young produced per occupied site (0.13) was the lowest reported for this species throughout its geographic range (Table 4). In addition, the number of young fledged per successful nest (1.10) was

also the lowest recorded for Bald Eagles, including other areas in Alaska. Hansen et al. (1984) studied productivity of Bald Eagles in the Chilkat River Valley from 1979–83 and found that 32% of occupied territories were successful in producing young with mean productivity rate of 0.42 young per occupied site. Steidl et al. (1997) reported higher mean productivity (0.86 young/occupied site) on the Gulkana River of central Alaska.

Potential causes of nesting failures that can reduce productivity of Bald Eagle populations include human disturbance, contaminants, nestling mortality, infertile eggs, food stress, weather, nearest-neighbor effects, or the failure to lay eggs (Anthony et al. 1994). Of these causes, human disturbance, contaminants, nearest-neighbor interactions, and/or food stress were considered to be the most likely factors to cause the extremely low productivity of Bald Eagles on Prince of Wales Island. I found no evidence for human disturbance being a major influence on productivity, because nesting failures occurred along remote as well as human occupied shorelines during all three years. In addition, nest sites that were successful in producing young were associated with shorelines with human activities as frequently as those that were associated with uninhabited shorelines. Also, low productivity was prevalent in unroaded and unlogged as well as human inhabited areas. Consequently, my data do not support the original hypothesis that human disturbance (i.e., logging or road construction) had an effect on productivity of Bald Eagles on Prince of Wales Island.

My analysis of nearest-neighbor distances suggested that nearest-neighbor interactions may have influenced productivity. The higher nearest-neighbor distance for successful versus failed sites in 1991 and 1993, and the higher productivity of “islet” versus “nonislet” territories (large vs. small nearest-neighbor distances) support this explanation. The extremely low success rates of eagles within our study area prevented us from conducting nearest-neighbor analyses comparable to those of Anthony et al. (1994) for Oregon. However, they observed negative effects of nearest-neighbor pairs at greater distances (<3200 m) than those among most pairs on this study area (\bar{x} = 1162 m, range = 175–3967 m). Therefore, it is possible that Bald Eagles on Prince of Wales Island were nesting so densely that all nests were subjected to nearest-neighbor interactions, which acted as a proximate effect on productivity.

Food stress is likely the ultimate factor influenc-

ing productivity on Prince of Wales Island and may result in nearest-neighbor interactions. Our limited data indicate that many of the nests failed during the egg-laying and incubation stages, which is a pattern associated with food-stressed populations (Newton 1979). Also, the spatially variable groupings of successful nests that I observed each year suggested local prey availability in these areas. Some of these groupings were in close proximity to streams with abundant salmon runs, which may have provided the necessary prey resources for successful reproduction. However, salmon were not present in streams until later in the summer after nesting failures have occurred. Other anadromous fishes such as eulachon (*Thaleichthys pacificus*), sand lance (*Ammodytes hexapterus*), and herring (*Clupea pallasii*) are some of the first foods available to eagles after the long winter, and their runs are highly variable spatially (P. Schempf pers. comm.). Consequently, the abundance of these fishes in space and time may influence Bald Eagle productivity. This is a hypothesis for future work and testing.

Several studies in Alaska have indicated that Bald Eagle productivity is controlled by prey abundance and/or availability. In southeastern Alaska, Hansen (1987) found that placing prey within Bald Eagle nesting territories increased their productivity. Hansen and Hodges (1985) attributed variability in breeding rates of Bald Eagles to variability in prey abundance. Lastly, Steidl et al. (1997) suggested that most variation in reproductive success of Bald Eagles along the Gulkana River in central Alaska was attributable to prey availability. The low productivity of Bald Eagles on Prince of Wales Island may be due to low prey abundance or availability (ultimate factor) and is displayed through nearest-neighbor interactions (proximate factor).

I could not rule out the possibility of environmental contaminants having an effect on productivity of Bald Eagles on Prince of Wales Island. This seemed unlikely because the area is remote from industrial and agricultural areas, the source of many pesticides that have been shown to effect Bald Eagle populations (Wiemeyer et al. 1984). However, elevated levels of DDE, PCBs, dioxins, or furans have been reported in waterfowl (Whitehead et al. 1990), seabirds (Elliott et al. 1989a), Great Blue Herons (*Ardea herodias*) (Elliott et al. 1989b), and Bald Eagles (Elliott et al. 1996) along the coast of British Columbia, Canada. The source of DDE and PCBs in these species of birds is un-

known; however, the source of dioxins and furans is usually from pulp and paper mills that use bleaching processes to produce paper. These two compounds are reported to be some of the most toxic substances to birds, and effects on reproduction have been documented in laboratory experiments on wood ducks (White and Seginak 1994) in concentrations of parts per trillion. In addition, Estes et al. (1997) and Anthony et al. (1999) have recently found elevated levels of DDE and PCBs in Bald Eagles in the western Aleutian Islands of Alaska. Consequently, environmental contaminants may be accumulating in food chains and affecting Bald Eagle reproduction on Prince of Wales Island. The possible effect of environmental contaminants on productivity of bald eagles should be investigated by collecting eggs from nests over a 2–3 yr period (Wiemeyer et al. 1984, Anthony et al. 1993).

I may have studied the Bald Eagles on Prince of Wales Island during a time when productivity was extremely low because productivity may have improved. Continued monitoring of reproductive success on the island would help answer this question. Monitoring trends of prey populations, particularly salmon, herring, sand lance, eulachon, and smelt, could be important also. The timing, location, and magnitude of these runs may explain the clumped but sparse nature of successful breeding attempts of Bald Eagles that varies among years on the island. Data on eagle productivity and characteristics of anadromous fish runs over several years will be necessary to determine if any relation exists between the two, but such information could be valuable in determining the cause(s) of low productivity on Prince of Wales Island.

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DISPERSAL OF JUVENILE AND IMMATURE BONELLI'S EAGLES IN NORTHEASTERN SPAIN

JOAN REAL AND SANTI MAÑOSA

Departament de Biologia Animal, Facultat de Biologia, Universitat de Barcelona, Avda. Diagonal 645, E-08028 Barcelona, Catalonia, Spain

ABSTRACT.—Between 1986–93, we wing tagged and banded 122 Bonelli's Eagles (*Hieraaetus fasciatus*) in northeastern Spain to analyze their dispersal before recruitment to the breeding population. By 1998, we had obtained 18 band returns and 42 incidental observations of juvenile and immature eagles ranging in age from 1–3 yr. These eagles were recorded from 1–1020 km from their nests with a geometric mean distance (95% C.I.) of 101 km (72–153). Up to 57% of the birds remained within a radius of 100 km of their nests, whereas 33% were found beyond 200 km. Short-distance dispersers were found mainly in northeastern Spain in central Catalonia (<200 km), while long-distance dispersers (>200 km) were found in central and southeastern Spain. No significant difference in dispersal distance was found between males (101 km, 40–273, $N = 15$) and females (189 km, 86–419, $N = 11$), but males were mostly recorded at shorter distances. Dispersal distances of juveniles (114 km, 68–193, $N = 43$) and immatures (77 km, 44–135, $N = 16$) also did not differ significantly, but immatures were mostly recorded at shorter distances. No significant difference was found between sighting (82 km, 54–137) and band recovery (167 km, 87–323) distances, but the proportion of band recoveries to sightings was lower for short- than for long-distance dispersers, and it increased with distance. The recording rate declined sharply at the end of the first year of life, suggesting high mortality during this period. The main causes of death were electrocution and human persecution. Most long-distance dispersers were reported dead, suggesting that long-distance movements entailed some mortality costs.

KEY WORDS: *Bonelli's Eagle*; *Hieraaetus fasciatus*; *subadult dispersal*; *Catalonia*.

Dispersión de juveniles de águila perdicera en Cataluña

RESUMEN.—Describimos el patrón de recuperaciones y observaciones de 122 Águilas Perdieras (*Hieraaetus fasciatus*) equipadas con marcas alares y anillas en Cataluña, España entre 1986–93 con objeto de obtener información sobre sus movimientos antes de que sean reclutadas en territorios de cría. Hasta el final de 1998, se obtuvieron 18 recuperaciones de anillas y 42 observaciones de águilas no adultas. Las águilas se registraron entre 1 y 1020 km de sus respectivos nidos. La media geométrica de la distancia de registro (95% I.C.) fue de 101 km (72–153). Un 57% de las águilas permanecieron dentro de un radio de 100 km del lugar de nacimiento, pero un 33% se alejó más allá de 200 km. La zona central de Cataluña fue la principal área de acogida para las aves que se dispersaron a corta distancia (<200 km), mientras que las aves que efectuaron largos desplazamientos (>200 km) se dirigieron principalmente al centro y al sureste de España. No se encontraron diferencias significativas en la distancia de dispersión entre machos (101 km, 40–273, $N = 15$) y hembras (189 km, 86–419, $N = 11$), aunque una elevada proporción de machos se encontraron cercanos a las áreas de nidificación. La distancia recorrida no difirió entre juveniles (114 km, 68–193, $N = 43$) e inmaduros (77 km, 44–135, $N = 16$), pero estos últimos se registraron más frecuentemente a cortas distancias de las áreas de nidificación. No se encontraron diferencias significativas en la distancia según fueran observaciones (82 km, 54–137) o recuperaciones (167 km, 87–323), pero la proporción de recuperaciones en relación a las observaciones fue menor para cortas que para largas distancias de dispersión e incrementó con la distancia. La tasa global de recuperaciones y observaciones disminuyó acusadamente al final del primer año de vida, sugiriendo una elevada mortalidad durante este período. Las causas principales de mortalidad fueron la electrocución y la persecución. Los ejemplares dispersados a larga distancia fueron más frecuentemente registrados muertos que vivos, sugiriendo que los movimientos a larga distancia conllevan costes de mortalidad.

[Traducción de Autores]

In many large birds of prey, juveniles show nomadic behavior soon after becoming independent (González et al. 1989, Cugnasse and Cramm 1990).

These juvenile dispersal movements, as they are called, may lead young birds to settle in juvenile dispersal areas, which are seldom occupied by

breeding conspecifics (Ferrer 1993a, 1993b, Mañosa et al. 1998). In most cases, these nomadic birds are philopatric and return to breed near their natal areas (Newton 1979). Long-distance juvenile dispersal has been associated with individuals in the best of health (Ferrer 1992, 1993b, Walls et al. 1999). It allows them to explore and settle in new optimal and unoccupied areas (Horn 1983, Nilsson 1989). However, it may also entail several costs in terms of increased mortality or reduced lifetime reproductive success (Belichon et al. 1996), which is associated with suboptimal areas.

Populations of Bonelli's Eagles (*Hieraetus fasciatus*) are declining in most parts of Europe (Rocamora 1994), mainly as a result of high mortality (Real and Mañosa 1997). A sharp decline in the population in northern Spain has been partially attributed to unbalanced patterns of dispersal that may favor more southern populations (Real and Mañosa 1997). Although adults are sedentary (Cramp and Simmons 1980), juvenile and immature Bonelli's Eagles (1–3 yr old) show a wandering behavior (Cramp and Simmons 1980, Cugnasse and Cramm 1990, Mañosa et al. 1998), which has been poorly described. The aim of our study was to obtain data on the location of nonbreeding areas used by juvenile and immature Bonelli's Eagles hatched in northeastern Spain. We also collected information on the average distances traveled and the proportion of individuals involved in these movements. Finally, we discuss the implications of these movements in terms of the life history, population status, and conservation of Bonelli's Eagles.

METHODS

We conducted a wing tagging and banding project in northeastern Spain in Catalonia involving 36 pairs and 83 breeding attempts of Bonelli's Eagles from 1986–93. Every nestling between 40–55 d of age was marked with a 6-g metal ring on one leg, a 6-g, 3-digit PVC ring on the other leg, and plastic wing tags (Kochert et al. 1983) on each wing. The tag on the right wing identified the bird's area of origin and the color of the left tag denoted the year of tagging. Wing tags measured 6.7×13.5 mm when folded and weighed 11 g including rivets. We wrapped the wing tags around the humerus between the tertaries and scapulars and secured them with two pop rivets and glue. Wing-tag components were supplied by Saflag (Safety Flag Co. of America, Pawtucket, RI U.S.A.) between 1986–87, and by TXN-18 (Cooley Inc., Pawtucket, RI U.S.A.) between 1988–93. The age and sex of every nestling was determined at the time of banding following Mañosa et al. (1995).

We compiled data on movements of tagged eagles from band recoveries of birds found dead or injured and from incidental sightings of tagged birds. We requested

information on sightings of tagged eagles in Spain, France, Portugal, Italy, and Morocco by advertising in journals and newsletters of the main ornithological and conservation associations of southern and central Europe and northern Africa. We did not consider successive sightings of the same tagged bird in a given area. Since our study focused on dispersal movements of juvenile and immature eagles and not on natal dispersal, we analyzed only sightings and band recoveries involving nonbreeding birds <3 yr old. According to published information about the postfledging period of Bonelli's Eagle (Real et al. 1998), the birds sighted or recovered before 100 days after fledging and within a radius of 8 km from the nest were not dispersed, and were not considered.

We computed distances traveled and compass directions from natal nests, if known, or from the geometric center of marking areas if the exact identity of birds was unknown. In this case, however, compass direction of the movement was only reported for birds observed outside the circle centered on the geometric center of the marking area and encompassing all the nests where young eagles were tagged.

Bird ages were all computed from 31 May (age 0) of the hatching year, the approximate average fledging date for the study population (Real 1991). We established two age categories: juvenile (<366 d of age) and immature (366–1095 d of age).

As dispersal distances showed a skewed distribution, results are given as geometric mean distances with 95% C.I. We used 2-tailed *t*-tests (unless otherwise stated) to compare log-transformed dispersal distances between sightings and recoveries, between males and females, and between juvenile and immature categories. We used Fisher exact probability tests to compare percentages. We conducted standard statistical analyses with the SPSS package for Windows (SPSS-Inc. 1990) and computed circular statistics following Zar (1984).

RESULTS

After accounting for tag loss in nests and mortality during the nestling period, we estimated that 122 tagged nestlings successfully fledged from nests. At least four of them died during the dependency period (3.3% of tagged birds). One was killed by an Eagle Owl (*Bubo bubo*), one starved, and two were electrocuted. We recorded 18 band recoveries (15%) and 42 sightings (35%) of tagged eagles between 1986–98. Most of these occurred in the first year after fledging and declined thereafter (Fig. 1).

Juvenile and immature eagles dispersed to 1–1020 km from natal areas (Fig. 2). Because these distances showed a bimodal distribution (Fig. 3), we classed the eagles as either short-distance (<200 km) or long-distance dispersers (>200 km). Some juvenile Bonelli's Eagles moved >500 km from their natal areas within 1 mo of fledging (Fig. 2). The geometric mean dispersal distance (95%

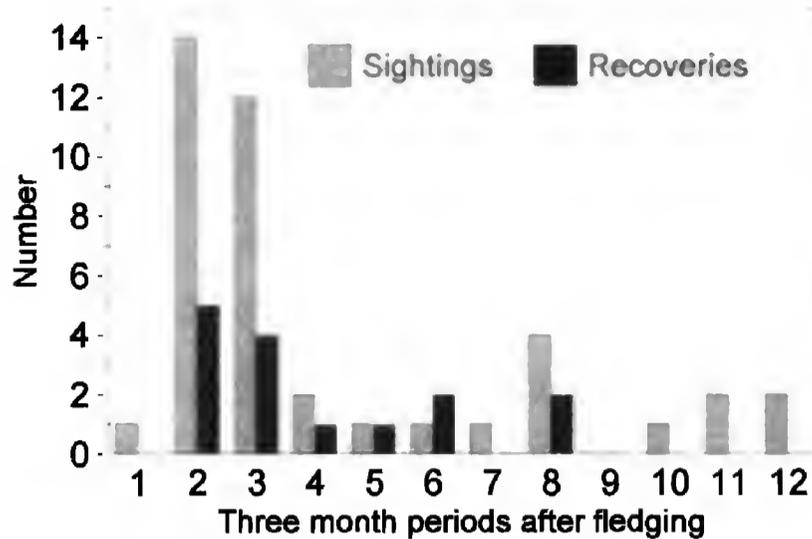


Figure 1. Number of sightings and band returns of juvenile and immature Bonelli's Eagles in relation to time after fledging.

C.I.) was 101 km (72–153, $N = 60$), with a median of 70 km. Although most birds (57%) were reported within 100 km of their natal sites, 33% went farther than 200 km (Fig. 3). The proportion of long-distance dispersers was similar in both sexes (5 of 11 females vs. 7 of 15 males), and the distance traveled by females (189 km, 86–419, $N = 11$) was not significantly different from that traveled by males (101 km, 40–273, $N = 15$; $t_{24} = -0.98$, $P = 0.34$). However, a higher proportion of males concentrated at shorter distances (Fig. 4a). The distance traveled did not differ between juvenile (114 km, 68–193, $N = 43$) and immature eagles (77 km, 44–135, $N = 16$; $t_{57} = 0.99$, $P = 0.33$); but, while the number of juveniles increased with distance, immatures showed the reversed trend (Fig. 4b).

The average azimuth to which eagles traveled was $258 \pm 59^\circ\text{E}$, $N = 33$). Most short-distance dispersals were recorded in central Catalonia, followed by the Ebre delta and the Aiguamolls de l'Empordà (Fig. 5a, b). Long-distance dispersers were mainly reported in central (Madrid, Toledo, and Extremadura) and southeastern (Alicante, Murcia, Albacete, and Eastern Andalusia) Spain, with fewer reports in northern Spain and France (Fig. 6). The distance at which sightings (82 km, 54–137) and band recoveries (167 km, 87–323) were reported did not vary significantly ($t_{59} = 1.66$, $P = 0.10$), whereas the proportion of band recoveries to sightings was lower for short-distance dispersers (9 vs. 31) than for long-distance dispersers (9 vs. 11) (one-tailed Fisher exact probability test = 0.07), and increased with distance, as did the absolute number of recoveries (Fig. 4c).

Of the 18 banded birds found dead, 10 (55%)

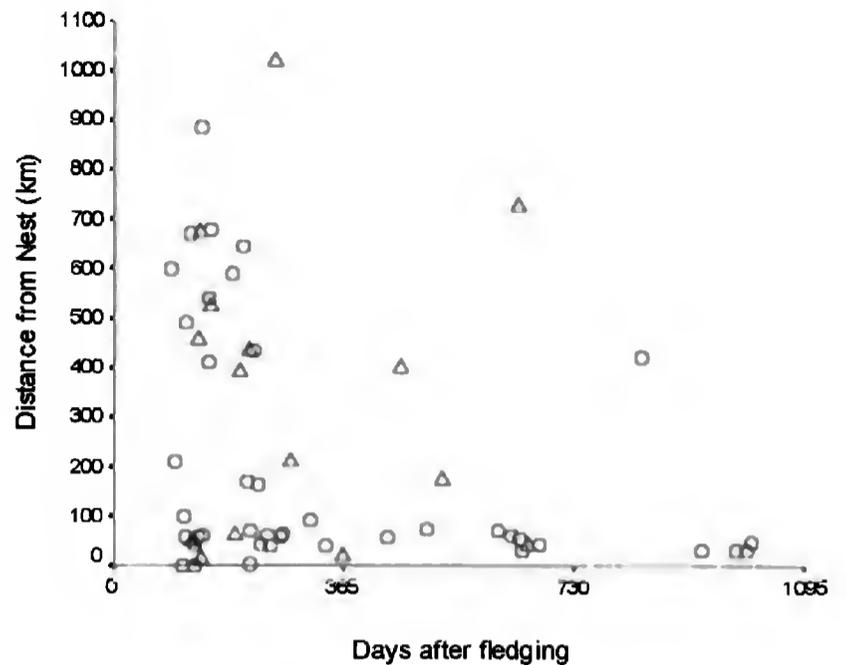


Figure 2. Dispersal distances of juvenile and immature Bonelli's Eagles after fledging. Circles represent sightings and triangles represent band recoveries.

were electrocuted, 4 (22%) were shot, trapped or poisoned, 1 (6%) starved, and the cause of death for the remaining 3 (17%) was unknown. For short-distance dispersers, 5 (72%) were electrocuted, 1 (14%) was shot, and 1 (14%) starved. For long-distance dispersers, 5 (63%) were electrocuted and 3 (37%) were killed by people.

DISCUSSION

A significant fraction of young Bonelli's Eagles produced in northeastern Spain travel long distances. Although banding and wing tagging are more likely to provide information on populated areas (Kochert et al. 1983, Young and Kochert 1987, Francis and Cooke 1993), we believe that the

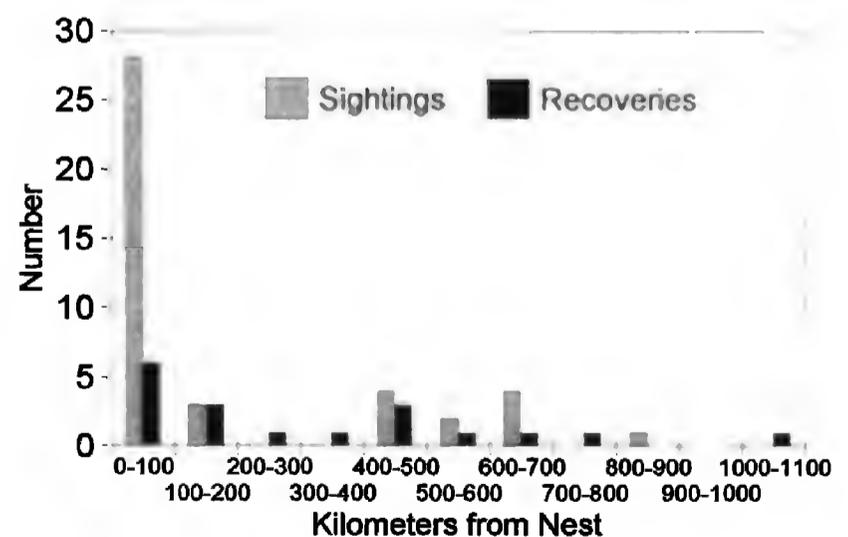


Figure 3. Distribution of the number of sightings and band recoveries of juvenile and immature Bonelli's Eagles according to distance (km) traveled.

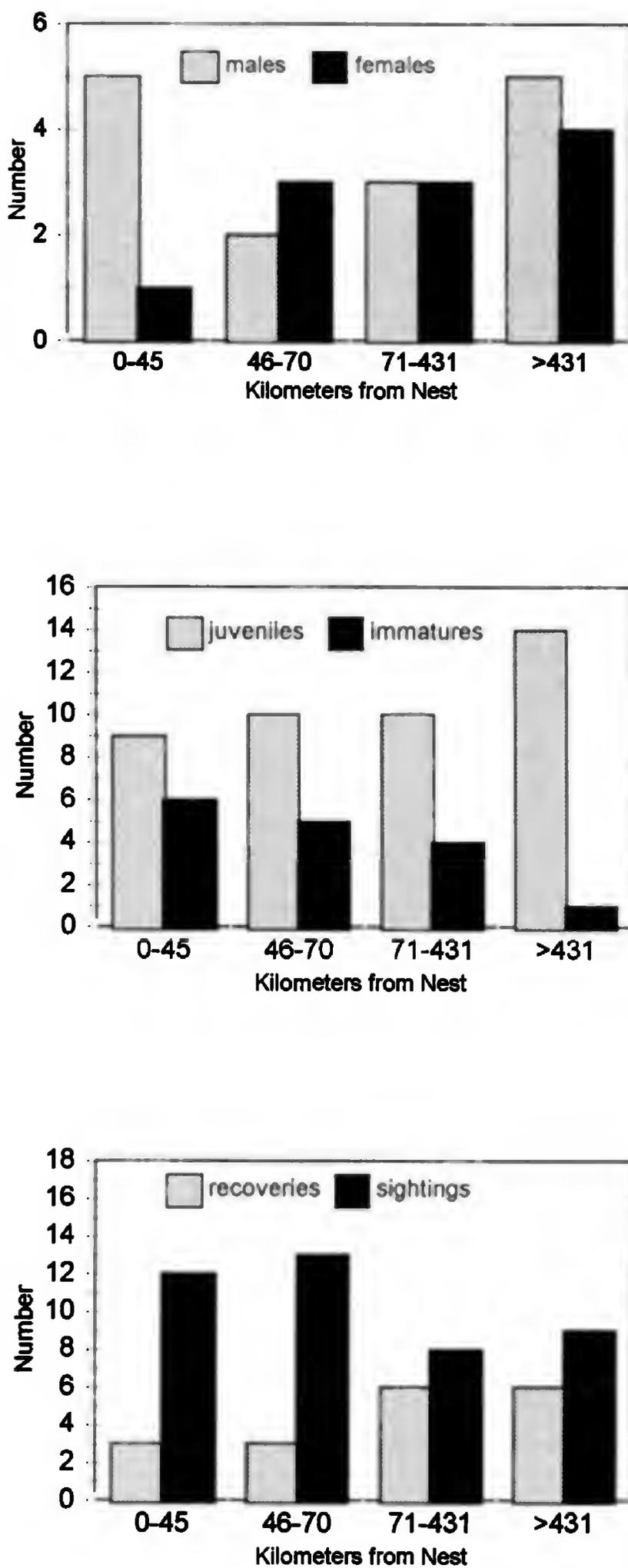


Figure 4. Distribution of distance traveled by (top) male and female Bonelli's Eagles, (middle) juvenile and immature Bonelli's Eagles, and (bottom) band recoveries and sightings. Intervals are 25% percentiles of the global distance distribution.

effect of such bias on our results was low. The areas with high observation rates (northeastern, central, and southeastern Spain) are not among the most frequently visited by ornithologists and birdwatchers. Moreover, the main dispersal areas we have identified agree with those recently-identified by conventional or satellite radio telemetry, as well as with areas where concentrations of juvenile and immature Bonelli's Eagles have been previously reported (Arroyo and Garza 1996, Cheylan and Marmasse 1998, Mañosa et al. 1998).

Male and female eagles showed different dispersal patterns. Although both genders moved long distances, male Bonelli's Eagles remained near their natal areas more often as is typical of other species of raptors (Greenwood et al. 1979, Newton and Mearns 1988, Ferrer 1993a, Walls and Kenward 1995). The opposite trend shown by juvenile and immature eagles may indicate that Bonelli's Eagles return to their natal areas as they grow older (González et al. 1989, Walls and Kenward 1994) or that long-distance dispersers suffer high mortality (Belichon et al. 1996). Higher mortality associated with dispersal could have accounted for the marked decline in the number of sightings and band recoveries with age. Our data suggest that power line casualties and illegal persecution by people remain chief causes of mortality for juvenile and immature Bonelli's Eagles.

The fact that relative and absolute numbers of recoveries (dead eagles) increased with distance from natal areas indicated that long-distance movements entailed a cost for eagle survival. Moreover, all the eagles that had moved to northern and Atlantic France, far from the usual distribution range of the species, were reported dead or in poor condition.

Juvenile Bonelli's Eagles that fledge in northeastern Spain undertake long-distance movements more often than eagles in France (Cheylan et al. 1996), and may thus experience additional mortality (Belichon et al. 1996). The population of Bonelli's Eagles in northeastern Spain is at the edge of the distribution range of the species, and might thus be particularly exposed to the negative consequences of dispersal (Gadgil 1971, Walters et al. 1999). Since a large fraction of the Bonelli's Eagles produced in northeastern Spain move to close or distant dispersal areas, their conservation should rely on the effective management of these areas. This includes the reduction of power line mortality and illegal persecution, and management to main-

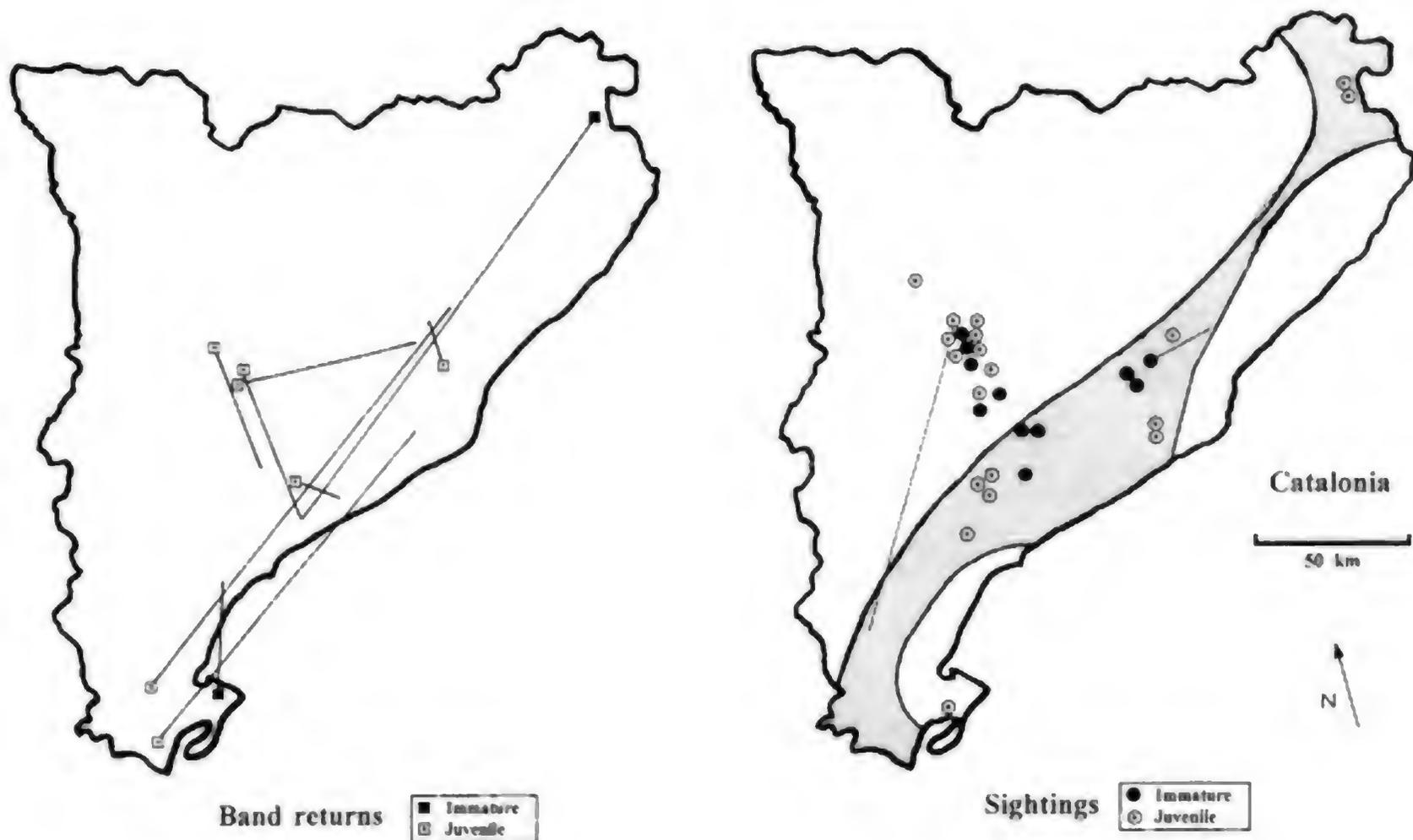


Figure 5. Maps of the study area showing short-distance (<200 km) records of juvenile and immature Bonelli's Eagles. The shaded area shows the tagging region. Lines join known natal sites and recovery sites.

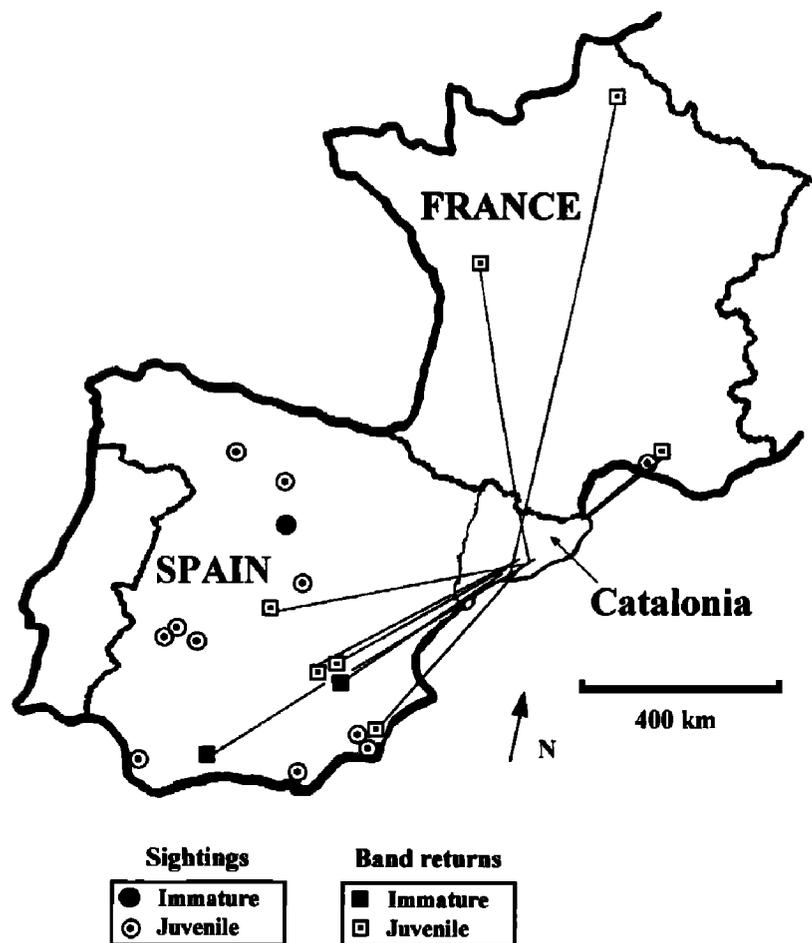


Figure 6. Map of long-distance (>200 km) band recovery and sightings of juvenile and immature Bonelli's Eagles dispersing from northeastern Spain. Lines join known natal sites and recovery sites.

tain sufficient prey availability (Bustamante et al. 1997, Ferrer and Harte 1997, Mañosa et al. 1998). These measures should be undertaken both in northeastern Spain and in distant dispersal areas in southern and central Spain.

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ESTIMATING THE BREEDING POPULATION OF BOOTED EAGLES IN THE CAPE PROVINCE, SOUTH AFRICA

DAVID PEPLER

*Department of Nature Conservation, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch,
Private Bag XI, Matieland 7602, South Africa*

ROB MARTIN

*Department of Forest Science, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch, Private Bag XI,
Matieland 7602, South Africa*

HUBERTUS J. VAN HENSBERGEN

*Department of Nature Conservation, Faculty of Agricultural and Forestry Sciences, University of Stellenbosch,
private Bag XI, Matieland 7602, South Africa*

ABSTRACT.—Data on the breeding range of Booted Eagles (*Hieraaetus pennatus*) were collected over 25 yr in the Northern, Western, and Eastern Cape Provinces, South Africa, to estimate the breeding population. Based on the distribution of 150 known nest sites, we used information from digital terrain models to define topographical characteristics of nest sites. This information was used to identify the total suitable nesting habitat in the study area. By calculating the mean inter-nest distance, we estimated the total nesting population through extrapolation. With a mean inter-nest distance of 9.7 km, we arrived at an estimate of 702 nests. In core areas that we have studied intensively, we found even higher breeding densities and therefore consider our estimate to be conservative.

KEY WORDS: *Booted Eagle*, *Hieraaetus pennatus*; *breeding density*; *South Africa*; *GIS habitat delineation*; *population estimation*.

Estimación de la población reproductiva de *Hieraaetus pennatus* en la provincia del Cabo, Suráfrica

RESUMEN.—Recopilamos datos sobre el rango de reproducción de *Hieraaetus pennatus* durante 25 años en el norte, oeste y este de la Provincia del Cabo, Suráfrica para estimar la población reproductiva. Con base en la distribución de 150 sitios de nidos, utilizamos información de modelos digitales del terreno para definir las características topográficas de los sitios de anidación. Esta información fue utilizada para identificar el total del habitat propicio para anidación en el área de estudio. Al extrapolar el cálculo de la media de la distancia entre nidos, estimamos el total de la población anidante. Con una media de distancia entre nidos de 9.7 km, llegamos a un estimativo de 702 nidos. En las áreas centrales que hemos estudiado intensivamente, encontramos densidades aún mas altas, por lo tanto consideramos que nuestro estimativo es conservador.

[Traducción de César Márquez]

In contrast to the Palearctic region, where the biology of the Booted Eagle (*Hieraaetus pennatus*) is well-known (Cramp and Simmons 1980, del Hoyo et al. 1994, Suárez et al. 2000), only its breeding biology has been studied in southern Africa (Steyn and Grobler 1981, 1985). This breeding population was only recently discovered (Martin and Martin 1974, Brooke et al. 1980) and the first modern breeding record was confirmed in 1973 (Martin and Martin 1974). The extent of the breeding range was clarified by models of seasonality and associated breeding by Boshoff and Allan (1997)

and Harrison et al. (1997) but the range is complicated because there appear to be three separate populations of Booted Eagles in southern Africa (Boshoff and Allan 1997). These populations consist of nonbreeding summer migrants from the Palearctic region, a relict breeding population from the Waterberg in Namibia, and a breeding population in the Cape Province (del Hoyo et al. 1994, Brooke et al. 1980). To further complicate the situation, some eagles overwinter in the southwestern Cape Province (Pepler and Martin 1997). To date, only one estimate of breeding population (400

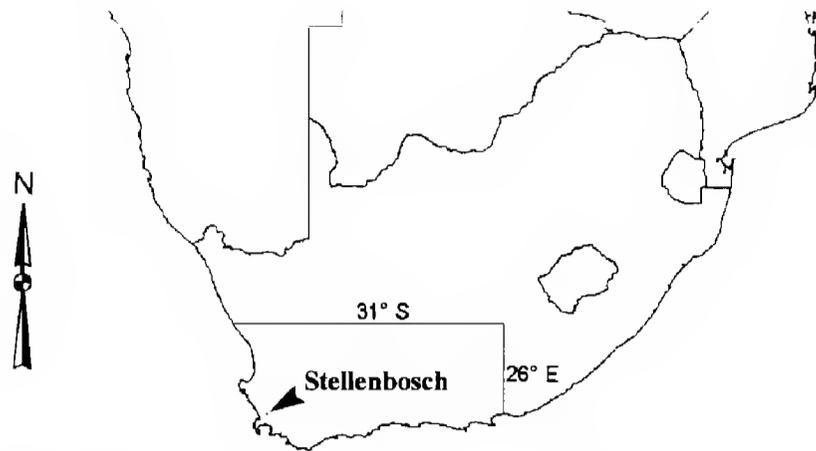


Figure 1. The study area in southern Africa.

pairs) has been made for the Cape Province (Martin and Martin 1991).

We collected data on the breeding range and density of the Booted Eagle population in the Cape Province over the past 25 yr through direct observations. We used elevation information from digital terrain models to define the topographical characteristics of Booted Eagle nesting sites based on the distribution of 150 known sites to determine the total area of suitable habitat. To estimate the total nesting population, we established the nesting density within suitable habitat by calculating the mean inter-nest distance following the method of Pepler et al. (1991). In this method a plot of the cumulative sum of deviations from the running mean (Lombaard 1989) indicates changes in density with distance. This method is more typically used in the analysis of time-series data but is applied in this case to the distance series. A systematic deviation from zero is indicative of a change in trend, in this case inter-nest distance.

STUDY AREA AND METHODS

The study area covered the portion of southern Africa south of 31°S and west of 26°E (Fig. 1). The total land area was 263 532 km². The town of Stellenbosch (33°55'S, 18°52'E) was used as our base. Our study area covered most of the perceived breeding range as described by Steyn (1982) and Boshoff and Allan (1997). The study was conducted annually from 1975–93. Timing of fieldwork was restricted to the breeding season, which was typically from September to December.

Within our study area, Booted Eagles hunted and bred in both hilly and open country, preferring habitats consisting of nama karoo, succulent karoo and fynbos (Low and Rebelo 1996) and, especially, the ecotones between these habitat types (Boshoff and Allan 1997). In recent years, however, we observed Booted Eagles hunting in suburban areas (Pepler and Martin 1996), and it is reasonable to assume that records of breeding from within these areas will be found in due course.

We searched for nests from roads that gave access to

mountainous areas, and strategic vantage points were selected that afforded the greatest possible field of view. The total distance covered during the course of the fieldwork was in excess of 500 000 km (approximately 2 km traveled per km² of the study area or 0.1/km per yr). Occupied nest sites were confirmed when one or both adults were seen carrying nesting material to a specific site, prey items were seen being carried to sites, or young were observed at sites before they fledged. Nests were typically situated behind small trees or shrubs growing on cliffs. Whitewash around occupied nest sites has a unique streaked appearance that helped us locate them from greater distances.

Breeding sites were plotted on 1:250 000 topographical maps and subsequently digitized into a format compatible with an ARC/INFO Geographic Information System (Environmental Systems Research Institute, Inc., 380 New York Street, Redlands, CA 92373-8100, U.S.A.). Elevation data for the study area were obtained from national digital elevation data (Department of Land Information Systems, Private Bag X10, Mowbray 7705, South Africa) and these data were also imported into the GIS. The vertical interval for the elevation data was 250 m.

Booted Eagle nest sites are associated with mountainous country with broken terrain (Steyn 1982). Elevation alone was not a good indicator of suitable habitat because the eagles do not nest on high plateaus. Steep slopes were also indicators of suitable habitat but evenly sloping areas are not used for nesting. The broken terrain used by Booted Eagles was identified using the rate of change of slope which was determined from the second derivative of the function describing the surface. The function was calculated for each point from the eight elevations immediately adjacent to a point as well as the elevation of the point itself. The value referred to a point at the center of a grid of nine points with a total dimension of 678 × 678 m. High values of this parameter indicated the rapidly changing slopes associated with broken hilly country while excluding plateaus and smooth inclines. Low values indicated constant slope. A number of values of this parameter were tried until one, which by inspection of the area covered on the map just included the distribution of the majority of the known nests, was found. The term "mountainous," in the context of this analysis, was taken as any area with a second derivative of height greater than, or equal to, 0.2. The cell size for the analysis was fixed at 226 × 226 m (51 076 m²) since this was the scale at which the second derivative was calculated. Finally, we calculated the total number of cells in the mountainous and nonmountainous areas and the percentage of the study area that was mountainous.

Since the survey was carried out from roads, it was possible that undetected nests in areas isolated from roads might cause an overestimate of the inter-nest distance and an underestimate of the density. Similarly, the survey was spread over a wide area and it was likely that nests closer to our base in Stellenbosch could have been more likely to be found. To determine if this was the case, we calculated the cumulative sum of deviations from the running mean (CUSUM, Lombaard 1989, Pepler et al. 1991) for inter-nest distances based on the observations ordered in increasing distance from a road and also on increasing distance from Stellenbosch.

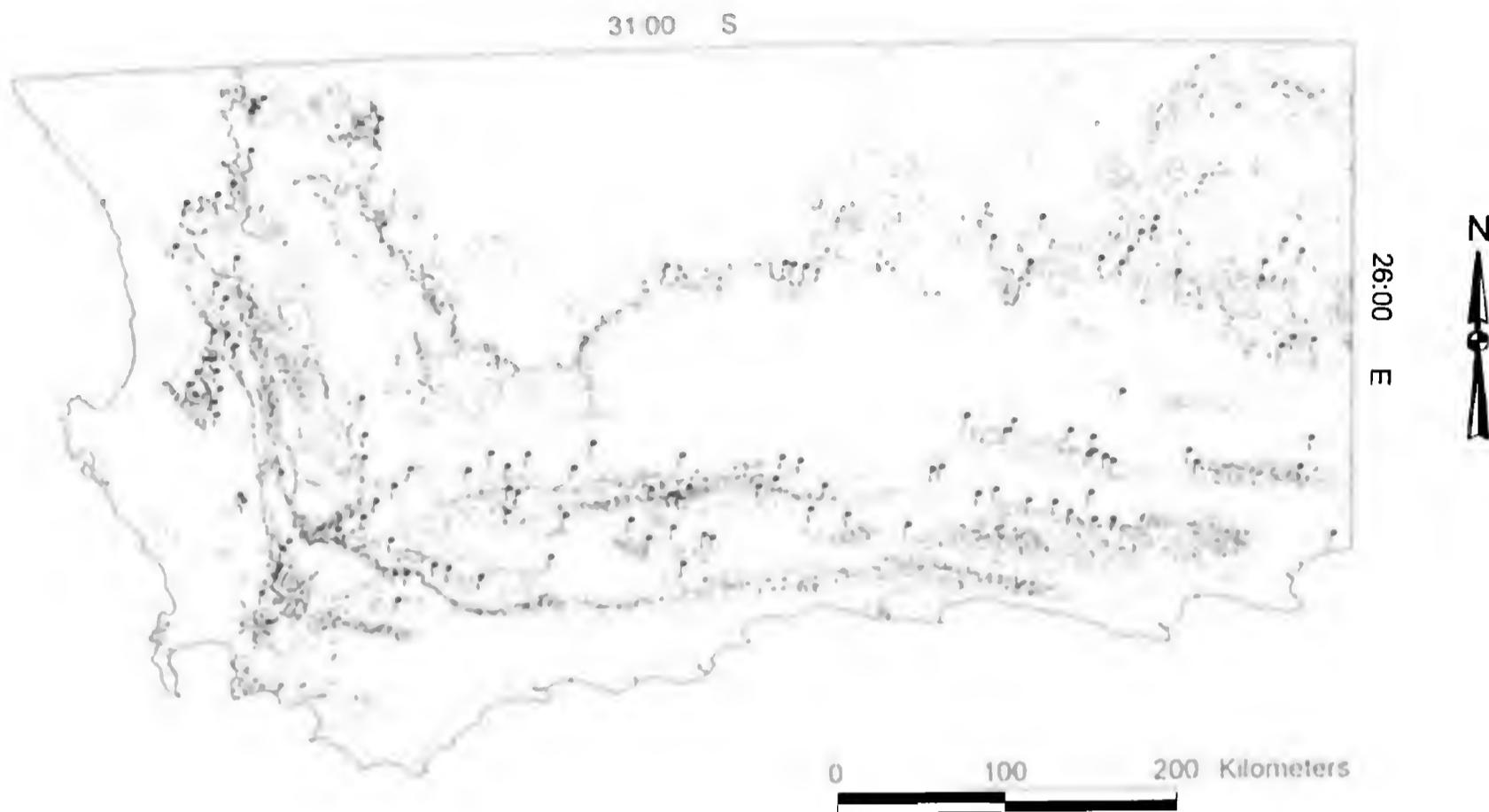


Figure 2. Breeding distribution of Booted Eagles in southern Africa. Nest sites are flagged and areas with second derivatives of the surface function >0.2 are shaded.

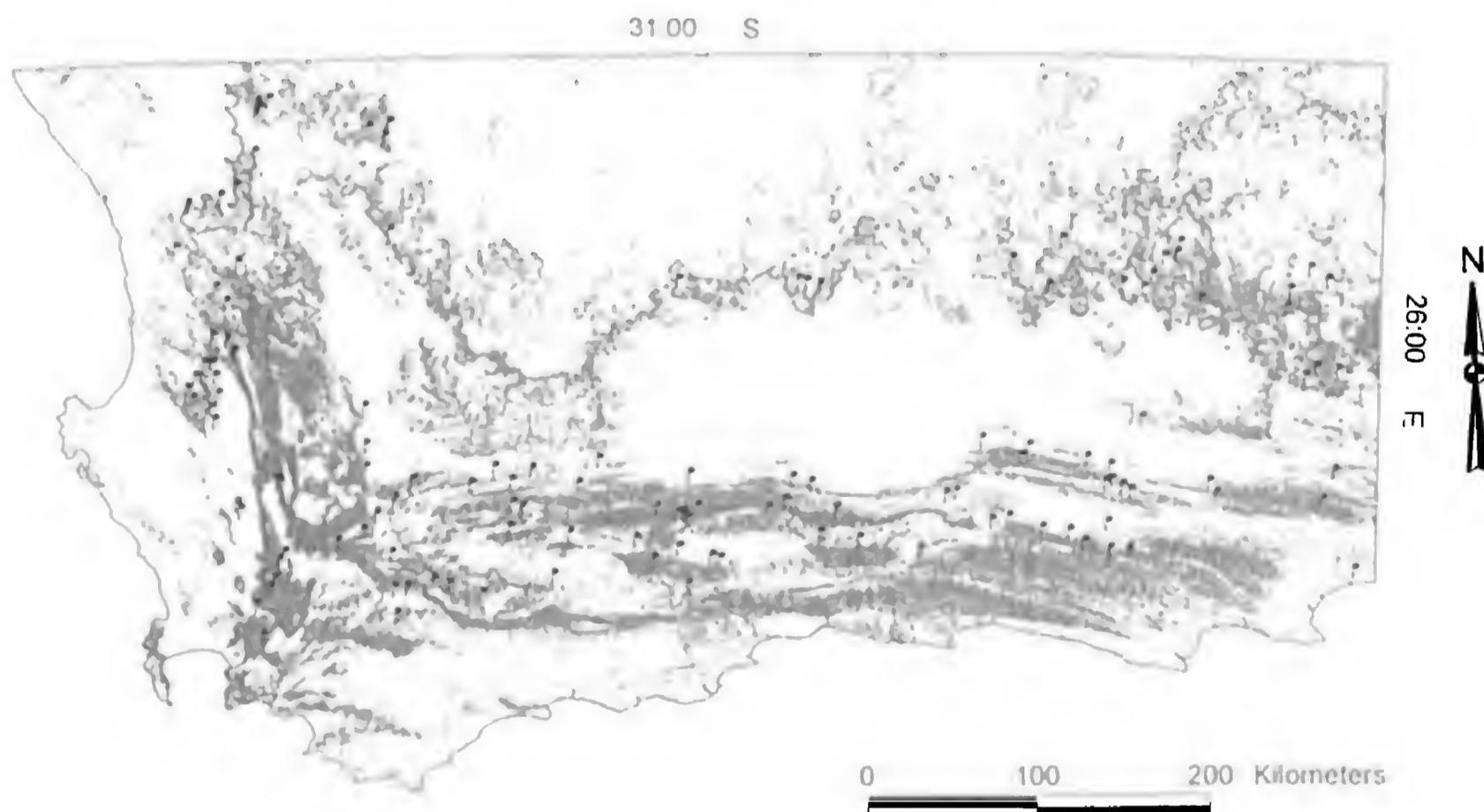


Figure 3. Breeding distribution of Booted Eagles in southern Africa. Nest sites are flagged and areas of steep slope with first derivative values >6.5 are shaded.

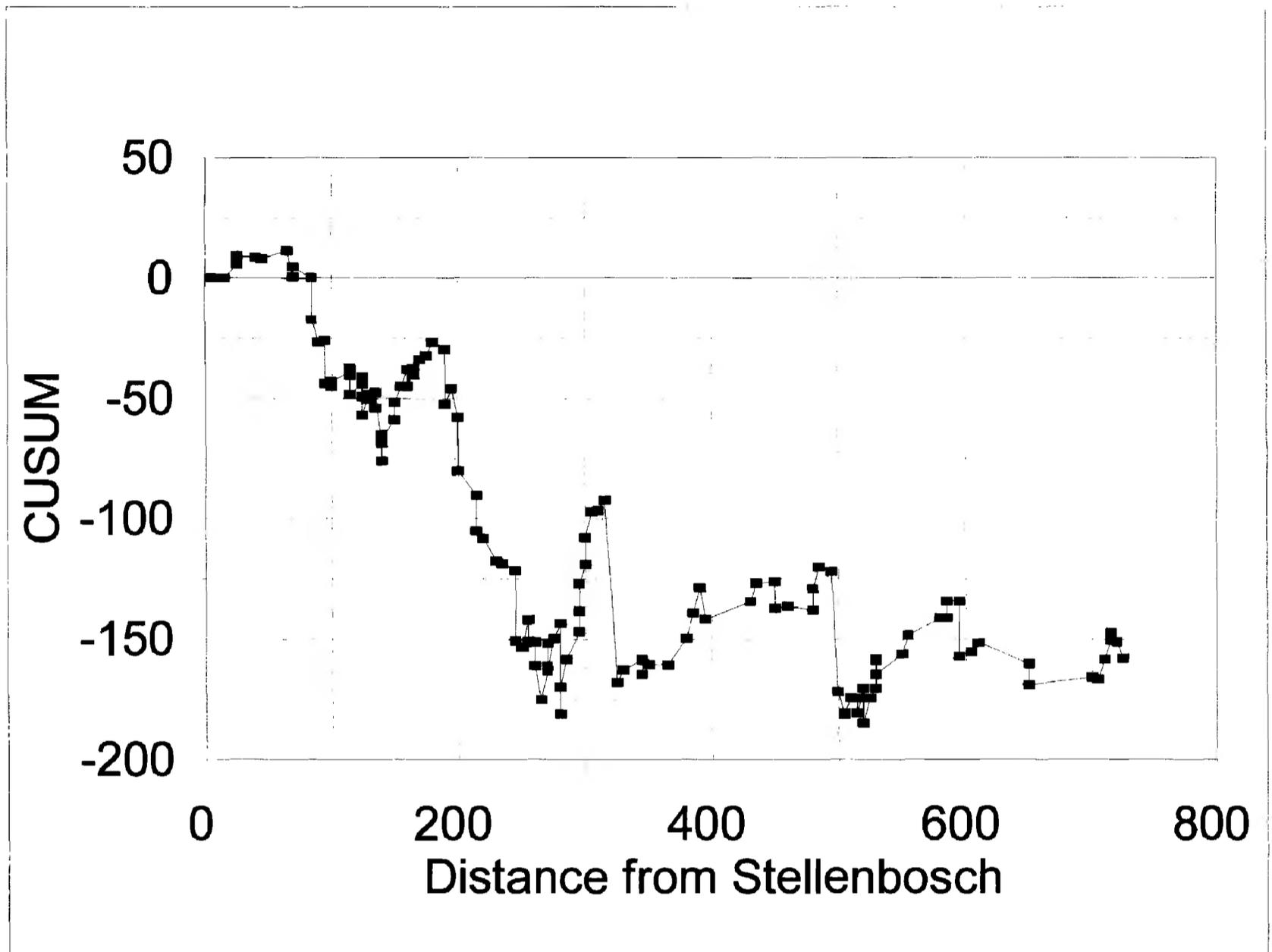


Figure 4. Cumulative sum of deviations from the running mean (CUSUM) plot for Booted Eagle inter-nest distances (km) and distances from Stellenbosch (km).

RESULTS

The breeding distribution of Booted Eagles corresponded closely with areas where the second derivative of the surface function had values >0.2 (Fig. 2). This differed from areas of steep slopes where first derivative values were >6.5 (Fig. 3). The total area of the habitat identified is 61 663 km².

CUSUM showed a possible change in inter-nest distance for sites in excess of 200 km from Stellenbosch (Fig. 4), so we based our calculations of inter-nest distances on nests at distances <200 km from Stellenbosch. There was no evidence that nest detection was based on distance from roads since no change point was evident in the CUSUM plot. Therefore, we used observations within 200 km of Stellenbosch to calculate our estimate of breeding density. Calculation of this estimate was based on two crucial assumptions. First, that the

area included in our survey was representative of the entire area in terms of the average inter-nest distance and, second, that the estimate of inter-nest distance was accurate. The mean inter-nest distance was 9.677 km (95% CI = 9.17–10.18) and the estimate of the total breeding population for the study area was 702 pairs (95% CI = 576–879).

DISCUSSION

The results of our analysis were comparable to the atlas data of Harrison et al. (1997), especially with their models of breeding rate based on seasonality and breeding in zones four and eight.

Our study was carried out over 25 yr and we assumed that all the recorded nests remained occupied throughout the study period. We made this assumption because we have, in a number of cases, observed the continuous occupation of particular nesting sites for periods ranging from 1972–99. Be-

cause our observations were made from roads, we made no attempt to sample many of the mountain massifs. Therefore, it was possible that densities within these massifs were lower than we estimated.

Given the very high breeding density of four pairs of breeding Booted Eagles in a 3 km² area that was recorded by Martin and Martin (1988, 1995) in parts of our study area, we considered our calculation of the total population to be a substantial underestimate. This did not imply that such a high density is evenly maintained throughout the entire breeding range, but the severe constraints of time and logistics placed on a study of this nature preclude saturation sampling. An example of such an undersampled area is the mountain range of the Great Escarpment between Beaufort West (32°20'S, 22°38'E) and Calvinia (31°27'S, 19°50'E).

We believe that our data present the first attempt at an estimation of an entire breeding population of Booted Eagles in Africa. It has been suggested that this southern breeding population may be a subspecies of the northern Booted Eagle (R. Yosef and G. Verdoorn pers. comm.), but this needs confirmation. Elsewhere in its range only "fairly approximate estimates" of breeding density exist (del Hoyo et al. 1994). With time, we are confident that additional data will expand our database and increase the accuracy of our breeding density calculations.

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SEX DETERMINATION IN BOOTED EAGLES (*HIERAAETUS PENNATUS*) USING MOLECULAR PROCEDURES AND DISCRIMINANT FUNCTION ANALYSIS

JAVIER BALBONTÍN, MIGUEL FERRER, AND EVA CASADO

Estación Biológica de Doñana (CSIC) Avda. María Luisa s/n, Pabellón del Perú, 41013 Sevilla, Spain

ABSTRACT.—We studied a breeding population of Booted Eagles (*Hieraaetus pennatus*) in Doñana National Park (southwestern Spain) to develop a method of determining the sex of an individual based on the use of discriminant functions. Because there are size differences between age classes and sexes of eagles, we developed two different discriminant functions for each age group. Our discriminant function method approached 100% accuracy in correctly aging individuals using forearm length and body mass as predictor variables. Sex of young eagles was also determined with 98.8% accuracy using forearm, tail, bill, and tarsus lengths.

KEY WORDS: *Booted Eagle*, *Hieraaetus pennatus*; sex determination; morphometrics; molecular sexing.

Determinación del sexo del águila calzada *Hieraaetus pennatus* utilizando técnicas de sexado molecular y análisis discriminantes

RESUMEN.—Una población reproductora de águila calzada ha sido estudiada en el Parque Nacional de Doñana (Sudoeste de España) con el objetivo de obtener un modelo de clasificación de los sexos basados en análisis discriminantes apoyados en procedimientos de sexado molecular. Existen diferencias importantes en el tamaño entre águilas adultas y pollos, por lo que se han desarrollado dos funciones discriminantes de sexo diferentes para cada clase de edad. El sexo de los adultos se determina con una función discriminante que clasifica bien el 100% de los individuos, utilizando el antebrazo y el peso como variables predictoras. El sexo de los pollos es determinado también correctamente con una función discriminante que clasifica bien el 98.8% de los individuos, utilizando cuatro variables predictoras: El antebrazo, la cola, el pico y el tarso.

[Traducción de Autores]

Easy and reliable methods to identify the sex of individuals are useful for the study of many aspects of avian biology, including foraging ecology (Anderson and Norberg 1981), behavior, evolutionary ecology and genetics (Clutton-Brock 1986), survivorship (Newton et al. 1983), and dispersion and conservation genetics (Griffith and Tiwari 1995). Sex determination is also important in conservation programs that concern the reintroduction of endangered birds when a fixed sex ratio is preferred. Recently, Ellegren (1996) proposed molecular methods to sex birds based on chromosome differences but few studies have used this information to develop additional methods to sex birds based on biometric data. Field methods to sex raptors have several advantages over molecular techniques that require time and/or money. Despite the fact that the majority of raptors are highly dimorphic in size, which should allow for the development of sexing methods based on morphomet-

ric data, only a few species have been utilized (Bortolotti 1984a, 1984b, Garcelon et al. 1985, Edwards and Kochert 1987, Ferrer and De Le Court 1992). The majority of these studies have been based on live individuals and museum skins. In most cases, both adults and immatures have been studied at museums or in private collections and few studies have been based on wild individuals. The objective of this study was to assess the differences between young and adult Booted Eagles (*Hieraaetus pennatus*) and to develop predictive discriminant models to determine the sexes of adults and immatures of the species.

METHODS

We used a sample of the breeding population of Booted Eagles in Doñana National Park. The park is located in southwestern Spain (37°N, 6°30'W). It has a Mediterranean climate with an Atlantic Ocean influence. Marshes, Mediterranean scrubland mixed with scattered cork oak (*Quercus suber*) or stone pine (*Pinus pinea*), and coastal

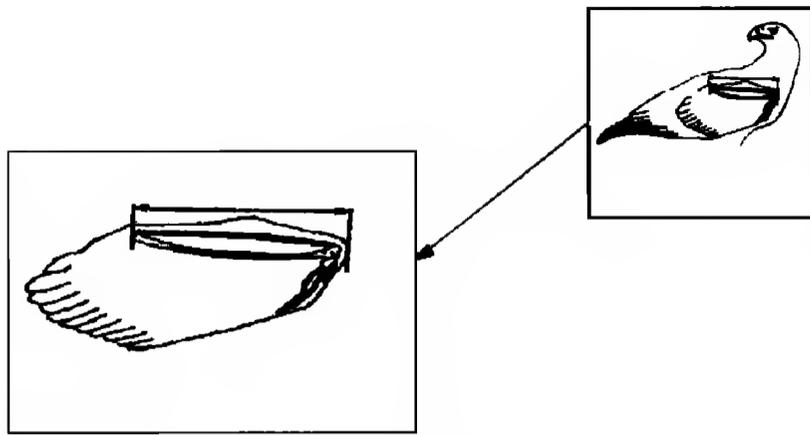


Figure 1. Measurement of forearm length in Booted Eagle.

sand dunes are the main habitats found in the area. A more detailed description of this area is presented in Rogers and Myers (1980).

Six morphometric measurements were taken from wild adult and immature eagles. To obtain measurements, we visited nests when young were 35–45 d old and their skeletons were completely grown but their feathers were still growing. Young leave the nest when they are about 55 d old (Balbontin unpubl. data). A total of 100 young were measured between 1996–98. Adults were trapped using a 2 × 3 m dho gaza net and an unreleasable captive owl (*Bubo bubo*) lure. Forty-two adults were caught using this method, 12 in 1997 and 30 in 1998. We took measurements of wing, tail, bill with cere, and tarsus lengths using a digital caliper to the nearest 0.1 mm and metal rulers to the nearest 1 mm (Bortolotti 1984). We also measured the forearm length, or the length from the front of the folded wrist to the proximal extremity of the ulna using calipers (Fig. 1) (Ferrer and De Le Court 1992). All the individuals were weighed with 1 kg or 2.5 kg Pesola scales with precisions of 5 g and 10 g, respectively.

We extracted 2 ml of blood from the brachial vein of each eagle and stored part of it (50 µl) in buffer and kept it refrigerated for later analysis. The cellular fraction was used to sex the eagles following Ellegren (1996). We used primers 2945F, cfR, and 3224R to amplify the W-

chromosome gene following Ellegren's (1996) recommendations. Using this technique, we identified the sexes of 81 immature (41 females, 40 males) and 41 adult eagles (16 males, 25 females) (Fig. 2). This sample of known-sex individuals was used to derive the discriminant function using morphometric data.

Because young often differ in size from adults (Bortolotti 1984b), we used multivariate analysis of variance (MANOVA) to check for differences in size between males and females and young and adult eagles. Six measurements taken from all age and sex classes were compared using univariate analysis of variance (ANOVA) and nonparametric statistics for those variables when homogeneity of variance was not met. We used the SPSS program (Norusis 1992) to do this analysis. We separated young from adults to examine differences between sexes. First, we checked for sexual differences for each of the six morphological characters using *t*-tests. We derived a discriminant function using DISCRIM procedure of the SAS System program (version 6.12). A jackknife procedure was applied to test the efficacy of the estimated discriminant function (Lachenbruch and Mickey 1968). Each individual in the sample was classified using a discriminant function derived from the total sample, excluding the individual being classified (Chardine and Morris 1989, Amat et al. 1993). We chose the function which had the lowest percentage of misclassification based on the molecular determination of gender.

RESULTS AND DISCUSSION

Our analyses of the morphometric data showed that adult Booted Eagles differed significantly in size from young eagles and that males were significantly smaller than females (MANOVA: sex - $F = 72.0$, $df = 6, 111$, $P < 0.001$; age - $F = 181.85$, $df = 6, 111$, $P < 0.001$). Tail, wing, and culmen measurement showed the greatest difference between age groups, with the features of adult individuals larger than those of immatures (Table 1). There were no significant age- or sex-specific differences in bone measurements such as tarsus and forearm

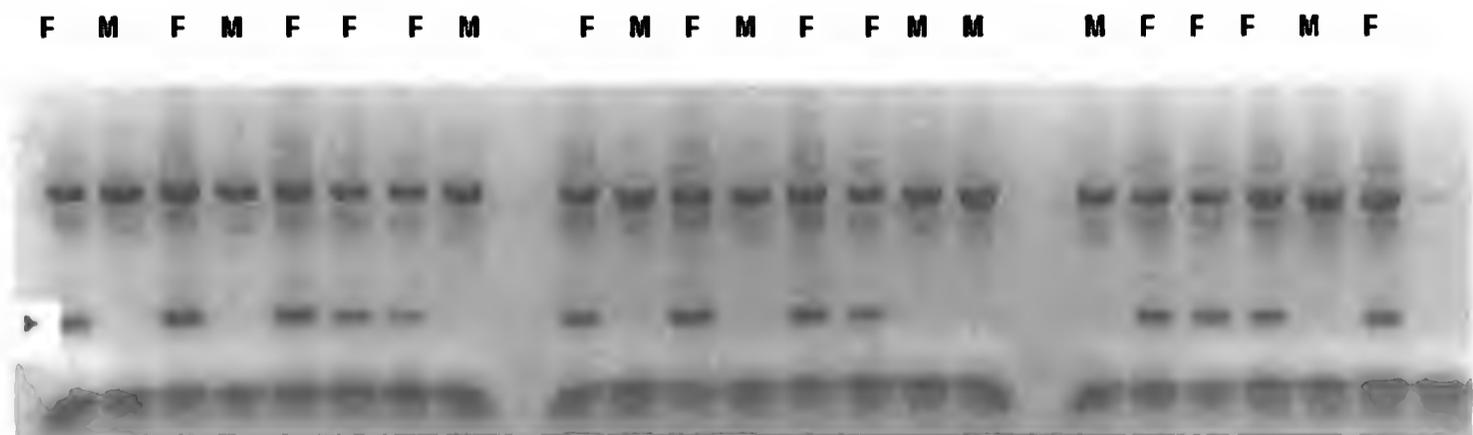


Figure 2. Gender identification using PCR test. A multiple amplification with 2945F and cfR specifically amplify a 210 bp fragment of the W chromosome in females and 2945F + 3224R that amplifies 630 bp fragments in both sexes. Females are indicated by the arrow.

Table 1. Morphometric measurements in mm of young and adult Booted Eagles.

| | MALES | | | | FEMALES | | | | | |
|---------|---|---|------|-------|---------|---|---|-------|-------|--------|
| | YOUNG (N = 40) ($\bar{x} \pm SD$) | ADULT (N = 16) ($\bar{x} \pm SD$) | F | Z | P | YOUNG (N = 41) ($\bar{x} \pm SD$) | ADULT (N = 25) ($\bar{x} \pm SD$) | F | Z | P |
| Tarsus | 64.4 ± 2.51 | 64.1 ± 2.77 | 0.33 | | 0.563 | 69.3 ± 3.30 | 69.4 ± 3.2 | 0.168 | | >0.05 |
| Forearm | 131.5 ± 2.64 | 132.2 ± 4.72 | 0.65 | | 0.658 | 140.0 ± 4.85 | 143.5 ± 3.2 | 10.26 | | <0.01 |
| Culmen | 28.8 ± 1.29 | 31.5 ± 1.14 | 54.1 | | <0.001 | 30.9 ± 1.0 | 34.8 ± 1.3 | 164.1 | | <0.001 |
| Wing | 244.4 ± 25.9 | 363.8 ± 7.99 | | -5.80 | <0.001 | 244.6 ± 28.8 | 389.2 ± 9.4 | | -6.77 | <0.001 |
| Tail | 121.0 ± 18.6 | 195.8 ± 8.65 | | -5.80 | <0.001 | 112.9 ± 21.5 | 208.7 ± 9.2 | | -6.74 | <0.001 |
| Mass | 656.3 ± 68.7 | 690.9 ± 40.9 | | -1.76 | >0.05 | 828.7 ± 88.3 | 973.2 ± 76.9 | 45.59 | | <0.001 |

lengths but forearm length was significantly smaller in young female eagles (Table 1). Booted Eagles show high sexual dimorphism in size and both adults and young differed significantly in the majority of the variables we studied. Adult females were significantly larger than males for all measurements taken, with forearm and body mass the most dimorphic characters (Table 2). Young females are also larger than males and they have also longer forearms and beaks, but similar-sized wings and tails. Our discriminant function analysis classified 100% of the adult female and male eagles correctly using body mass and forearm as predictor variables. The discriminant function equation for adults was:

$$D = -178.885 + 0.05613(\text{MASS}) + 0.95937(\text{FOREARM})$$

Young were classified most accuracy using the four variables forearm, tail, bill, and tarsus as predictors in the model. The discriminant function misclassified only one female. The discriminant function for young was:

$$D = -197 + 0.6761(\text{FOREARM}) - 0.19286(\text{TAIL}) + 2.99438(\text{BILL}) + 0.5858(\text{TARSUS})$$

Values of $D > 0$ represent females and values of $D < 0$ represent males. By deleting tail and wing measurements which are highly variable from the model, young eagles were also classified with 84% accuracy using only tarsus and forearm measurements in the discriminant function:

$$D = -33.815 + 0.147(\text{FOREARM}) + 0.207(\text{TARSUS})$$

The equations we derived for sexing Booted Eagles should be useful for future work on the biology of this species. For immature eagles, measurements of wings and tails should be taken carefully if they are used to discriminate gender because the feathers of young birds keep growing after they first take flight. Adults were correctly classified to gender in 100% of cases examined by using the two variables, body mass and forearm. The latter is an easy measurement to take and repeated measurements taken by different observers showed low variances (Ferrer and De Le Court 1992). Gender discrimination for young eagles is valid at 35–45 d of age when nestlings have almost completed their growth.

Table 2. Differences in morphometric measurements between male and female young and adult Booted Eagles.

| | ADULTS | | | | YOUNG | | | |
|---------|---|---|----------|----------|---|---|----------|----------|
| | MALE | FEMALE | <i>t</i> | <i>P</i> | MALE | FEMALE | <i>t</i> | <i>P</i> |
| | (<i>N</i> = 16) ($\bar{x} \pm \text{SD}$) | (<i>N</i> = 25) ($\bar{x} \pm \text{SD}$) | | | (<i>N</i> = 40) ($\bar{x} \pm \text{SD}$) | (<i>N</i> = 41) ($\bar{x} \pm \text{SD}$) | | |
| Tarsus | 64.1 ± 2.77 | 69.4 ± 3.23 | -5.715 | <0.001 | 64.4 ± 2.51 | 69.1 ± 3.30 | -7.15 | <0.001 |
| Forearm | 132.2 ± 2.64 | 143.5 ± 3.20 | -12.40 | <0.001 | 131.5 ± 4.72 | 140.0 ± 4.85 | -7.95 | <0.001 |
| Culmen | 31.5 ± 1.14 | 34.8 ± 1.32 | -8.604 | <0.001 | 28.8 ± 1.29 | 30.9 ± 1.09 | -7.93 | <0.001 |
| Wing | 355.0 ± 27.8 | 389.2 ± 9.41 | -5.712 | <0.001 | 244.4 ± 25.9 | 244.6 ± 28.8 | -0.03 | 0.970 |
| Tail | 195.6 ± 8.41 | 208.7 ± 9.24 | -4.763 | <0.001 | 121.0 ± 18.6 | 112.9 ± 21.5 | 1.78 | 0.078 |
| Mass | 690.3 ± 40.9 | 973.2 ± 76.9 | -13.46 | <0.001 | 656.3 ± 68.7 | 828.7 ± 88.3 | -9.81 | <0.001 |

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THE ANNUAL AND DIEL CYCLES OF GOSHAWK VOCALIZATIONS AT NEST SITES

VINCENZO PENTERIANI

Estación Biológica de Doñana, CSIC, Avda. María Luisa s/n, Pabellón del Perú, 41013 Sevilla, Spain

ABSTRACT.—I attempted to quantify seasonal and daily Northern Goshawk (*Accipiter gentilis*) vocalizations at nest sites and identify their function. Both duration and number of calls showed significant differences among different periods of the year. The daily distribution of vocalizations differed through the breeding season both as a whole and in individual stages. My results suggested that the *kek-kek-kek* call may have two meanings as an alarm call and as a call to excite mates. During courtship, vocal activity was most intense in the early morning (female fertile period), but during other stages of the breeding season, vocal activity occurred throughout the day and was related to parental care. My results suggested that vocalizations of goshawks function primarily in territorial defense, intra-pair communication, and protection of paternity of young. Young goshawks showed a rapid increase in the duration of their total daily vocalizations within the first 10 d after fledging. Afterward their vocalization rates decreased until 40 d after fledging.

KEY WORDS: *Northern Goshawk; Accipiter gentilis; annual vocal activity; daily vocal activity; functions of vocalizations.*

Los ciclos de vocalizaciones diarias y anuales de *Accipiter gentilis* en sus sitios de anidación

RESUMEN.—Intenté cuantificar e identificar la función de las vocalizaciones estacionales y diarias de *Accipiter gentilis* en los sitios de anidación. Tanto la duración como el número de vocalizaciones mostraron diferencias significativas entre los diferentes períodos del año. La distribución diaria de las vocalizaciones mostraron diferencias significativas entre los diferentes períodos del año. La distribución diaria de las vocalizaciones fue diferente a través de la estación reproductiva en su totalidad como por etapas individuales. Mis resultados sugieren que la vocalización del *Kek-kek-kek* puede tener dos significados, como señal de alarma y para atraer a la pareja. Las vocalizaciones fueron más intensas en la mañana durante el cortejo (período fértil de la hembra) que durante las otras etapas de la actividad reproductiva, la actividad vocal durante el día estuvo más relacionada con el cuidado parental. Mis resultados sugieren que las vocalizaciones de los azores son parte principal de la defensa del territorio, de la comunicación entre la pareja y de la protección y paternidad de los pichones. Los azores jóvenes mostraron un rápido incremento en la duración total de sus vocalizaciones diarias después de diez días de haber emplumado, luego su tasa de vocalizaciones disminuyó a partir del día 40 después de haber emplumado.

[Traducción de César Márquez]

Forest and woodland birds use songs to communicate in visually-obstructed habitats and contact between mates may be maintained acoustically rather than visually (Keast 1985, 1994). Vocalization patterns and their evolution have been described and quantified in passerines (Kroodsma and Miller 1996) but, for other groups of birds, the literature is not as extensive. In particular, vocalizations of raptors have rarely been quantified (Rosenfield and Bielfeldt 1991). Falconids in the genus *Herpetotheres* and *Micrastur* typically vocalize in the morning (Staicer et al. 1996) and their vocalizations may serve as greeting displays between mates (Cramp and Simmons 1980). In male Cooper's

Hawks (*Accipiter cooperii*), there is marked vocal activity at dawn (Stewart et al. 1996) and a specific dawn call is given (Rosenfield and Bielfeldt 1991). Similar behavior has been observed in the Sparrowhawk, (*Accipiter nisus*) (Newton 1986).

The vocalizations of Northern Goshawks (*Accipiter gentilis*) have been described by various authors (e.g., Gromme 1935, Cramp and Simmons 1980, Squires and Reynolds 1997). These descriptions have sometimes been supplemented with remarks concerning associated behavior (Schnell 1958, Pateau 1989). However, the vocalizations of adult and young goshawks have never been quantified. In the vocabulary of goshawks, there are two basic types

of calls (Cramp and Simmons 1980, Squires and Reynolds 1997): a guttural, chattering call and a plaintive, wailing call. The chattering call has been described by Zirrer (1947), Schnell (1958), Cramp and Simmons (1980), and Squires and Reynolds (1997) as a slow *kek . . . kek . . . kek* call that is used in advertising and pair contact. There is also a fast *kek-kek-kek* call that is used as a threat and mobbing call, a subdued *kai-kai-kai* alarm call, and a soft and quick *kew-kew-kew* chattering call. Adult wailing calls (*whee-oo . . . whee-oo*) are categorized as food calls. In my analysis of adult goshawk vocalizations, I used only these major call types, because other calls are easily overlooked in the field (Penteriani unpubl. data, Squires and Reynolds 1997).

The calls of young goshawks have been described by Schnell (1958) as a *whee . . . whee . . . whee* food and location call, a distress call consisting of a rapid, high-pitched twitter like chickens make, a contentment call similar to the previous call but consisting of more widely-spaced, single calls, an aggressive chatter *ke-ke-ke* call used by nestlings when they have food, and a *kikk-kikk-kikk* used by nestlings to express protest or alarm.

The first objective of my study was to quantify seasonal and daily levels of goshawk vocalizations to determine if the frequency of these vocalizations varied seasonally and annually. My second objective was to determine if goshawk calls are used mainly in territorial defense, intra-pair communication (i.e., sexual attraction and sexual conflict when the presence and/or actions of one mate interfere with the adaptive interests of the other, Davies 1989), or to protect paternity. If so, I predicted that they would continue throughout the breeding season, albeit at reduced rates, and they should peak during the fertile period of females during courtship and egg laying (Birkhead and Møller 1992, Catchpole 1973, Björklund et al. 1990, Merilä and Sorjonen 1994). If vocalizations only function to attract and retain mates, then I predicted that they would occur at higher rates before incubation and cease after the start of egg laying. Because in dense habitats, such as forests, limited visual signaling leads to the development of acoustic communication, as in the case of forest passerines (Kroodsma and Miller 1996), I predicted that goshawks would spend the majority of their time vocalizing during the year and daily vocalization patterns would show similarities with song patterns of woodland passerines.

METHODS

I noted goshawk vocalizations from 1 January 1996–31 December 1996 in a 5000-ha area of beech-forested hills of Côte d'Or (Burgundy region, France). I divided each month into three periods each consisting of 10 d. For each 10-d period and each solar day in the period, I computed the number of minutes per period and equally distributed them among eight neighboring goshawk pairs. Consequently, an hourly block was assigned to each pair on a rotation basis, and during each day of each 10-d period, I noted the vocalizations of the eight pairs. As significant changes in the breeding cycle might interfere with call data, each site was systematically monitored during the breeding period. Because each pair successfully reproduced, the annual analysis was carried out for all eight pairs selected at the start of the study.

I made observations at each nest from a location where I did not disturb the pair (about 100 m away) and I noted calls without changing my position. From these points, I also made observations concerning the behavioral context of vocalizations. This position prevented me from hearing some calls of nestlings when they were in their first few weeks of life, vocalizations of adults outside the nest stand, and vocalizations of juvenile goshawks after they left the nesting area. In each 10-d period, I recorded the time of the first and last vocalizations of the day, choosing days with minimum interference from precipitation and wind. For each type of call, I recorded the time when the call began, and its duration from a series of single calls (e.g., *kek*, *whee-oo* and *whee*) or call-series (e.g., *kek-kek-kek*, *kai-kai-kai*, *kew-kew-kew*, and *kikk-kikk-kikk*). I measured the duration of the vocalizations with a stopwatch, counting the seconds elapsed from the start to the last call given <60 sec from the previous one. I assumed one minute of silence between calls or between call sequences indicated the end of a vocalization. An isolated single call received an arbitrary value of 1 sec.

Sampling units were goshawk pairs for adult vocalizations and nestlings and/or fledglings at each occupied nest for vocalizations of young. I analyzed the call data in relation to month and to the different periods of the annual breeding cycle: nonbreeding (September–January), courtship (February–March), incubation (April–early May), nestling period (early May–late June), and fledgling period (late June–August). If a single vocalization implied multiple call numbers, I took the average value. Only nonparametric statistics were used in the analyses (Hollander and Wolfe 1973).

RESULTS

Adult Vocalizations. Adult goshawk vocalizations showed one major peak during the year that coincided with the courtship period (Fig. 1). The duration of the vocal events differed significantly between months ($H = 73.11$, $P < 0.001$, Kruskal-Wallis) and between periods ($H = 54.86$, $P < 0.001$). The duration of the vocal events increased during the courtship period and decreased during incubation (Table 1).

During most of the annual cycle, the first call

Table 1. Features of adult and juvenile Northern Goshawk vocal activity ($N = 8$) during the year. The duration (sec) represents the minimum, maximum, and average (\pm SD) call length of the monthly vocalizations by goshawks at nest sites.

| MONTH | ADULT CALL | YOUNG CALL |
|-------|---|---|
| | DURATION (sec) min-max ($\bar{x} \pm$ SD) | DURATION (sec) min-max ($\bar{x} \pm$ SD) |
| Jan | 1-966 159.7 \pm 194.5 | |
| Feb | 1-749 272.5 \pm 265.6 | |
| Mar | 2-330 240.7 \pm 297.2 | |
| Apr | 2-59 110.1 \pm 158.4 | |
| May | 2-55 99.7 \pm 88 | |
| Jun | 1-112 103 \pm 130.3 | 1-1086 161.5 \pm 241.5 |
| Jul | 2-352 85.8 \pm 77.4 | 1-1491 310.9 \pm 273.6 |
| Aug | 4-42 15.9 \pm 10 | 1-560 61.9 \pm 66.1 |
| Sept | 2-30 12.2 \pm 5.5 | |
| Oct | 1-128 23.7 \pm 48.3 | |
| Nov | 1-136 32.2 \pm 39.1 | |
| Dec | 0-86 17.4 \pm 12.9 | |

was uttered at different times of the day, except during courtship, when it was always uttered before sunrise (range = 4-45 min before sunrise). The last call was always uttered prior to sunset, except in April, when it was recorded 22 min afterwards. The last call was less related to dusk than the first call was to dawn.

During courtship, the vocalizations reached one major peak both in the first hour before sunrise and three hours after sunrise (Penteriani 1999). During incubation, nestling, and fledgling periods, the daily distribution of the vocalizations was more irregular. There was a significant difference ($H = 23.54$, $P < 0.001$) in the duration of vocalizations in various hours of the day. In the nonbreeding period, the diurnal distribution of vocalizations varied and their duration was shorter. An excep-

tion was the month of January, when a peak in the same time period as in the courtship period was observed, although the duration of the vocalizations was shorter (Fig. 1). I found a difference in the day-long distribution of vocal events between courtship and incubation periods ($D_n = 0.78$, $P < 0.001$), between courtship and nestling periods ($D_n = 0.86$, $P < 0.001$), and between courtship and fledgling periods ($D_n = 0.79$, $P < 0.001$).

The chattering call *kek . . . kek . . . kek* was the most common call throughout the year (37.6%). A common pattern between the duration of the vocal events and the call number characterizing them was observed for nonbreeding ($r_s = 0.6$, $P < 0.01$, Spearman rank), courtship ($r_s = 0.4$, $P < 0.01$), nestling ($r_s = 0.46$, $P < 0.05$), and fledgling periods ($r_s = 1$, $P < 0.001$), but not for the incubation period ($r_s = 0.24$, $P > 0.05$). The chattering call was the second most frequently-used call throughout the year (34.6%) but there was no common pattern between the duration of the vocalizations and the number of calls that characterized them in the nonbreeding ($r_s = 0.19$, $P > 0.05$), courtship ($r_s = 0.15$, $P > 0.05$), incubation ($r_s = 0.29$, $P > 0.05$), nestling ($r_s = 0.37$, $P > 0.05$), and fledgling ($r_s = 0.08$, $P > 0.05$) periods. A total of 63.2% of chattering calls were preceded and/or followed at ≤ 1 -min intervals by one call or a series of calls, such as pair-contact calls, food calls, and greeting calls (only once upon mating), or by an observed copulation and prey delivery. The remaining 36.8% of chattering calls were isolated vocalizations. The difference between these two situations was significant ($N = 171$, $z = 2.86$, $P < 0.05$, Mann-Whitney U -test).

A common pattern between the duration of vocal events and number of vocalizations characterizing the wailing call *whee-oo . . . whee-oo . . . whee-oo* (frequency = 21%) was observed for the nonbreeding ($r_s = 0.83$, $P < 0.05$), courtship ($r_s = 0.46$, $P < 0.01$), incubation ($r_s = 0.8$, $P < 0.05$), and the fledgling ($r_s = 0.72$, $P < 0.05$) periods, but not for the nestling period ($r_s = -0.27$, $P > 0.05$).

Vocalizations of Young. The duration of the vocal events differed between months ($H = 5.76$, $P < 0.05$), but not between nestling and fledgling periods ($H = 2.16$, $P > 0.05$). The duration of vocalizations by young goshawks during the nestling and fledgling periods increased rapidly until about the 10th day after fledging and quickly declined until about the 40th day. No vocalizations were recorded afterwards (Fig. 2).

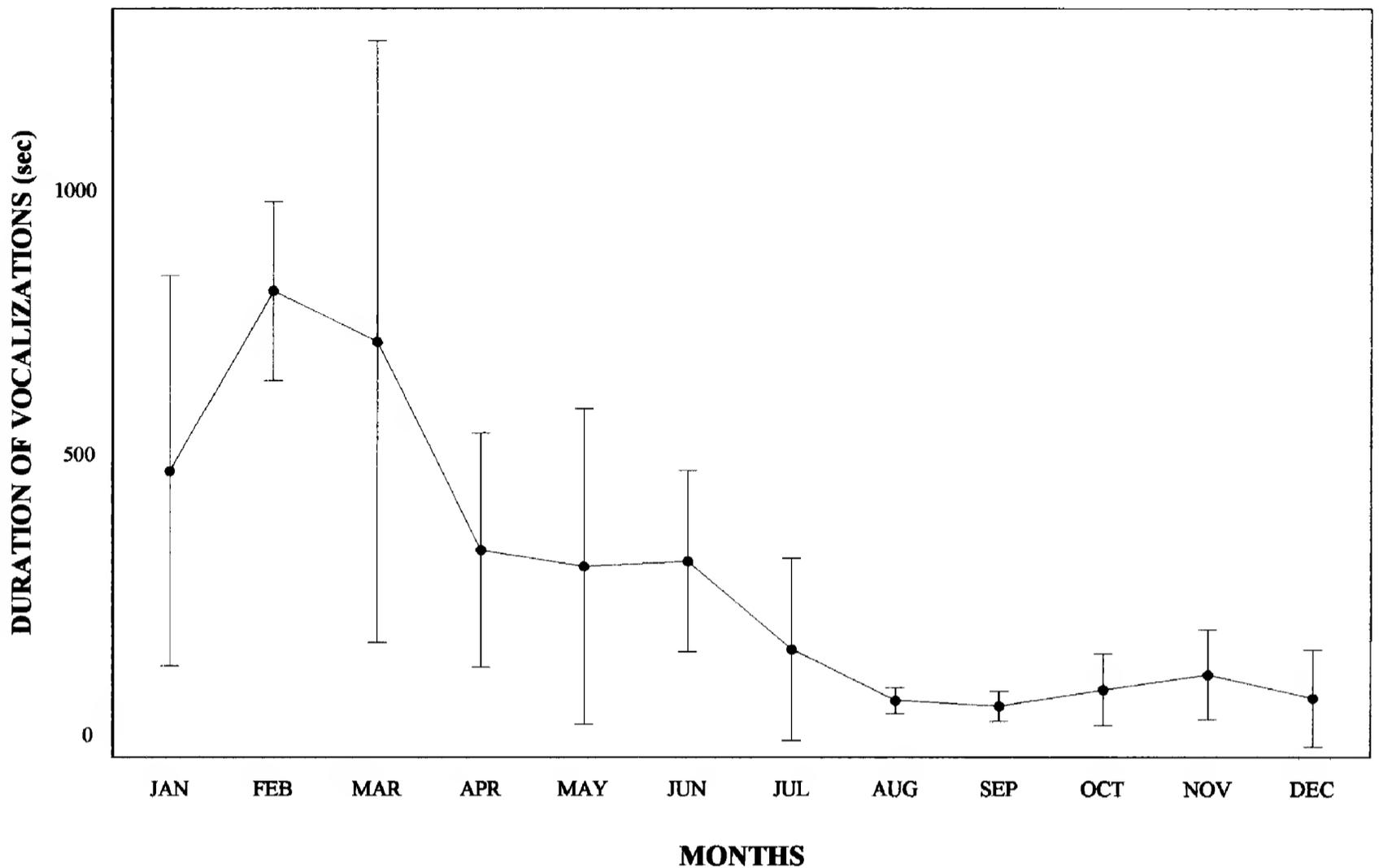


Figure 1. Annual vocalization pattern in adult Northern Goshawks at nest sites: sum of goshawk vocal activity (sec \pm SD) per month ($N = 8$).

During these two periods, the time of the first call was variable, whereas the last call was always uttered before sunset. During nestling, the peaks in vocalizations occurred during the 4th and 13th hr after sunrise; conversely, during fledgling, vocalizations were clustered in the central hours of the day, between the 7th and 10th hr after sunrise. During these periods, prey delivering was related to vocal activity.

A common pattern between the duration of the vocal events and number of vocalizations characterizing the *whee . . . whee . . . whee* call (frequency = 95.1%) was observed in both the nestling ($r_s = 0.71$, $P < 0.05$) and fledgling ($r_s = 0.78$, $P < 0.001$) periods.

DISCUSSION

My study indicated that most adult goshawk vocalizations occurred during the courtship period. Most vocalizations occurred in late winter and early spring, prior to breeding and corresponded to initial courtship and territory establishment. Various studies of Northern Hemisphere birds have made similar observations (e.g., Kelsey 1989, Logan et al.

1990, Catchpole and Slater 1995). It was noteworthy that the types of calls recorded from January onwards (about 3 mo before egg laying) were similar to those recorded during courtship. Starting in January, goshawks begin to become more territorial and they utter their alarm calls when people walk close to their nests. They are regularly observed displaying over nesting territories and woods (Anonymous 1990, Toyne 1997). Goshawks also intensified their vocalizations at the end of their reproductive cycle when young were dispersing from nest areas. The sole period when no vocalizations were recorded near nests was from late November to the first 20 d of December. A comparison of the durations and numbers of calls given showed a similar pattern during the year with the period with the longest and most numerous vocalizations coinciding with the courtship period. Overall, the greatest number of daily vocalizations, the longest series of calls, and the most complex individual calls within each series of calls occurred during the courtship period.

During the courtship period, vocalizations were clustered from 1 hr before sunrise through the

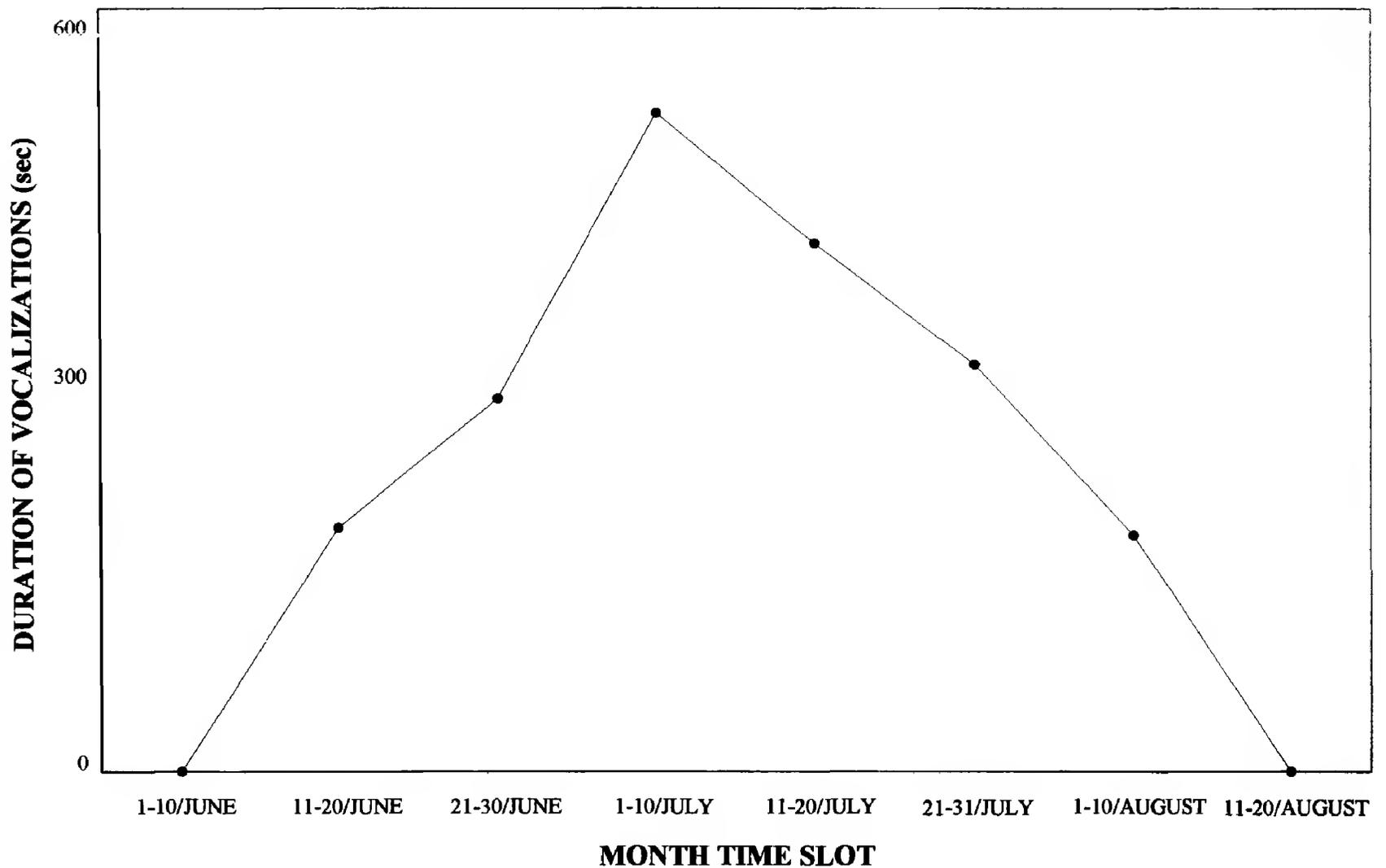


Figure 2. Vocalization pattern in juvenile Northern Goshawks during the nestling and fledgling periods (from June to August).

three following hours and the first call was always uttered prior to sunrise. This finding was pertinent to the survey methodologies currently being used to locate goshawk nests (Penteriani 1999). This time period also corresponded to the daily copulation pattern of adults with a peak occurring around the time of egg laying early in the morning and when male goshawks spend most of their time near females (Møller 1987).

The second peak in goshawk vocalizations during the breeding cycle might be ascribed to the intense activity of goshawks near their nests during the nestling period. The third and less intense peak during fall might be dependent on levels of gonadal hormones which are responsible for the activation of song behavior in most adult birds (Nottebohm et al. 1978, Brenowitz and Kroodsma 1996). Elevated levels of hormones might also be a nonfunctional cause of the singing peak at dawn (Staicer et al. 1996).

The high frequency of the *kek-kek-kek* alarm call during the courtship period indicated that the meaning so far attributed to this call (e.g., Kimmel and Yahner 1990, Speiser and Bosakowski 1991,

Kennedy and Stahlecker 1993) should not be confined to threat and mobbing, at least near the nest. The fact that up to 60% of these calls were always preceded and/or followed by pair contact, food, and greeting calls strongly supported this function. Nevertheless, I attributed a twofold meaning to this call related to alarm and high excitement during mate contacts. In most cases, this chattering call followed a series of *kek . . . kek . . . kek* or pair-contact calls, especially during territory establishment and until egg laying. Therefore, it was not necessarily related to stress or defense but also to breeding period. In a species, the same call may be uttered in different contexts, including conspecific territorial fights, defense against predators, and intra-pair interactions without the presence of any predator or territorial competitor (Logan 1994). It should also be emphasized that, during the reproductive season, aggressive calls may also express sexual conflicts (Davies 1989).

I considered the *whee-oo . . . whee-oo . . . whee-oo* call to be an exclusive female food call. During the incubation period, it was given by females when food deliveries were made by males (Schnell 1958)

and it denoted a very important stage in the breeding activity of the pair. In fact, during incubation and nestling (Schnell 1958, Penteriani unpubl. data), females utter this call as soon as they see or hear males in the nest area (recognition scream), upon prey delivery (transfer scream), and if males remain in the nest area after food delivery (dismissal scream). During the fledgling period, this call might be part of the communication between females and young when females continue to feed young after fledging (Schnell 1958).

The vocalizations of young at nests increased from hatching until the first 10 d after they fledged. After that, vocalizations diminished and ended about 40 d after the young first left nests or approximately 80 d after hatching when dispersal from nesting areas typically occurs (Kenward et al. 1993a). This decrease in vocalizations after fledging may have been due to the fact that, before dispersing, juveniles can fly as far as 1 km from nests (Kenward et al. 1993b). Since the *whee . . . whee . . . whee* call of young goshawks is mainly interpreted as a food call, the day-long pattern I observed suggested that adults continued to make food deliveries to nests. Although food may be supplied to nestlings at all times of the day (Schnell 1958), peaks in vocalizations by young in my study, as well as the changes observed between the nestling and fledgling periods, fit the peaks reported by Schnell (1958) for food deliveries by male goshawks (74–85% of total food deliveries).

The day-long and annual patterns of goshawk vocalizations suggested that the vocal activity in goshawks functions primarily in territorial defense and intra-pair communication. This finding was supported by the fact that vocalizations continued throughout the breeding season and the year, albeit at different rates. Moreover, as vocalizations showed a peak during the fertile period of females, it also seemed that calls may be used to protect paternity.

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BREEDING RATES OF EURASIAN KESTRELS (*FALCO TINNUNCULUS*) IN RELATION TO SURROUNDING HABITAT IN SOUTHWEST SPAIN

JESÚS M. AVILÉS, JUAN M. SÁNCHEZ, AND DESEADA PAREJO

Conservation Research Group, Department of Zoology, University of Extremadura, Badajoz E-06071, Spain

ABSTRACT.—We studied breeding success of Eurasian Kestrels (*Falco tinnunculus*) in nest boxes in seven different habitat types in the southwest of Spain. A total of 567 nest boxes was installed on power pylons in fallow fields, cereal cropland, holm oak land, olive orchards, pastureland, irrigated cropland, and shrubland. Occupation of boxes did not vary among the habitats and there were no significant differences among the seven habitat types in laying date, clutch size, or breeding success. When habitats with low numbers of breeding pairs were removed from analyses, we were able to detect significant differences in mean laying dates, clutch sizes, and breeding success rates among the three habitat types with the highest sample sizes. Kestrels nesting in pastureland showed higher clutch sizes and higher breeding success than those nesting in the cerealland. A seasonal decline in clutch size was found in all three habitat types with the highest sample sizes. Our results suggested that habitat features influence the breeding biology of Eurasian Kestrels.

KEY WORDS: *Eurasian Kestrel*, *Falco tinunculus*; *habitat features*; *breeding success*; *agricultural intensification*; *Spain*.

Tasas de reproducción de *Falco tinnunculus* en relación al habitat circundante en el suroeste de España

RESUMEN.—Se ha estudiado la influencia del habitat de nidificación sobre la biología reproductora del Cernícalo Vulgar *Falco tinunculus* en una población reproductora del sudoeste de España. Se instalaron en postes de líneas de conducción eléctrica 567 cajas-nido dentro de siete tipos diferentes de hábitats: Barbechos, siembras de cereal, dehesas arboladas de encinas, olivares, pastizales, cultivos de regadío y áreas con cobertura de matorral. No existieron diferencias significativas en los porcentajes de ocupación de los nidos entre los siete hábitats. No se detectaron diferencias entre los siete hábitats en las fechas medias de puesta, tamaños de puesta y tasas reproductoras de los cernícalos. Sin embargo, cuando se extrajeron de los análisis aquellos hábitats con menor número de parejas nidificantes, existieron diferencias entre hábitats en el inicio de la reproducción. Del mismo modo, el tamaño de puesta y el éxito reproductor variaron entre los tres hábitats con mayores tamaños muestrales. Los cernícalos que nidificaron en pastizales tuvieron mayores tamaños de puesta y mayor éxito reproductor que los que lo hicieron en cultivos de cereal. En los tres hábitats con mayor tamaño muestral se detectó un descenso estacional del tamaño de puesta que no varió entre los hábitats. Los resultados sugieren la influencia de los rasgos del hábitats sobre la biología de reproducción de la especie en nuestra zona de estudio.

[Traducción de Autores]

European Kestrel (*Falco tinnunculus*) populations are declining in the Palearctic because of the intensification of agriculture (Village 1990, Shrubbs 1993). In Spain, the breeding population has remained stable since the 1970s at 25 000–30 000 pairs (Aparicio 1997). Although this population has been used as a tool in experimental studies (Aparicio 1994a, 1994b, 1998), there is little information on its basic biology. Some studies have reported breeding rates (Aparicio 1994a, Gil-Delgado et al. 1995, Avilés et al. 2000), but almost nothing is known about its breeding

biology in different habitats in the Iberian Peninsula.

Nest boxes are readily accepted by kestrels (Village 1990). Although care should be taken when testing hypotheses related to fitness in such artificial nesting situations (Møller 1989), nest boxes offer an exceptional opportunity to conduct breeding studies in cavity-nesting species of birds (Clutton-Brock 1988). The aim of this study was to test the effect of habitat type on the breeding performance of Eurasian Kestrels in the Serena region in the southwest of Spain.

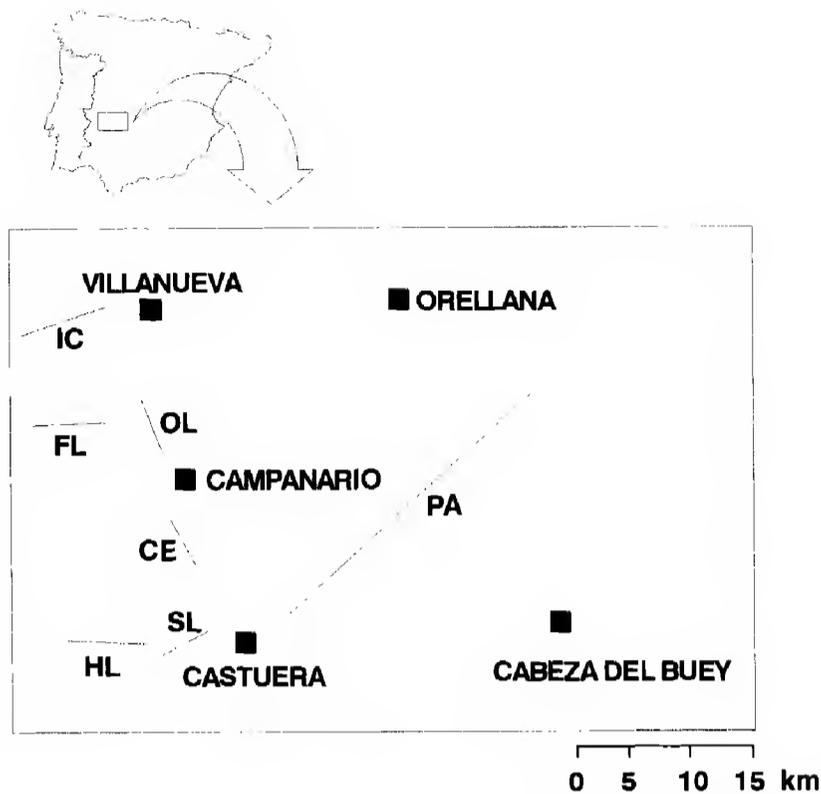


Figure 1. Map of the location of the study area and the length of electric power lines (lines) in each habitat type. Squares represent the major towns in the Serena region. Codes for habitat types are: fallowlands (FL), cereal croplands (CE), holm oaklands (HL), olive orchards (OL), pasturelands (PA), irrigated croplands (IC), and shrublands (SL).

STUDY AREA AND METHODS

The study area was located in the Serena region of Spain (39°03'N, 5°14'W). The climate of the area is Mediterranean and mean temperature and rainfall during May and June is 17.7°C and 11.6 mm, respectively (Avilés et al. 2000). In February and March of 1989, 567 nest boxes were installed on all the power pylons that crossed patches of seven different habitats in the study area: fallowlands ($N = 26$ nest boxes), cereal croplands (oats, wheat, and barley, $N = 159$ nest boxes), holm oaklands (*Quercus rotundifolia*) ($N = 63$ nest boxes), olive orchards ($N = 14$ nest boxes), pasturelands ($N = 237$ nest boxes), irrigated croplands (rice and maize, $N = 18$ nest boxes), and shrublands (mainly *Retama sphaerocarpa*, $N = 50$ nest boxes) (Fig. 1). Habitat patches with possible natural cavities (holm oakland and olive orchards) and farmhouses with possible nesting sites were searched for pairs of breeding kestrels but we did not find any kestrels breeding in natural cavities. We considered a patch of habitat to accurately represent kestrel breeding parameters when all the boxes in it were surrounded at least by 1 km of this same habitat type. The minimum distance between two patches was 1.5 km between holm oaklands and shrublands (Fig. 1). Although we did not make observations of hunting activities of the kestrels, we considered 1.5 km to be a reasonable estimation of the hunting territories taking into account the fact that breeding kestrels forage at a maximum distance of 2 km from their nests in Spain (Veiga 1982). We did not expect any density-dependent effects on kestrel breeding performance because the mean (\pm SD) density of nest boxes was $9.43 \pm$

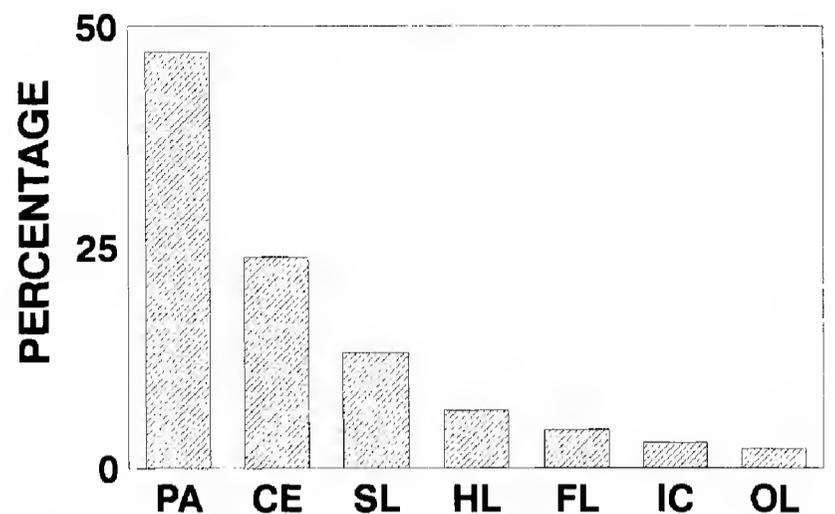


Figure 2. Percent distribution of nest-boxes used by breeding Eurasian Kestrels in relation to habitat type. Codes for habitat types are: pasturelands (PA), cereal croplands (CE), shrublands (SL), holm oaklands (HL), fallowlands (FL), irrigated croplands (IC), and olive orchards (OL). Habitats are ordered in relation to their nest box use.

0.26 boxes/km of power line independent of habitat type, and the percent of boxes occupied by kestrels in all seven habitats was <50% (Fig. 2).

All the boxes were monitored weekly from the first stages of breeding in 1989. We assumed that nest-box availability in each habitat type did not affect breeding of kestrels because the interhabitat distribution of nest boxes and breeding pairs of kestrels did not vary (G -test $G_6 = 5.96$, $P = 0.42$), Eurasian Rollers (*Coracias garrulus*) that also use nest boxes began egg laying in our study area at least 1 mo later than kestrels (Avilés et al. 1999), and there was no evidence of damage to kestrel eggs or young by rollers when kestrels were the first to breed in nest boxes (Cramp and Simmons 1980, Avilés pers. obs.). In boxes occupied by kestrels, nest visits were increased to one visit every 3–4 d during the nesting period to determine breeding success accurately. Laying dates were determined by subtracting the incubation period from the hatching date (Cramp and Simmons 1980). When determining hatching dates, we took into account the fact that the laying interval in the species is two days (Cramp and Simmons 1980). We measured percent hatching success as the percent of eggs in each clutch that hatched, the number of fledglings per successful nest with successful nests being those at which at least one young fledged, and breeding success as the number of fledglings per pair that laid at least one egg.

We checked for interhabitat differences in the percent of boxes used using a contingency table with a Chi-square test. Normality of the variables was checked with Kolmogorov-Smirnov tests. Any nonnormality in differences in laying dates, clutch size, and breeding rates among habitat types was checked with Kruskal-Wallis tests. Differences between pairs of habitats were tested using non-parametric Tukey-type multiple comparisons. Seasonal declines in clutch size were analyzed using two-tailed Spearman correlations. We checked for interhabitat differences between clutch sizes and laying dates based on

the comparison of correlation coefficients from independent samples (Zar 1996).

RESULTS

The percent of nest boxes used by nesting kestrels ranged from 47.1% in pasturelands to 2.17% in olive orchards, but it did not vary significantly among the seven habitats in our study ($\chi^2_6 = 7.55$, $P = 0.27$) (Fig. 2). Likewise, no significant differences between the seven habitat types were detected in mean laying dates ($H_6 = 11.4$, $P = 0.08$, $N = 88$), clutch sizes ($H_6 = 8.8$, $P = 0.83$, $N = 136$), hatching success ($H_6 = 3.9$, $P = 0.67$, $N = 123$), breeding success ($H_6 = 8.8$, $P = 0.82$, $N = 125$), or fledgling success ($H_6 = 7.65$, $P = 0.26$, $N = 115$) (Table 1).

Because our results were probably influenced by the low number of breeding pairs in fallowlands, olive orchards, holm oaklands, and irrigated croplands, we tested for differences in breeding parameters in the three habitat types with the largest sample sizes: cereal croplands, pasturelands, and shrublands. We found significant differences in mean laying dates ($H_2 = 9.47$, $P = 0.008$, $N = 73$), clutch sizes ($H_2 = 6.17$, $P = 0.04$, $N = 114$), and breeding success rates ($H_2 = 7.01$, $P = 0.02$, $N = 108$), but not in hatching success ($H_2 = 0.91$, $P = 0.63$, $N = 106$) and fledglings per successful nest ($H_2 = 4.14$, $P = 0.12$, $N = 100$) (Table 1). Pairs nesting in boxes in pasturelands showed a higher clutch size and a higher breeding success than those nesting in cereal croplands ($P < 0.05$ in both cases, Table 1). However, there were no significant differences between clutch sizes and breeding values of kestrels nesting in shrublands and the other two habitats types ($P > 0.05$ in all cases, Table 1).

Considering only the three habitats with the greatest numbers of breeding pairs, clutch size of kestrels decreased seasonally in cereal croplands ($r_s = -0.65$, $P < 0.05$, $N = 19$), and marginally in pasturelands ($r_s = -0.30$, $P < 0.06$, $N = 39$) and shrublands ($r_s = -0.55$, $P < 0.06$, $N = 13$); however, correlation coefficients did not vary significantly among the habitat types ($P > 0.05$ in all the cases).

DISCUSSION

Our results suggested that habitat features can influence the breeding biology of Eurasian Kestrels. Previous studies in northern latitudes have reported effects of habitat on food preferences (Pettifor 1984) and breeding rates (Valkama et al.

Table 1. Mean Julian egg laying dates and reproductive rates ($\bar{x} \pm \text{SD}$) of Eurasian Kestrels in relation to habitat type. Sample size in each habitat type is shown in parentheses.

| | FALLOW- LAND | | CEREAL CROPLAND | | HOLM OAKLAND | | OLIVE ORCHARDS | | PASTURE- LAND | | IRRIGATED CROPLAND | | SHRUB- LAND | |
|--------------------------------------|--------------------|----------------------|--------------------|---------------------|----------------------|---------------------|----------------------|--|------------------|--|-----------------------|--|----------------|--|
| | | | | | | | | | | | | | | |
| Laying date | 147.6 ± 4.3 (5) | 148.7 ± 11.9 (19) | 149.0 ± 2.3 (4) | 137.5 ± 12.0 (2) | 145.6 ± 13.6 (39) | 156.3 ± 18.8 (4) | 134.2 ± 35.2 (15) | | | | | | | |
| Clutch size | 3.8 ± 1.5 (6) | 3.7 ± 1.4 (33) | 4.0 ± 1.6 (9) | 4.7 ± 0.6 (3) | 4.4 ± 1.1 (65) | 3.0 ± 1.8 (4) | 4.5 ± 0.9 (16) | | | | | | | |
| Hatching success (%) | 87.5 ± 25.0 (4) | 76.1 ± 37.9 (31) | 81.2 ± 37.2 (8) | 100.0 ± 0.0 (3) | 85.8 ± 27.6 (59) | 77.5 ± 3.5 (2) | 88.2 ± 17.2 (16) | | | | | | | |
| Breeding success | 3.8 ± 1.9 (4) | 2.9 ± 1.9 (31) | 3.9 ± 1.9 (8) | 4.7 ± 0.6 (3) | 3.9 ± 1.6 (59) | 3.5 ± 0.7 (2) | 3.9 ± 0.9 (18) | | | | | | | |
| Fledglings per successful nest | 4.7 ± 0.6 (3) | 3.5 ± 1.4 (26) | 4.4 ± 1.3 (7) | 4.7 ± 1.3 (3) | 4.2 ± 1.3 (56) | 3.5 ± 0.7 (2) | 3.9 ± 0.9 (18) | | | | | | | |

1995), but our study was the first to show effects of habitat on the reproduction of Eurasian Kestrels in the Mediterranean region. Our results demonstrate the influence of farming practices on kestrel populations which have been indicated to be the principal cause for declines of European Kestrels in the Palearctic region (Tucker and Heath 1994). In the Serena region, kestrels nesting in the natural pasturelands showed higher clutch sizes and breeding success than kestrels nesting in such agricultural habitats as cereal croplands, indicating that intensification of farming practices in the Mediterranean area may have caused declines in breeding populations of Eurasian Kestrels.

Avilés and Costillo (1998) reported poor insect abundance in cereal croplands but pasturelands in the study area had the highest middle and large insect abundances. Kestrels mainly feed on middle and large insects in the central portion of Iberia (Veiga 1982) so kestrels nesting in pasturelands probably had higher food availability than kestrels nesting in croplands which may have resulted in the larger clutch sizes we observed (Martin 1987, Arcese and Smith 1988). However, we cannot confirm that the differences in breeding rates between pasturelands and cereal croplands were mediated by food availability because we did not determine the availability of the prey types in the study area.

Our results showed that, as in northern Palearctic regions, agriculture can be a major factor in the decline of breeding populations of kestrels in southern areas of Europe. Although Spain is probably one of the main strongholds for the Eurasian Kestrel in Europe (Tucker and Heath 1994) and the breeding population appears to have been stable since the 1970s (Aparicio 1997), conservation measures ensuring the maintenance of traditional pastoral forms of agriculture will probably favor the species in future years.

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THE MIGRATION OF STEPPE EAGLES (*AQUILA NIPALENSIS*) AND OTHER RAPTORS IN CENTRAL NEPAL, AUTUMN 1999

ROBERT DECANDIDO

Department of Ecology and Evolutionary Biology, The Graduate Center of the City University of New York, Suite 4315, 365 Fifth Avenue, New York, NY 10016-4309 U.S.A.

DEBORAH ALLEN

The Linnaean Society of New York, P.O. Box 1452, Peter Stuyvesant Station, New York, NY 10009 U.S.A.

KEITH L. BILDSTEIN

Hawk Mountain Sanctuary, 1700 Hawk Mountain Road, Kempton, Pennsylvania 19529 U.S.A.

ABSTRACT.—Counts of migrating Steppe Eagles (*Aquila nipalensis*) and at least eight other species of raptors were made at Khare, a raptor-migration watchsite in central Nepal, on nine days (27 October–4 November) in autumn 1999. Totals of 821 migrating Steppe Eagles (15.2 birds/h) and 129 other migrating raptors (2.4 birds/h), including the globally vulnerable Lesser Kestrel (*Falco naumanni*) (0.2 birds/h), were seen at the watchsite. Individuals representing 10 additional species that could not be distinguished as migrants versus local residents also were seen, but were not included in the count. Most autumn migrants at Khare are believed to represent individuals from populations of raptors that breed in central and eastern Asia and overwinter in southeastern and southwestern Asia, the Indian Subcontinent, and Africa. Raptor migration appears to be a regular and predictable phenomenon at the site, leading us to recommend its use by local residents, as a source of ecotourism revenue and as a focal point for environmental-education activity for school children, and by raptor conservationists, as a continentally significant monitoring site.

KEY WORDS: *Steppe Eagle*, *Aquila nipalensis*; *Lesser Kestrel*; *Falco naumanni*; *migration*; *Central Asia*; *Nepal*.

La migración de *Aquila nipalensis* y otras aves rapaces en el centro de Nepal, otoño de 1999

RESUMEN.—Los conteos de *Aquila nipalensis* en migración y de por lo menos otras ocho especies de aves rapaces se llevaron a cabo en Khare, un observatorio de aves rapaces migratorias en el centro de Nepal durante nueve días (27 Octubre–4 Noviembre) del otoño de 1999. Un total de 821 *Aquila nipalensis* (15.2 aves/hr) y otras 129 aves rapaces migratorias (2.4 aves/hr), incluyendo el globalmente vulnerable *Falco naumanni* (0.2 aves/hr) fueron observados en este sitio. Algunos individuos que representaron 10 especies adicionales no pudieron ser identificados como migratorios versus residentes locales también fueron observados, pero no fueron incluidos en el conteo. La mayoría de los migratorios en Khare son considerados como representantes de poblaciones de aves rapaces que anidan en el centro y este del Asia y que permanecen durante el invierno en el sureste y suroeste del Asia, en el subcontinente Indio y en Africa. La migración de aves rapaces parece ser un fenómeno regular y predecible en este sitio, lo cual conlleva a la recomendación de utilizar este sitio por los pobladores locales como una fuente de ingresos a partir del ecoturismo y como un punto focal para actividades de educación ambiental para niños en edad escolar, para conservacionistas de aves rapaces y como un sitio importante de monitoreo a nivel continental.

[Traducción de César Márquez]

Central and eastern Asian breeding populations of Steppe Eagles (*Aquila nipalensis*) and other species of raptors, including the globally vulnerable Lesser Kestrel (*Falco naumanni*) (*sensu* Collar et al. 1994), as well as large numbers of Demoiselle Cranes (*Anthropoides virgo*), have been known to mi-

grate north-to-south through mountain passes in the Annapurna range of the Himalayan Mountains of central Nepal and then east-to-west along the range's southern foothills, at least since the 1970s (Ali and Ripley 1978, Fleming 1983, Inskipp and Inskipp 1991, Grimmett et al. 1999). The magni-

tude of Steppe Eagle migration in the region, the extent and location of the presumed east-to-west route used by them south of the Annapurna range, and the number of species of raptors migrating through the region remain unclear (Fleming 1983, de Roder 1989, Bijlsma 1991).

We present data on raptor migration collected at a *Hawks Aloft Worldwide* watchsite (Zalles and Bildstein 2000) near the village of Khare, in central Nepal, 150 km west-northwest of the capital of Kathmandu, and discuss use of the site and its migration by local residents and raptor conservationists.

STUDY AREA

Khare (28°20'N, 8°40'E, elevation 1646 m) is a mountaintop watchsite in a small, 50-house village along the Jomson trek, a footpath that connects the towns of Naudanda to the east and Birethane to the west, approximately 18 km northwest of Pokhara and 150 km west-northwest of Kathmandu in the Himalayan Mountains of central Nepal. The site, which sits atop an east-west, 1650 m ridge south of the Annapurna range, is directly southeast of 8090 m Annapurna I, the highest point in the region. Khare has a 360° view of the surrounding countryside, including the Yamdi Khola valley to the northeast and the Marse Khola valley to the south-southeast. Agricultural lowlands surround the site, and oak (*Quercus*)-rhododendron (*Rhododendron*) forest occurs at higher elevations (Inskipp and Inskipp 1991, Zalles and Bildstein 2000).

The watchsite and timing of our observations were chosen because earlier counts had been conducted there at approximately the same time in 1984 and 1985 (de Roder 1989, Bijlsma 1991), and because of its potential as a regionally-significant monitoring point for migratory populations of central and eastern Asian raptors (Zalles and Bildstein 2000).

METHODS

Migrating raptors were counted during 54 h and 10 min of observations on nine consecutive days (27 October–4 November) in autumn 1999. Counts were made by two observers using 10× and 8.5× binoculars for 4–7 hr daily. Observations typically began at 0900–1000 H local time and ended at 1600–1700 H. Raptors were identified to species and, when possible, Steppe Eagles were identified to age class (Grimmett et al. 1999). The species identity of several individuals was confirmed from photographs taken at the site (Porter et al. 1986, Forsman 1999, Grimmett et al. 1999). Although a few individuals, representing two species of small falcons (Eastern Red-footed Falcon [*Falco amurensis*] and Northern Hobby [*F. subbuteo*]) and at least one species of harrier (*Circus* spp.), were sometimes difficult to identify, most raptors were readily assigned to species.

Two observers (RDC and DA) scanned mainly to the east, in the direction of the small village of Naudanda, Kaskikot Hill, and, in the distance, Pokhara. Raptors, representing eight species (Western Marsh Harrier [*Circus*

aeruginosus], Eurasian Sparrowhawk [*Accipiter nisus*], Eurasian Buzzard [*Buteo buteo*], Steppe Eagle, Booted Eagle [*Hieraaetus pennatus*], Lesser Kestrel [*Falco naumanni*], Eastern Red-footed Falcon, Northern Hobby), were considered migrants if they passed east-to-west across an imaginary north-south line at the watchsite, and continued west and out of sight over a ridge approximately 1.5 km west of the site. Most Steppe Eagles were identified to species as they approached to within 1.5 km and, in many instances, their age was determined if they approached within 1.0 km.

It proved impossible to assign migrant or nonmigrant status to individuals representing 10 additional species seen at the site (Black Kite [*Milvus migrans*], Egyptian Vulture [*Neophron percnopterus*], Bearded Vulture [*Gypaetus barbatus*], Himalayan Griffon [*Gyps himalayensis*], Asian White-backed Vulture [*Gyps bengalensis*], Red-headed Vulture [*Sarcogyps calvus*], Long-legged Buzzard [*Buteo rufinus*], Asian Black Eagle [*Ictinaetus malayensis*], Crested Hawk Eagle [*Spizaetus cirrhatus*], and Eurasian Kestrel [*Falco tinnunculus*]). Observations of these species are not included in our counts of migrants.

RESULTS AND DISCUSSION

We counted 950 raptors (17.5 birds/h), representing at least nine species, migrating at the site (Table 1). Because it was not always possible to assign Eurasian Buzzards and Northern Hobbies to migrant versus nonmigrant status, and because we were conservative in classifying individuals of these two species as migrants, counts of buzzards and hobbies should be viewed as minimal estimates.

Steppe Eagles were the most common migrant, representing 86% (821 of 950 birds seen) of the flight (see also Bijlsma 1991). Eastern Red-footed Falcons and *Falco* spp., all of which almost certainly were *naumanni*, *amurensis* or *subbuteo*, made up 5% and 4% of the flight, respectively. Seventy-nine percent of the Steppe Eagles seen at the site (649 of 821 birds) were counted on three of the nine days of observation (30 and 31 October, and 3 November). Ninety-two percent of all Steppe Eagles seen were counted between 1100–1700 H, with the peak hour of eagle passage occurring at 1100–1200 H (Fig. 1). Twenty-eight percent of the Steppe Eagles seen were aged. Of these, 15% were first-year birds, 65% were subadults (2nd–4th year birds), and 20% were adults (>4th year birds) (*sensu* Grimmett et al. 1999). Species diversity was highest on the three days (i.e., 30 and 31 October, and 3 November) when most individuals were counted. On these three days, migrant species totaled 6, 6, and 4, respectively (Table 1).

Although a few raptors migrated east-to-west south of the site, most migrants passed east-to-west directly overhead, or within 750 m north of the

Table 1. Daily counts of migrants at the Khare raptor-migration watchsite, central Nepal, 27 October–3 November 1999.

| SPECIES | OCTOBER | | | | | NOVEMBER | | | | ALL DAYS |
|--|---------|----|----|-----|-----|----------|------|------|------|----------|
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | |
| Western Marsh Harrier (<i>Circus aeruginosus</i>) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Harriers (<i>Circus</i> spp.) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 3 |
| Eurasian Sparrowhawk (<i>Accipiter nisus</i>) | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 3 |
| Eurasian Buzzard (<i>Buteo buteo</i>) | 0 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 4 |
| Buzzard (<i>Buteo</i> spp.) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Steppe Eagle (<i>Aquila nipalensis</i>) | 0 | 1 | 14 | 176 | 231 | 70 | 64 | 238 | 27 | 821 |
| Booted Eagle (<i>Hieraaetus pennatus</i>) | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 3 |
| Lesser Kestrel (<i>Falco naumanni</i>) | 0 | 0 | 0 | 5 | 0 | 0 | 1 | 4 | 0 | 10 |
| Eastern Red-footed Falcon (<i>F. amurensis</i>) | 0 | 1 | 4 | 34 | 0 | 4 | 0 | 0 | 0 | 43 |
| Northern Hobby (<i>F. subbuteo</i>) | 0 | 0 | 3 | 9 | 6 | 0 | 0 | 1 | 0 | 19 |
| Small falcons (<i>Falco</i> spp.) | 0 | 0 | 0 | 30 | 10 | 0 | 0 | 0 | 0 | 40 |
| Large falcons (<i>Falco</i> spp.) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| All species | 0 | 3 | 22 | 257 | 252 | 76 | 66 | 245 | 29 | 950 |
| Hours of observation | 5.33 | 6 | 5 | 6.5 | 7 | 6.5 | 5.75 | 5.83 | 4.25 | 54.16 |

site. Those passing overhead migrated at 25–75 m above the surrounding landscape. Most eagles were first detected soaring in thermals above the Yamdi Khola valley north of Naudanda and east of the site, and along a lower ridge between Naudanda and the watchsite. Eagles seen thermaling and

riding on updrafts in the distance typically passed the watchsite within 5–7 min.

DISCUSSION

Regional cloud cover appeared to have a profound affect on the numbers of eagles counted at the site. Two of the three highest daily counts for eagles, 30 October and 3 November, occurred on days when clouds began to build over the Annapurna range earlier than on other days, and when the range's foothills were covered in clouds by 0930 H. It appeared that heavy cloud cover forced eagles to shift their flight path south of the range and toward the hills and valleys near the watchsite (Fleming 1983, de Roder 1989). Indeed, our highest hourly count of eagles (149 birds) occurred at 1100–1200 H on 31 October, the same hour in which clouds completely obscured both the massif and its foothills that day.

Neither wind speed nor wind direction, both of which remained relatively constant at <20 kph from the south, varied sufficiently during our ob-

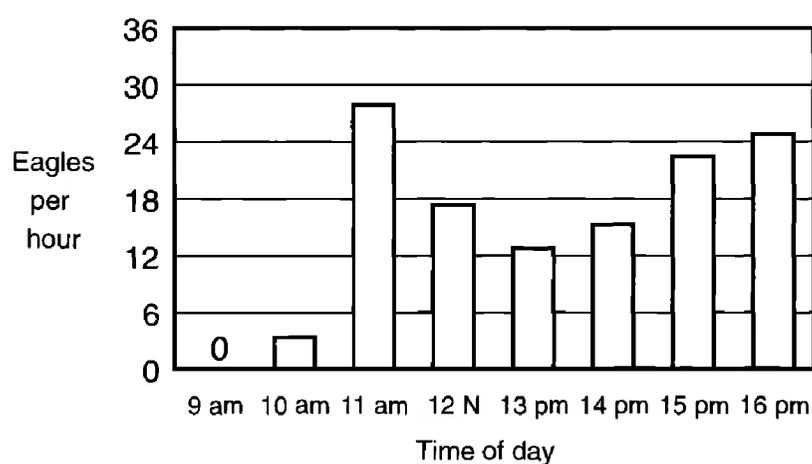


Figure 1. Passage rates of Steppe Eagles (*Aquila nipalensis*) by time of day at the Khare raptor migration watchsite in central Nepal, 27 October–4 November 1999.

servations to allow us to determine their effect, if any, on raptor migration at the site.

Our observations of the diurnal periodicity of the flight, which indicate a decided peak at 1100–1200 H (Fig. 1), followed by a second peak in late afternoon, are similar to those of de Roder (1989), who also noted that the greatest movements of eagles occurred between midday and late afternoon. Possible explanations for the diurnal periodicity include the location of appropriate roosting areas several hours flying-time to the east, and the diurnal shifts in soaring conditions at the site, both of which merit additional investigation.

A large-scale, east-to-west, autumn movement of *Aquila* eagles along the southern foothills of the Himalayan Mountains was first observed by R.L. Fleming, Jr. in 1983 (Fleming 1983). The 821 eagles we counted over 9 d in late October–early November 1999, together with the 1100 seen by Bijlsma (1991) in approximately the same area over the same 9 d in 1984, and the 4907 seen by de Roder (1989) at Khare during the same 9 d in 1985, largely confirm Fleming's initial description of the flight. The route, which apparently results when south-bound migrants from central and east Asia detour around the eastern flank of the Tibetan Plateau, enables the birds to soar on updrafts and thermals along the southern foothills of the Himalayan Mountains of Nepal, and presumably, northern India (Fleming 1983, Bijlsma 1991). Although the ultimate destination of the birds is thought to be southern Asia, including India and possibly Arabia, some of the birds may reach Africa (Welch and Welch 1991).

Still unclear, however, is the seasonal magnitude of the flight, which to date has been observed for only relatively brief periods of time in any one autumn (i.e., 25 d in 1984, 18 d in 1985, and 9 d in 1999). Fleming (1983) estimated a seasonal passage of at least 45 000 eagles, while de Roder (1989) estimated the passage at between 10 000–20 000 individuals. Our observations lead us to suggest that while >10 000 eagles probably do pass the site in most autumns (see Zalles and Bildstein 2000), additional season-long observations (i.e., late September–early December) are needed to provide more accurate estimates of the magnitude of the flight.

In addition to Steppe Eagles, we identified 18 additional species of raptors at the site, at least eight of which certainly included migratory individuals (Table 1). Fleming (1983) initially reported

Table 2. Raptors reported as migrants at or near the Khare raptor-migration watchsite in central Nepal.

| SPECIES | SOURCE ^a |
|---|----------------------------------|
| Eastern Honey Buzzard (<i>Pernis ptilorhynchus</i>) ^b | 1, 3 |
| Black Kite (<i>Milvus migrans</i>) | 1, 2, 3, this study ^c |
| White-tailed Sea Eagle (<i>Haliaeetus albicilla</i>) ^b | 2, 3 |
| Black Vulture (<i>Aegypius monachus</i>) ^b | 2, 3 |
| Egyptian Vulture (<i>Neophron percnopterus</i>) | 1, 2, 3 |
| Short-toed Eagle (<i>Circaetus gallicus</i>) ^b | 2, 3 |
| Western Marsh Harrier (<i>Circus aeruginosus</i>) ^b | This study |
| Hen Harrier (<i>C. cyaneus</i>) | 1, 2, 3 |
| Pallid Harrier (<i>C. macrourus</i>) ^b | 1, 3 |
| Montagu's Harrier (<i>C. pygargus</i>) ^b | 1, 3 |
| Besra (<i>Accipiter virgatus</i>) | 1, 3 |
| Shikra (<i>A. badius</i>) ^b | 1, 3 |
| Eurasian Sparrowhawk (<i>A. nisus</i>) ^b | 1, 2, 3, this study |
| Eurasian Buzzard (<i>Buteo buteo</i>) | 1, 2, 3, this study |
| Long-legged Buzzard (<i>B. rufinus</i>) | 1, 2, 3, this study |
| Steppe Eagle (<i>Aquila nipalensis</i>) | 1, 2, 3, this study |
| Imperial Eagle (<i>A. heliaca</i>) | 1, 2, 3 |
| Booted Eagle (<i>Hieraaetus pennatus</i>) | 2, this study |
| Lesser Kestrel (<i>Falco naumanni</i>) | 1, 2, 3, this study |
| Eurasian Kestrel (<i>F. tinnunculus</i>) | 2 |
| Eastern Red-footed Falcon (<i>F. amurensis</i>) | 1, 2, 3, this study |
| Northern Hobby (<i>F. subbuteo</i>) | 2, this study |
| Saker Falcon (<i>F. cherrug</i>) ^b | 1, 3 |
| Peregrine Falcon (<i>F. peregrinus</i>) ^b | 1, 3 |
| Barbary Falcon (<i>F. pelegrinoides</i>) ^b | 1, 3 |

^a 1—de Roder (1989), 2—Bijlsma (1991), 3—Zalles and Bildstein (2000).

^b Irregular or uncommon migrant.

^c Seen in 1999, but not separated numerically from local residents.

that at least five species used the corridor, de Roder (1989) reported 18 species, and Bijlsma (1991) 16 species. Zalles and Bildstein (2000) summarizing these earlier efforts, suggested that 21 species regularly migrate at the site (Table 2).

RECOMMENDATIONS

Our observations, together with those of Fleming (1983), de Roder (1989), and Bijlsma (1991), confirm a significant east-west movement of Steppe

Eagles and smaller numbers of as many as 20 other species of raptors through the region. One of the species migrating at the site, the Lesser Kestrel, is a globally vulnerable raptor whose western European populations recently have declined precipitously and whose central Asia populations are little studied (Collar et al. 1994). It may merit additional monitoring at the site (Zalles and Bildstein 2000).

The fairly-consistent nature of the flight (local weather conditions notwithstanding) suggests that the Khare watchsite has potential for monitoring regional populations of central and east Asia migratory raptors, and for serving as an environmental education center for local inhabitants and as a source of ecotourism revenue. Indeed, during our stay at Khare we were visited by a teacher from a local school, along with several of his students, all of whom were both curious and enthusiastic about our activities. Although local villagers were able to distinguish vultures from other raptors, none was aware of the substantial migration of Steppe Eagles and other birds of prey. Nepalese schools are in recess from mid-October through mid-November, presenting an ideal opportunity to train and use students to monitor the migration on a long-term basis.

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LARC, P.O. Box No. 1 Pokhara, Gandaki Zone, Nepal. This is Hawk Mountain Sanctuary contribution number 45.

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DENSITY, PRODUCTIVITY, DIET, AND HUMAN PERSECUTION OF GOLDEN EAGLES (*AQUILA CHRYSAETOS*) IN THE CENTRAL-EASTERN ITALIAN ALPS

PAOLO PEDRINI

Raptor Conservation Research Unit, Museo Tridentino di Scienze Naturali, via Calepina 14, 38100 Trento, Italy

FABRIZIO SERGIO¹

Edward Grey Institute of Field Ornithology, Department of Zoology, South Parks Road, Oxford OX1 3PS, U.K.

ABSTRACT.—A Golden Eagle (*Aquila chrysaetos*) population of 46 pairs was regularly censused between 1982–92 in a 7800-km² study plot in the central-eastern Italian Alps. Density was stable at 5.9 territorial pairs per 1000 km². Mean nearest-neighbor distance was 8.7 km ($N = 46$), and nest areas were regularly dispersed. Sixteen percent of 70 pairs consisted of an adult and a nonadult individual. Mean laying date was 23 March ($N = 27$). The percentage of successful territorial pairs was 55% ($N = 109$). Mean number of fledged young was 0.61 per territorial pair ($N = 109$) and 1.10 per successful pair ($N = 56$). Diet was dominated by mammals (64%) belonging to the orders Artiodactyla, Rodentia, Lagomorpha, and Carnivora, and by birds (32%) belonging to the order Galliformes ($N = 247$ prey items). Productivity was affected by age of territory holders and the extent of woodland or grassland within the potential foraging range. Illegal shooting accounted for the deaths of 15 individuals between 1980–89. Compared to other alpine populations, the study population showed a low density, average nearest-neighbor distance and productivity, and a typical frequency of nonadult territory holders. We suggest that the future long-term population trends of alpine Golden Eagles will be determined by the interactions among increasing food supply, declining availability of foraging habitat, decreasing human persecution, and increasing human disturbance.

KEY WORDS: *Aquila chrysaetos*; Golden Eagle; breeding success; density; diet; Italian Alps; land use changes.

Densidad, productividad, dieta y persecución humana de águilas doradas (*Aquila chrysaetos*) en los Alpes centro orientales

RESUMEN.—Una población de águilas doradas (*Aquila chrysaetos*) de 46 pares fue censada regularmente entre 1982–92, en una parcela de 7800 km en el centro—oriente de Los Alpes. La densidad fue estable en 5.9 pares territoriales por 1000 km. La distancia media al vecino más próximo fue de 8.7 km ($N = 46$), las distancias de los nidos fueron regularmente dispersadas. Diez y seis por ciento de las 70 parejas consistieron de un adulto y un individuo subadulto. La media de la fecha de postura fue el 23 de marzo ($N = 27$). El porcentaje de parejas exitosas fue del 55% ($N = 109$). La media de pichones emplumados fue de 0.61 por pareja territorial ($N = 109$) y 1.10 por pareja exitosa ($N = 56$). La dieta estuvo representada por mamíferos en un 64% de los órdenes Artiodactyla, Rodentia, Lagomorpha y Carnívora y por aves en un 32% pertenecientes al orden Galliformes ($N = 247$ presas). La productividad fue afectada por la distancia del vecino más próximo, edad de los poseedores del territorio y por el tamaño de los bosques y pasturas dentro del área de forrajeo. La caza ilegal fue la causa de la muerte de 15 individuos entre 1980–89. Comparado con otras poblaciones alpinas, la población estudiada mostró una baja de densidad, un promedio de distancia entre el vecino más próximo, y una frecuencia típica de los poseedores del territorio no adultos. Sugerimos que la tendencia poblacional a largo plazo de las águilas doradas alpinas puede estar determinada por las interacciones entre el incremento de alimento, la declinación de la disponibilidad del habitat de forrajeo, la disminución de la persecución humana y el incremento de la perturbación humana.

[Traducción de César Márquez]

¹ Present address: Raptor Conservation Research Unit, Trento Natural History Museum, via Calepina 14, 38100 Trento, Italy.

In Europe, populations of Golden Eagles (*Aquila chrysaetos*) are generally stable or increasing, but declines have been reported for Spain, Portugal, Albania, Romania, Greece, Belarus, and Ukraine (Watson 1994, Haller and Sackl 1997). In the Alps, Golden Eagles usually nest near tree line and hunt in alpine areas at higher elevations (Haller 1996). Alpine populations have recently recovered from a long history of human persecution and are currently considered to be stable or slightly increasing (Fasce and Fasce 1992, Haller and Sackl 1997). Land abandonment in remote mountain valleys, however, is causing widespread woodland expansion (Potter 1997, Tucker and Dixon 1997, Pedrini and Sergio 2001), mainly at the expense of alpine pastures, which are the main foraging habitats of Golden Eagles in the Alps (Haller 1996). Land abandonment and afforestation are predicted to have a high impact on Golden Eagle populations in European mountainous areas, with declines of more than 20% of the overall population over the next 20 yr if these trends continue (Tucker and Dixon 1997). Such habitat loss emphasizes the need for quantitative monitoring of the density and productivity of these eagle populations. Despite the intensive studies conducted on this species in the western-central Alps (Huboux 1985, Fasce and Fasce 1992, Haller 1996), very little data are available for the eastern portion of the alpine chain (Tormen and Cimbien 1995).

Here, we report the results of an 11-yr study on a Golden Eagle population in the central-eastern Italian Alps. We provide quantitative data on the density, diet, and productivity of the population, compare them with estimates from other alpine populations, and examine some of the factors potentially affecting reproductive success.

STUDY AREA

Golden Eagles were surveyed within a 7800 km² study area in the central-eastern Italian Alps and pre-Alps, within the administrative provinces of Trento, Vicenza, Brescia, and Belluno (45°N, 11°E). Elevation of the study area ranged from 65–3764 m and 31% of the land was <1000 m (Tomasi 1962); these areas were rarely used by Golden Eagles for hunting. Twenty-eight percent of the area was between 1000–1500 m, 22% between 1500–2000 m, 13% between 2000–2500 m, and 6% was >2500 m (Tomasi 1962). The natural tree line is at 1800–1900 m, but was often lower because of human activities and sheep grazing (Piussi 1992). The landscape is characterized by cultivated valley floors, mountain slopes covered by forests interspersed with sparse pastures, and by montane grassland, rocky outcrops, and permanently snow-covered ground above tree line. In particular, 52% of the area

was covered by woodland, 18% by montane grassland and pastures, 6% by agricultural crops (mainly vineyards and apple groves), and 3% by human development. Forest composition varied from deciduous to coniferous depending on elevation, slope orientation, and local microclimate. With increasing elevation, woodland tended to be dominated by *Quercus pubescens*, *Quercus-Tilia-Acer* spp., *Fagus-Abies* spp., *Picea* spp., and *Larix-Cembra* spp., respectively (P.A.T. 1995). Eighty-two percent of the woodland area was managed for wood production; 73% of this woodland was managed as mature forest and 27% by stool shoots regeneration (P.A.T. 1995). Woodland extent is currently increasing at a rate of 1.0% every three years, mainly at the expense of alpine and subalpine grassland (P.A.T. 1995).

METHODS

The Golden Eagle population was censused annually from 1982–92 inclusive, and intensively monitored between 1984–89. A nest area was defined as an area where more than one nest was found in the same or in different years, but where only one pair nested each year (e.g., Newton 1979, Sergio and Bogliani 1999, Sergio and Boto 1999). Each Golden Eagle pair occupied a traditional nest area, containing 1–9 alternate nests. Nest-area occupancy was checked each year during the two months before the average laying date (23 March, $N = 27$). Territorial and courtship displays, copulations, nest material transfers, or presence of at least one freshly refurbished nest were considered as minimum evidence of nest-area occupation. The center of each nest area was defined as the arithmetic center of the locations of all alternative nests within the nest area. Nearest-neighbor distance (NND) was calculated as the distance from the center of the nest area of a pair to the center of the nest area of the nearest pair (Tijernberg 1985). Nest-area dispersion was examined by means of the G -statistic (Brown 1975), calculated as the ratio between the geometric and the arithmetic mean of the squared NNDs; the G -statistic ranges from 0–1 and values >0.65 indicate a regular dispersion of nest areas (Brown 1975). Statistical significance of the deviation from randomness towards regularity was tested according to Clark and Evans (1954), with the modification applied by Donnelly (1978). Details of the mathematical procedure can be found in Krebs (1989).

Individual eagles within territorial pairs were aged on the basis of plumage characteristics, following Jollie (1947), Mathieu (1986), and Tijernberg (1988). Immature and subadult eagles were both classified as non-adults, following Mathieu (1986), and Tijernberg (1988).

Nest contents were checked at least three times during the breeding cycle: during incubation to assess whether egg laying had taken place, just after hatching to record hatching date, and when the nestlings were >60-d old to record fledging success (nestlings usually fledge at 70–80 d old, Cramp and Simmons 1980). To minimize disturbance, nest contents were checked from a distance >800 m with a 20–60x telescope. Hatching dates were estimated from feather development, following Cramp and Simmons (1980) and Mathieu (1985). Laying dates were estimated by subtracting 44 d, the median incubation

period (Cramp and Simmons 1980), from hatching dates.

To analyze the factors potentially affecting breeding output, we first calculated a mean estimate of productivity for each nest area within the study period. This measurement of nest area productivity was expressed as the percentage of nesting attempts which were successful (≥ 1 young raised until fledging), and as the mean number of fledged young per nesting attempt. Only nest areas where productivity had been checked for at least three years between 1984–89 were used for such analyses. To examine the effect of land use on productivity, we measured the percentage extent of woodland and grassland habitats within 5 km of the nest-area center of 22 pairs. The measure of 5 km was slightly higher than half the average NND of the study population, and the area within 5 km of the nest-area center was assumed to be an estimate of the potential hunting range of the resident pair (Watson 1992, Pedrini and Sergio 2001).

To minimize disturbance, collection of prey remains was carried out at all accessible nests 7–15 d after the first flight of the young (Watson 1997). Prey remains were identified to genus or species level by comparison to a reference collection of the Trento Museum of Natural History. Prey weights were calculated using Mathieu and Choisy (1982), Haller (1996), and Macdonald and Barrett (1993). Because capture roe deer (*Capreolus capreolus*) were mainly juveniles, they were assigned a weight of 3700 g, following Haller (1996).

A reproductive pair was one which laid eggs, a successful pair was one which raised at least one young until fledging, and breeding success was the percentage of territorial pairs which were successful (Steenhof 1987).

To meet the assumptions of normality of parametric tests, variables were logarithmically, square root, or arcsin-square root transformed as necessary (Sokal and Rohlf 1981). All proportions of land-use types were arcsin-square root transformed. Differences in mean productivity values between or among groups were tested by means of *t*-tests, or ANOVA; differences in frequency of successful territorial pairs or in frequency of successful pairs raising two young to fledging were tested by means of χ^2 -tests (Sokal and Rohlf 1981). The effect of laying date, NND, and habitat composition within the potential hunting range on productivity was assessed by means of parametric and nonparametric correlations, and by partial correlation analysis (Sokal and Rohlf 1981). Means are given ± 1 SE. All tests were two-tailed and statistical significance was set at $P \leq 0.05$.

RESULTS

Density and Nest Dispersion. Between 1982–92, the study area supported a stable population of 46 territorial pairs of eagles. This corresponded to a density of 5.9 pairs per 1000 km². NND ranged from 4–15 km, averaging 8.7 ± 0.4 km ($N = 46$). The *G*-statistic value of 0.82 indicated a regular dispersion of nest areas. The pattern of nest dispersion deviated significantly from randomness towards regularity ($z = 17.26$, $P < 0.0001$, Krebs 1989).

Nest Sites. The number of alternate nests within a nest area ranged from 1–9, averaging 2.7 ± 0.3 ($N = 46$). All but one of 123 censused nests were positioned on cliffs. The only tree nest was in a spruce fir (*Picea excelsa*). Mean nest elevation was 1445 ± 32 m (range = 750–2280 m, $N = 108$). Eighty-six percent of the nests ($N = 108$) were between 1000–2000 m.

Age of Territory Holders, Breeding Season, and Productivity. We classified both partners of 70 pairs as adult or nonadult: 59 pairs (84.3%) were composed of adult individuals, 6 pairs (8.6%) of one adult male and one nonadult female, and 5 pairs (7.1%) of one adult female and one nonadult male. Mean laying date was 23 ± 1.5 March (range = 1 March–7 April, $N = 27$). Between 1984–89, there were no significant differences among years in mean number of young fledged per territorial pair ($F_{5,84} = 0.74$, $P = 0.59$, Table 1), mean number of young fledged per successful pair ($F_{5,43} = 0.49$, $P = 0.78$), or percentage of nesting attempts which were successful ($\chi^2_5 = 2.48$, $P = 0.79$).

Factors Affecting Breeding Output. The number of fledged young was not related to laying date ($r_s = -0.26$, $N = 27$, $P = 0.19$). Breeding success was not correlated with NND (square root transformed) ($r = 0.289$, $N = 25$, $P = 0.161$). The mean number of fledged young was not correlated with percentage woodland extent within the potential hunting range (Pedrini and Sergio 2001). When controlling for NND through partial correlation, the relationship between mean number of fledged young per territory was not related to percentage woodland extent within the potential hunting range ($r = -0.41$, $N = 19$, $P = 0.063$), or to percentage amount of grassland habitats within the potential hunting range ($r = 0.40$, $N = 19$, $P = 0.075$), though both results neared significance. Mean number of fledged young was higher for pairs composed by two adults (0.71 ± 0.1 , $N = 55$) than for pairs composed by one adult and one nonadult individual (0.11 ± 0.1 , $N = 9$) ($t_{62} = 4.28$, $P = 0.0001$).

Diet. Diet was dominated by mammals and birds which accounted for 64% and 32% of 247 prey items collected between 1984–89 (Table 2). The importance of mammalian prey was even higher in the analysis by fresh weight, with mammals accounting for 85% of consumed food. In particular, diet was mainly composed by species belonging to the order Artiodactyla (20% by number and 40% by fresh weight), Rodentia (29% and 25%), Laga-

Table 1. Mean (\pm SE) productivity estimates of a Golden Eagle population in the central-eastern Italian Alps between 1982-92.

| VARIABLE | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1982-92 |
|--|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Number of checked pairs | 9 | 14 | 12 | 16 | 22 | 17 | 109 |
| Percentage successful pairs | 44 | 64 | 50 | 56 | 45 | 65 | 55 |
| Mean no. of young fledged per territorial pair | 0.44 \pm 0.2 | 0.71 \pm 0.2 | 0.58 \pm 0.2 | 0.63 \pm 0.2 | 0.45 \pm 0.1 | 0.76 \pm 0.2 | 0.61 \pm 0.1 |
| Mean no. of young fledged per successful pair | 1.00 \pm 0.0 | 1.11 \pm 0.3 | 1.17 \pm 0.4 | 1.11 \pm 0.3 | 1.00 \pm 0.0 | 1.18 \pm 0.1 | 1.10 \pm 0.0 |

Table 2. Diet of breeding Golden Eagles in the central-eastern Italian Alps (1984-89), as estimated by food remains collected in nests.

| PREY CATEGORY | NUMBER OF ITEMS (%) | % FRESH WEIGHT |
|--|---------------------|----------------|
| Mammals | 157 (64) | 84.6 |
| Roe deer (<i>Capreolus capreolus</i>) | 38 (15) | 30.6 |
| Alpine marmot (<i>Marmota marmota</i>) | 26 (11) | 22.6 |
| Edible dormouse (<i>Glis glis</i>) | 25 (10) | 0.7 |
| Hares (<i>Lepus</i> sp.) | 19 (8) | 11.6 |
| Red squirrel (<i>Sciurus vulgaris</i>) | 13 (5) | 1.0 |
| Red fox (<i>Vulpes vulpes</i>) | 9 (4) | 5.9 |
| Chamois (<i>Rupicapra rupicapra</i>) | 11 (4) | 8.9 |
| Other mammals ^a | 16 (6) | 3.3 |
| Birds | 80 (32) | 15.0 |
| Black Grouse (<i>Tetrao tetrix</i>) | 31 (13) | 7.1 |
| Hazel Grouse (<i>Bonasa bonasia</i>) | 9 (4) | 0.6 |
| Rock Ptarmigan (<i>Lagopus mutus</i>) | 9 (4) | 0.8 |
| Other birds ^b | 31 (13) | 6.4 |
| Reptiles ^c | 10 (4) | 0.4 |
| Total | 247 | — |

^a Includes: common dormouse (*Muscardinus avellanarius*, $N = 4$), pine marten (*Martes martes*, $N = 3$), beech marten (*Martes foina*, $N = 1$), domestic cat (*Felis silvestris*, $N = 1$), brown rat (*Rattus norvegicus*, $N = 1$), *Mustela* spp. ($N = 3$), *Apodemus* spp. ($N = 1$), unidentified rodents ($N = 2$).

^b Includes: domestic fowl (*Gallus* spp., $N = 7$), Capercaillie (*Tetrao urogallus*, $N = 3$), Rock Partridge (*Alectoris graeca*, $N = 3$), Eurasian Jay (*Garrulus glandarius*, $N = 3$), Eurasian Kestrel (*Falco tinnunculus*, $N = 2$), Alpine Chough (*Pyrrhocorax graculus*, $N = 2$), Ring Ouzel (*Turdus torquatus*, $N = 2$), Ring-neck Pheasant (*Phasianus colchicus*, $N = 1$), Common Cuckoo (*Cuculus canorus*, $N = 1$), Mistle Thrush (*Turdus viscivorus*, $N = 1$), Hooded Crow (*Corvus corone cornix*, $N = 1$), unidentified Galliform ($N = 5$).

^c Includes: Aesculapian snake (*Elaphe longissima*, $N = 4$), western whip snake (*Coluber viridiflavus*, $N = 1$), *Vipera* spp. ($N = 1$), unidentified Colubridae ($N = 4$).

morpha (8% and 12%), Carnivora (7% and 9%), and Galliformes (28% and 15%). Main prey species by number were roe deer, alpine marmot (*Marmota marmota*), Black Grouse (*Tetrao tetrix*), and edible dormouse (*Glis glis*). Main prey species by weight were roe deer, alpine marmot, hares (*Lepus* spp.), and chamois (*Rupicapra rupicapra*).

Comparison of Breeding Parameters with Other Alpine Populations. We obtained estimates of density, mean NND, and productivity of Golden Eagles in other alpine areas (Table 3). It was possible to compare mean NND in our study area with one in the western Italian Alps (Fasce and Fasce 1984) and in the French pre-Alps (Mathieu and Choisy 1982). Mean NND did not vary significantly among

Table 3. Estimates of density, mean (\pm SE) nearest-neighbor distance (NND), and productivity for 13 Golden Eagle populations in the alpine chain (1978-94).

| AREA | YEAR ^a | DENSITY (N) ^b | MEAN NND (N) ^c | BREEDING SUCCESS ^d (N) | MEAN NO. OF | | PERCENTAGE SUCCESSFUL PAIRS RAISING TWO YOUNG (N) | SOURCE |
|----------------------|-------------------|--------------------------|---------------------------|-----------------------------------|---|-----------|---|--------|
| | | | | | FLEDGED YOUNG PER TERRITORIAL PAIR ^e | YOUNG | | |
| France: | | | | | | | | |
| Southern Alps | 1978-80 | — | 10 (19) | 29 (51) | 0.29 \pm 0.1 | 0.0 (15) | Mathieu and Choisy 1982 | |
| South-western Alps | 1982-92 | 13.7 | — | 64 (105) | 0.82 \pm 0.1 | 39.6 (67) | Couloumy 1996 | |
| Southern Alps A | 1980-84 | — | 7 (31) | 36 (107) | 0.44 \pm 0.1 | 26.7 (38) | Huboux 1984 | |
| Southern Alps B | 1980-84 | — | 8.8 (26) | 31 (93) | 0.35 \pm 0.1 | 16.0 (29) | Huboux 1984 | |
| Haute-Savoie | 1980-84 | 9.3 (28) | — | 38 (95) | 0.38 \pm 0.1 | 0.0 (36) | Estève and Matérac 1987 | |
| Switzerland: | | | | | | | | |
| Grisons | 1984-89 | 13 (61) | 6.1 (61) | 80 (74) | 0.95 \pm 0.1 | 22.9 (59) | Haller 1996 | |
| Berne | 1987-89 | 11.9 (33) | — | 35 (105) | 0.38 \pm 0.1 | 8.8 (37) | Jenny 1992 | |
| Pre-Alps | 1980-84 | 11.3 (18) | — | 42 (60) | 0.47 \pm 0.1 | 13.6 (25) | Henninger et al. 1986 | |
| Pre-Alps | 1983-94 | — | — | 55 (33) | 0.55 \pm 0.1 | 0.0 (18) | Haller 1996 | |
| Italy: | | | | | | | | |
| Western Alps | 1980-83 | — | 8.6 (80) | 65 (153) | 0.76 \pm 0.1 | 2.2 (99) | Fasce and Fasce 1984 | |
| Western Alps | 1972-87 | 9.5 (31) | 6.8 (31) | 68 (168) | 0.79 \pm 0.0 | 2.0 (114) | Bocca 1989 | |
| Eastern Alps | 1989-92 | — | 9.9 (27) | 36 (67) | 0.36 \pm 0.1 | 0.0 (24) | Tormen and Cimbien 1995 | |
| Central-eastern Alps | 1982-92 | 5.9 (46) | 8.7 (46) | 55 (109) | 0.61 \pm 0.1 | 11.1 (60) | This study | |

^a The study period indicated refers to the years in which productivity was checked. Whenever possible, data were employed for periods coinciding as much as possible with the study period of our systematic survey (1984-89).

^b Number of territorial pairs per 1000 km².

^c Measured in km.

^d Percentage successful pairs.

^e Sample size is the same as for breeding success.

areas ($F_{2, 142} = 1.17$, $P = 0.31$). Mean number of fledged young per territorial pair varied significantly among populations ($F_{12, 1207} = 12.22$, $P < 0.0001$). In particular, mean number of fledged young in our study population was lower than recorded in the western Italian Alps (Fasce and Fasce 1984, Bocca 1989), southwestern French Alps (Coulumy 1996), and Swiss Grisons (Haller 1996) and it was higher than recorded in the French pre-Alps (Mathieu and Choisy 1982, Huboux 1984), Haute Savoie (Estève and Matérac 1987), Canton of Berne (Jenny 1992), and eastern Italian Alps (Tormen and Cimbien 1995) (Duncan's multiple range test, $P < 0.05$). The percentage of successful pairs raising two young to fledging also varied significantly among populations ($\chi^2_{12} = 43.7$, $P = 0.0001$): in our study area it was higher than in Haute Savoie (Estève and Matérac 1987) ($\chi^2_1 = 5.8$, $P = 0.015$), but lower than in the southwestern French Alps (Couloumy 1996) ($\chi^2_1 = 7.1$, $P = 0.008$). The proportion of pairs composed of one adult and one nonadult individual was 35% ($N = 26$) in the French pre-Alps in 1979–80 (Mathieu and Choisy 1982), 4% ($N = 132$) in the western Italian Alps between 1980–83 (Fasce and Fasce 1984), 10% ($N = 31$) in the western Italian Alps in 1987 (Bocca 1989), 21% in the eastern Italian Alps (Tormen and Cimbien 1995), and 16% in this study. The estimate from our population was similar to both the western Italian Alps in 1987 ($\chi^2_1 = 0.69$, $P = 0.40$) and the eastern Italian Alps in 1989–94 ($\chi^2_1 = 0.62$, $P = 0.43$), higher than in the western Italian Alps in 1980–83 ($\chi^2_1 = 8.41$, $P = 0.004$), and lower than in the French pre-Alps in 1979–80 ($\chi^2_1 = 3.83$, $P = 0.05$).

Human Persecution and Electrocution. Between 1970–89, 18 deaths were caused by illegal shooting and reported to local authorities, or directly to the authors. Fifteen of the deaths occurred between 1980–89. Electrocution caused the death of three individuals in the same time period.

DISCUSSION

In our study area, Golden Eagles occupied traditional nest areas and showed remarkable population stability over a period of 6–11 yr. Density was the lowest published for the Alps, but mean nest spacing was comparable and not different from those reported for other alpine populations. Productivity was lower than reported in the Swiss Grisons, southwestern French Alps, and in the western Italian Alps, but similar or higher than all other

nine estimates for eastern, central, and western populations. Finally, diet was dominated by roe deer, marmots, hares and chamois, as observed elsewhere within the alpine chain (Huboux 1984, Henninger et al. 1986, Haller 1996).

Golden Eagle population density and productivity are affected by food availability (Watson et al. 1989, Watson et al. 1992, Steenhof et al. 1997), land use changes (Marquiss et al. 1985), human persecution and unintentional disturbance (Jenny 1992, Watson 1994, McGrady 1997), and intraspecific interference competition (Jenny 1992, Haller 1996). In our study area, populations of all main prey species are currently increasing (Perco 1990, P.A.T. 1995), mainly due to better management of hunting activities, more effective wildlife legislation, and marmot reintroduction programs. As an example, between 1982–94, the local roe deer and chamois populations increased by 12% and 101%, respectively (P.A.T. 1995). While food supply was increasing, land abandonment and consequent forest expansion were causing an increasing loss of alpine pastures (P.A.T. 1995, Pedrini and Sergio 2001), the main Golden Eagle foraging habitat in the Alps (Haller 1996). This trend is common throughout the alpine chain and is causing considerable concern over its long-term impact on local eagle populations (Mathieu and Choisy 1982, Huboux 1984, Estève and Matérac 1987, Fasce and Fasce 1992). The negative long-term effects of afforestation on Golden Eagle reproduction have been demonstrated in Scotland by Marquiss et al. (1985) and Watson (1992). In our study, the amount of woodland and grassland habitats within 5 km of the nest-area center appeared to be almost significantly related to productivity, after removing the effects of density, which may be important in explaining variations in productivity in some alpine populations (Jenny 1992, Haller 1996). We suggest that further woodland expansion could cause significant long-term declines in productivity. Watson (1992) showed how afforestation can affect Golden Eagle breeding success with a time lag of up to 10 yr.

Persecution accounted for the death of 15 individuals between 1980–89. In the province of Trento, Golden Eagles were given legal protection in 1970. Since then, illegal shooting and trapping have declined markedly. However, our data suggest a level of persecution higher than estimates from the Italian Alps (Bocca and Maffei 1984, Fasce and Fasce 1984) and similar to reports from the Ap-

pennines, where Golden Eagles are reported to be kept at low densities mostly by human persecution (Ragni et al. 1986). Also, the 15 deaths from persecution were probably a minimum estimate, as killings are illegal and thus likely to go usually unrecorded. Thus, the real level of persecution may be much higher. The high percentage of pairs with nonadult partners further testified to elevated levels of persecution (Steenhof et al. 1983, Watson et al. 1989), though it may have also been associated with a possible population increase, suggested by data collected in the late 1990s (Pedrini unpubl. data). More public education on the well-demonstrated insignificant impact of Golden Eagles on domestic or game species (Clouet 1981, Mathieu and Choisy 1982, Haller 1996) could be beneficial in decreasing the level of illegal shooting.

If the trend in direct human persecution is slowly declining within the alpine chain, unintentional disturbance seems to be a steadily increasing threat. Road construction has allowed easy access to once remote areas. The rapid expansion of "green" tourism is leading to considerable human presence in remote mountain valleys. Off-site skiing is expanding human presence in areas far away from ski runs during the winter and early spring period, both of which are sensitive stages during the breeding cycle. Various recreational activities have been widely reported to cause breeding failures or prevent usage of hunting grounds by alpine Golden Eagles. These include climbing, para-gliding, hang gliding, hiking, heli-skiing, snowmobile and helicopter activities, and nature photography (Mathieu and Choisy 1982, Bocca 1989, Jenny 1992, Beaud and Beaud 1995, McGrady 1997). In Switzerland, 27% of known breeding failures were caused by unintentional disturbance near occupied nests (Jenny 1992). Problems are aggravated by the high sensitivity of Golden Eagles to human presence around nest areas and by the fascination of this raptor to photographers (Jenny 1992). We know of one case of premature fledging caused by disturbance by photographers in our study area. In the province of Trento, disturbance connected with nature photography has been increasing so rapidly in the last decade that a mass media campaign against photography at the nest has been undertaken and, in 1998, led to a new law against disturbance to wildlife.

Finally, breeding success in our study area was not related to NND, a difference from the density-dependent reproductive output reported for the

Swiss Alps (Jenny 1992, Haller 1996). In these studies, productivity was negatively affected by intraspecific interference competition early in the breeding season and, particularly so, by territorial disputes between resident pairs and intruding floaters.

In conclusion, alpine populations of Golden Eagles have been reported to be locally increasing to almost carrying capacity (Haller and Sackl 1997). Despite this, we suggest that the future long-term population trends of Golden Eagles in the Alps will be determined by the interaction among increasing food supply, declining availability of suitable foraging habitat, decreasing human persecution, and increasing unintentional human disturbance. We also warn that the local density dependency of productivity and the potential time lags in the effects of land-use changes on productivity could be masking the long-term effects of habitat loss on alpine populations. As a result, we strongly recommend the continuous monitoring of Golden Eagle density and productivity within the alpine chain. Current threats to alpine Golden Eagles could be decreased by: (1) increasing subsidies of the Common Agricultural Policy for extensive agro-pastoral practices; (2) educating hunters, farmers, foresters, development planners, and local communities on the ecological role of top predators within alpine ecosystems; (3) informing organizations and institutions related to the growing industry of tourism and recreational outdoor activities on ways to minimize unintentional disturbance to nesting pairs; and (4) increasing the current knowledge of factors affecting the selection of nesting and foraging habitat by territorial and non-territorial eagles in the Alps.

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MANAGEMENT OF NONRELEASABLE RAPTORS FOR CONSERVATION EDUCATION PROGRAMS

JOE N. CAUDELL¹

University of Georgia, Warnell School of Forest Resources, Athens, GA 30602 U.S.A.

KEN A. RIDDLEBERGER, JR.

Georgia Department of Natural Resources, Wildlife Resources Division, Special Permit Unit, Social Circle, GA 30025 U.S.A.

ABSTRACT.—Nonreleasable raptors are utilized throughout the United States to enhance conservation education programs. Their management is often based on practices found in literature as well as through operational experience. Management practices must also comply with state and federal regulations. To document current management practices, we surveyed conservation education facilities throughout the United States regarding species and numbers of raptors utilized, sizes and types of enclosures, health problems, feeding regimes, and other aspects of management. We also mailed a similar survey to all facilities utilizing nonreleasable raptors in Georgia and we inspected a subset of the respondents and nonrespondents. This information was then combined with scientific literature, popular literature, and unpublished management methods to create a set of best management practices for nonreleasable raptors in Georgia, which comply both with Georgia Department of Natural Resources (GADNR) wildlife exhibition regulations and recent changes to United States Fish and Wildlife Service (USFWS) educational permit requirements. In most cases throughout the United States and in Georgia, the mean or median management practices exceeded those required by the USFWS. Less than 7% of all raptors housed under those management conditions experienced serious health problems. Results between the voluntary United States survey and the Georgia survey were similar, with most differences attributable to regional conditions. We discovered only minor discrepancies between survey results and inspections. An unexpected benefit from inspections was that operators appreciated GADNR taking an interest in their programs and most welcomed any advice provided regarding their facilities.

KEY WORDS: *captive raptors; captive raptor care; environmental education.*

Manejo de las aves rapaces no aptas para la liberación en programas de educación ambiental

RESUMEN.—Las aves rapaces no aptas para liberación son utilizadas a través de los Estados Unidos para realzar los programas de educación ambiental. Su manejo está basado en prácticas encontradas en la literatura como también a partir de la experiencia operativa. Las prácticas de manejo deben cumplir con las regulaciones estatales y federales. Con el fin de documentar las prácticas de manejo, investigamos los centros de educación ambiental a través de los Estados Unidos con relación al número de especies y rapaces utilizadas, tamaño y tipo de encierros, problemas de salud, dietas y otros aspectos de manejo. También enviamos un cuestionario similar a todos los centros que utilizan aves rapaces no aptas para liberación en Georgia, e inspeccionamos a los grupos que respondieron o no. Esta información fue confrontada con la literatura científica, la popular y con los métodos de manejo sin publicar para elaborar un juego apropiado de prácticas de manejo para rapaces no aptas para liberación en Georgia, que cumpliera con ambos requisitos: Los del Departamento de Recursos Naturales de Georgia (DRNG), con las regulaciones para la exhibición de la fauna silvestre y los cambios recientemente hechos por el Servicio de Pesca y Vida Silvestre (USFWS) a los permisos de educación Ambiental. En la mayoría de los casos a través de los Estados Unidos y en Georgia, la media o la mediana de las prácticas de manejo excedieron a los requerimientos del USFWS. Menos del 7% de todas las aves rapaces en cautiverio experimentaron serios problemas de salud entre las encuestas voluntarias de los Estados Unidos y los de Georgia fueron similares, la mayoría de las diferencias fueron atribuibles a condiciones regionales. Descubrimos unas pocas discrepancias menores entre los resultados y las inspecciones. Un beneficio

¹ Current address: Jack H. Berryman Institute, Utah State University, 5210 Old Main Hill, Natural Resources Rm 206, Logan, UT 84322-5210 U.S.A.

inesperado de las inspecciones fue el agradecimiento hecho al DRNG por el interés mostrado en este tipo de programas y la bienvenida a cualquier tipo de sugerencia hecha con relación a su infraestructura.

[Traducción de César Márquez]

Environmental education centers throughout the United States often include wildlife classes in their curriculum. In order to enhance these classes, live animals, such as small mammals, snakes, and raptors are commonly utilized. Until recently, laws and regulations concerning the management of non-releasable raptors were vague (Official Code of Georgia Annotated OCGA § 27-2-13). Few states have regulations that apply specifically to non-releasable raptors. Some states, including Georgia, have provisions in their wildlife laws that allow the natural resource agency to determine appropriate management practices. Other states have no provisions at all. This often results in permit officers or other wildlife biologists making decisions on acceptable management practices.

In 1998, the United States Fish and Wildlife Service (USFWS) modified their regulations regarding the care of captive raptors for education programs (USFWS Standard Conditions, Special Purposes-Possession/Education (Live Specimens), 50 CFR 21.27). These regulations specifically defined requirements for the use of captive raptors for conservation education programs. Criteria for housing and maintaining them were based on suggested guidelines of the University of Minnesota Raptor Center (Arent and Martell 1996). These new regulations provide specific, well-defined guidelines concerning the proper operation of captive raptor facilities but it is uncertain how these new regulations will affect the management practices at environmental education centers.

We began this study in 1996 to document and evaluate current nonreleasable raptor management practices in Georgia. The study was expanded to document practices throughout the United States to provide data with which to evaluate management practices in Georgia. We surveyed individuals and organizations in both Georgia and throughout the United States who utilize raptors in educational programs. In Georgia, the survey was followed up by on-site inspections and interviews with caretakers. We compared results from Georgia with results from centers outside Georgia and, when possible, with the current USFWS captive raptor regulations.

METHODS

The Sample. We sent a questionnaire to a sample of individuals and organizations possessing raptors used in environmental education programs in 1996. The Georgia sample was compiled from persons possessing Georgia Department of Natural Resources (GADNR) wildlife exhibition permits for raptors. The United States sample was compiled using two methods. A search was conducted using LYCOS®, YAHOO®, Infoseek®, and EXCITE® search engines during January 1998. Keywords included *raptor(s)*, *bird of prey*, *environmental education*, *rehabilitation*, and combinations of these. Links were examined at each site to locate additional related internet sites. A list of raptor centers throughout the United States which indicated that they rehabilitated raptors, used raptors in education, or maintained raptors in captivity was compiled from Internet web pages. Those persons indicating that they had E-mail were then sent a query to determine if raptors were used for educational programs and if they would participate in the survey. The survey was mailed to respondents providing a positive response.

The second method was to survey list-server users. Membership registers and messages were examined to determine how many members potentially had educational birds. E-mail inquiries were placed on two list servers for rehabilitators and one for falconers. The inquiry consisted of a message explaining the nature of the survey, time needed to complete the questionnaire, and purpose for the research. Respondents indicating they held nonreleasable raptors and used them for education programs were mailed a survey. Both methods were dependent upon the respondents owning a computer and having access to the world-wide web.

The Survey. Survey questions were based upon OCGA § 27-5-6 which contains the specifications for management of captive wild animals (Caudell and Riddleberger 2000). In general, the survey consisted of questions about the species and number of raptors possessed, facilities, space requirements, feeding, watering, sanitation, employees, separation of species, veterinary care, handling, and transportation. Questions were designed to obtain qualitative data for each of these areas. The United States survey was modified by removing questions regarding cleaning frequency and methods, pest control techniques, carrying cages, and program times to decrease the length of the instrument in order to increase the response rate (Caudell and Riddleberger 2000).

The Georgia surveys were mailed from the GADNR office in Social Circle, Georgia in late August 1997. Surveys were sent with a letter on official letterhead with return envelopes addressed to the GADNR office. A second survey was mailed to nonrespondents during the first week of January 1998 and reminders sent three weeks later. Request for United States participants were E-mailed from the last week of December 1997 through 20 February 1998. Surveys were mailed to United States participants on University of Georgia letterhead with re-

turn envelopes enclosed. Return envelopes were addressed to the university.

Respondents and nonrespondents in Georgia were randomly chosen from a stratified sample for on-site inspections in March and April 1998. Criteria of inspections were based on the Georgia survey. Questions regarding training procedures, past inspections, and educational programs were asked.

RESULTS

Sample Results. Twenty-three individuals and organizations that held Georgia permits for raptors used in environmental programs were sent the questionnaire. Seventeen surveys were returned. Of the five centers that did not return surveys, two reported that they did not have the time to answer, one did not believe that they used birds in programs in the manner specified in the instructions, and two did not respond. Nine centers (six respondents and three nonrespondents) were chosen for on-site inspections.

From the Internet search, 43 sites were located that possibly had nonreleasable raptors used in educational programs. Of these, 11 facility managers indicated that they possessed birds and would participate in the survey. From the list-server search, 42 facilities were identified that possibly had nonreleasable raptors and 29 responded that they had birds and would participate in the survey. Forty surveys were mailed. Nine surveys were returned from the Internet search and 27 were returned from the list-server search. Response rate from the combined groups was 90%.

The two samples were not mutually exclusive. Four centers used in the United States sample also possessed raptors in Georgia. These four centers were selected because they voluntarily returned the survey and had Internet access. The distribution of the surveys was spread throughout the continental United States based on the current USFWS regions (Arent and Martell 1996). Eleven surveys were returned from centers in Region 4, nine surveys were returned from Region 1, five surveys were returned from Region 3, four surveys were returned from Regions 2 and 5, and three surveys were returned from centers in Region 6. We did not receive any surveys from centers in Region 7.

Survey Results. Sixteen Georgia facilities reported housing 98 raptors used in educational programs. Thirty-six facilities throughout the United States reported housing 428 raptors. Education centers throughout the United States and Georgia utilized *Buteo* spp. most frequently (Table 1). *Accip-*

iters (*Accipiter* spp.), Ospreys (*Pandion haliaetus*), Mississippi Kites (*Ictinia mississippiensis*), and Ferruginous Pygmy-Owls (*Glaucidium brasilianum*) were rarely used. American Kestrels (*Falco sparverius*) were used infrequently in Georgia, but were commonly used throughout the rest of the United States.

Enclosure sizes varied as did the types of materials used in their construction. There were no major differences between the median enclosure size found in Georgia and those reported throughout the United States (Table 2). Median cage size areas were greater than or equal to current USFWS requirements for nonflighted birds (Arent and Martell 1996).

The two most commonly-used perch materials were artificial turf and tree branches. Throughout the United States, 27% of facilities used tree branches and 25% used artificial turf. In Georgia, 39% of facilities used tree branches and 22% used artificial turf. Other perch materials used by facilities included rope (12% in Georgia, 11% throughout the United States), stumps or logs (17% in both Georgia and the United States), large stones (3% in Georgia, 6% throughout the United States), and wood blocks (6% in both Georgia and the United States). Perch material selection was not mutually exclusive. In 93% of the facilities, more than one type of perch material was used. None of the materials used in perches throughout the United States or in Georgia were considered unacceptable by USFWS standards.

Throughout the United States, round river rock was utilized by 24% of facilities as floor substrate while only 12% of facilities in Georgia utilized this material. The two most commonly used substrates in Georgia were pine needles (19%) and crushed gravel (19%). Throughout the United States, 7% and 13% of facilities used pine needles and crushed gravel, respectively. Other commonly used substrates included dirt or no substrate (15% in Georgia, 13% throughout the United States), sand (8% in Georgia, 10% throughout the United States), grass (4% in Georgia, 13% throughout the United States), concrete floors (8% in Georgia, 5% throughout the United States), and newspaper (8% in Georgia, 3% throughout the United States). Fifteen percent of floor coverings throughout the United States were considered unacceptable by current USFWS standards. In Georgia, 27% of the materials used as floor covering would be

Table 1. Numbers and relative frequencies of nonreleasable raptors used in environmental education programs in the United States and Georgia.

| SPECIES OF RAPTOR | U.S. SURVEY | | GEORGIA SURVEY | |
|---------------------------------|--------------|--------------------|----------------|--------------------|
| | TOTAL NUMBER | RELATIVE FREQUENCY | TOTAL NUMBER | RELATIVE FREQUENCY |
| <i>Buteo</i> spp. | 84 | 19.6 | 27 | 28.1 |
| <i>Otus</i> spp. | 45 | 10.5 | 15 | 15.6 |
| <i>Falco sparverius</i> | 43 | 10.1 | 1 | 1 |
| <i>Bubo virginianus</i> | 41 | 9.6 | 15 | 15.7 |
| <i>Strix varia</i> | 29 | 6.8 | 19 | 19.8 |
| <i>Falco</i> sp. | 29 | 6.8 | 0 | 0 |
| <i>Haliaeetus leucocephalus</i> | 28 | 6.5 | 1 | 1 |
| <i>Tyto alba</i> | 25 | 5.8 | 10 | 10.4 |
| <i>Aquila chrysaetos</i> | 17 | 4 | 0 | 0 |
| <i>Cathartes aura</i> | 14 | 3.3 | 5 | 5.2 |
| <i>Asio</i> spp. | 13 | 3 | 0 | 0 |
| <i>Aegolius funereus</i> | 11 | 2.6 | 0 | 0 |
| <i>Accipiter</i> spp. | 10 | 2.3 | 0 | 0 |
| <i>Parabuteo unicinctus</i> | 10 | 2.3 | 1 | 1 |
| <i>Coragyps atratus</i> | 10 | 2.3 | 0 | 0 |
| <i>Circus cyaneus</i> | 5 | 1.2 | 0 | 0 |
| <i>Pandion haliaetus</i> | 5 | 1.7 | 2 | 2.1 |
| <i>Ictinia mississippiensis</i> | 3 | 0.7 | 0 | 0 |
| <i>Polyborus plancus</i> | 2 | 0.5 | 0 | 0 |
| <i>Athene cunicularia</i> | 2 | 0.5 | 0 | 0 |
| <i>Glaucidium</i> spp. | 1 | 0.2 | 0 | 0 |
| <i>Nyctea scandiaca</i> | 1 | 0.2 | 0 | 0 |

considered unacceptable by current USFWS standards.

Wooden slats and solid wood were the most common building materials used. In wall construction, 56% of facilities throughout the United States and 26% of facilities in Georgia used wood. To cover enclosures, 30% of facilities throughout the United States and 15% of facilities in Georgia used wood.

Plastic mesh was the next most widely used material followed by netting, galvanized hardware cloth, and polyvinyl chloride bars. The choices for the sides and roof materials were not mutually exclusive. Two percent of materials utilized in raptor enclosures throughout the United States were considered unacceptable by current USFWS standards, primarily chicken wire. In Georgia, 4% of the ma-

Table 2. Enclosure dimensions of captive raptors from throughout the United States.

| SPECIES | N | LENGTH (m) | | WIDTH (m) | | HEIGHT (m) | | AREA (m ²) | |
|--------------|----|------------------------|--------|-----------|--------|------------|--------|------------------------|--------|
| | | MEAN ± SE ¹ | MEDIAN | MEAN ± SE | MEDIAN | MEAN ± SE | MEDIAN | MEAN ± SE | MEDIAN |
| Hawk | 31 | 5.0 ± 0.5 | 4.2 | 3.2 ± 0.2 | 2.4 | 2.9 ± 0.1 | 2.4 | 19.9 ± 3.1 | 11.8 |
| Large owl | 34 | 4.8 ± 0.5 | 3.7 | 3.1 ± 0.3 | 2.4 | 2.6 ± 0.1 | 2.4 | 19.1 ± 4.3 | 9.6 |
| Small owl | 27 | 2.2 ± 0.1 | 2.4 | 1.7 ± 0.2 | 1.4 | 1.9 ± 0.1 | 2.0 | 4.0 ± 0.5 | 3.2 |
| Large falcon | 13 | 3.3 ± 0.2 | 2.4 | 2.6 ± 0.1 | 2.4 | 3.2 ± 0.2 | 2.4 | 9.2 ± 1.0 | 7.4 |
| Small falcon | 21 | 3.3 ± 0.2 | 3.1 | 5.6 ± 0.2 | 2.4 | 2.3 ± 0.1 | 2.4 | 9.9 ± 1.6 | 5.8 |
| Eagle | 12 | 5.3 ± 0.2 | 5.4 | 4.2 ± 0.3 | 3.7 | 2.8 ± 0.1 | 2.8 | 24.0 ± 2.3 | 16.7 |
| Vulture | 5 | 6.9 ± 0.5 | 4.9 | 2.8 ± 0.1 | 2.4 | 2.8 ± 0.1 | 2.4 | 21.0 ± 2.3 | 11.8 |

¹ SE = standard error.

materials utilized would be considered unacceptable by the USFWS standards.

The average number of employees working in facilities in Georgia was 4.5 ± 1.3 (\pm SE) and ranged from 1–20. The average number of employees working in facilities throughout the United States was 14.8 ± 3.6 and ranged from 1–83. The amount of formal training provided to employees or volunteers ranged from a few hours to months. The mean number of years of the primary caretaker's experience reported in Georgia and throughout the United States was 12.2 ± 2.1 and 13.5 ± 1.4 yr, respectively. The level of training ranged from having no formal training to veterinary technician certification. In Georgia, three caretakers reported having rehabilitation experience and three reported having a wildlife-related degree. Approximately 33% of the caretakers surveyed throughout the United States had rehabilitation experience and only one reported having a degree in wildlife or a related field.

Questions regarding cleaning frequency and methods, pest control techniques, carrying cages, and program times were asked only on the Georgia survey. The frequency of cleaning water bowls and food dishes ranged from once per day to once per week. The frequency of cleaning cages and substrate ranged from once per day to once per month. Commonly used disinfectants and cleaning solutions included chlorine bleach, other disinfectants, and soap and water. Twenty-seven percent of centers have an established pest control program for external parasites, internal parasites, or predators. Most facilities (88%) had at least one transport cage per bird. All facilities provided a rest break between performances that was at least as long as the performance period.

All facilities in Georgia and throughout the United States used the same veterinarian on a regular basis. Of the veterinarians used in Georgia and throughout the United States, 75% and 86%, respectively, reported having prior experience treating raptors. Visits to raptor facilities by veterinarians in Georgia ranged from none to weekly. Throughout the United States, visits to raptor facilities by veterinarians ranged from none to daily. Of the 98 nonreleasable raptors reported being housed in Georgia, only 10 problems were reported in 1996. Of the 428 raptors housed in the United States, 62 problems were reported. Physical injuries, bumblefoot, and problems related to old age were most frequently reported. There was no

obvious relationship between occurrences of problems and the number of routine visits by veterinarians to the facilities or routine checkups.

Raptors were fed a variety of food items (Table 3). Few birds were fed a single type of food item. The most common food item among all birds was mice or rats. The most notable exceptions were bald eagles (*Haliaeetus leucocephalus*) and accipiters which were fed mostly fish and fledgling domestic chickens, respectively. Nutrient supplements were used by 60% of the facilities. None of the foods utilized in either Georgia or throughout the United States were considered unacceptable by current USFWS standards.

Based upon qualitative observations, there did not appear to be any major discrepancies or misrepresentation between our inspections and the responses to the survey. The most noticeable differences were due to acquisition of new birds and new construction. Food items, food supplements, construction materials, cage substrate, and perch materials used were nearly identical to reported practices.

DISCUSSION

Although it was stated in the instructions that responses from Georgia were voluntary, mailing the survey from the GADNR Special Permit Unit could have affected the responses in several ways. Fear of not receiving permit renewal may have influenced persons to return surveys or persons may have refused to participate due to animosities with GADNR. They may have also misrepresented their center's management practices due to anxiety over permit renewal. However, this did not appear to be the case based on our inspections. The primary sample bias from throughout the United States was that most respondents were probably from the better centers (i.e., those with enough funds for Internet access and computers and those willing to provide details about their center's operations). Management practices of nonrespondents in Georgia did not appear to differ from respondents. However, this observation was based upon qualitative assessment rather than quantitative measures due to the small sample size of only three nonrespondents inspected and the lack of randomness in the sampling method. To further validate the responses, additional nonrespondents throughout the United States should be sampled in conjunction with random, voluntary surveys.

Species abundance at education centers reflects

Table 3. Food items (mean \pm SE) fed to captive raptors in environmental education programs throughout the United States and in Georgia.

| SPECIES | N | FOOD ITEMS | | | | | | | | | |
|---|-----------------|-----------------|----------------|----------------|-----------------------|----------------|----------------|----------------|----------------|---------------|--|
| | | MICE | RATS | POULTS | BOP ^a DIET | ROAD KILL | QUAIL | INSECTS | OTHER | | |
| <i>Accipiter</i> spp. | 3 | 9.7 \pm 2.5 | 9.7 \pm 2.5 | 4.7 \pm 1.2 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 66.7 \pm 8.6 | 0.0 \pm 0.0 | 9.3 \pm 2.4 | | |
| <i>Aegolius</i> spp. | 3 | 83.3 \pm 4.3 | 0.0 \pm 0.0 | 13.3 \pm 3.4 | 0.0 \pm 0.0 | 3.3 \pm 0.9 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | |
| <i>Aquila chrysaetos</i> | 10 | 3.9 \pm 1.4 | 51.9 \pm 5.0 | 8.7 \pm 3.6 | 0.0 \pm 0.0 | 7.9 \pm 2.5 | 10.5 \pm 2.3 | 0.0 \pm 0.0 | 15.1 \pm 3.5 | | |
| <i>Asio</i> spp. | 2 | 100.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | |
| <i>Buteo</i> spp., <i>Parabuteo</i> sp. | 34 | 31.9 \pm 4.6 | 29.3 \pm 4.4 | 12.5 \pm 2.9 | 7.8 \pm 3.5 | 1.0 \pm 0.4 | 7.0 \pm 2.2 | 0.9 \pm 0.8 | 9.4 \pm 3.2 | | |
| <i>Bubo virginianus</i> | 23 | 45.6 \pm 5.0 | 23.4 \pm 3.7 | 11.5 \pm 3.6 | 3.9 \pm 2.8 | 0.9 \pm 0.4 | 5.0 \pm 2.7 | 0.0 \pm 0.0 | 8.7 \pm 3.5 | | |
| | 10 ^b | 7.5 \pm 2.0 | 42.5 \pm 7.5 | 36.1 \pm 7.8 | 7.1 \pm 3.1 | 3.0 \pm 1.3 | 4.0 \pm 1.6 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | |
| <i>Cathartes</i> sp., <i>Coragyps</i> sp. | 10 | 26.8 \pm 3.2 | 47.0 \pm 5.6 | 7.1 \pm 1.2 | 0.0 \pm 0.0 | 1.0 \pm 0.5 | 2.0 \pm 0.9 | 0.0 \pm 0.0 | 16.1 \pm 2.5 | | |
| | 4 ^b | 0.0 \pm 0.0 | 57.5 \pm 8.4 | 5.0 \pm 1.9 | 0.3 \pm 0.1 | 25.0 \pm 9.6 | 12.5 \pm 4.8 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | |
| <i>Falco sparverius</i> | 24 | 69.8 \pm 4.5 | 1.7 \pm 0.8 | 12.2 \pm 2.8 | 0.4 \pm 0.3 | 0.2 \pm 0.2 | 9.4 \pm 3.0 | 1.0 \pm 0.6 | 3.6 \pm 1.1 | | |
| <i>Falco</i> spp. | 7 | 20.7 \pm 2.9 | 1.4 \pm 0.6 | 10.0 \pm 2.7 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 38.6 \pm 5.6 | 0.0 \pm 0.0 | 29.3 \pm 7.2 | | |
| <i>Haliaeetus leucocephalus</i> | 12 | 1.3 \pm 0.5 | 24.9 \pm 2.8 | 11.3 \pm 3.9 | 0.0 \pm 0.0 | 2.7 \pm 1.3 | 10.8 \pm 3.4 | 0.0 \pm 0.0 | 49.9 \pm 3.3 | | |
| | 4 ^b | 10.0 \pm 2.4 | 16.3 \pm 3.8 | 25.0 \pm 8.4 | 10.0 \pm 3.8 | 0.0 \pm 0.0 | 10.0 \pm 3.8 | 0.0 \pm 0.0 | 24.0 \pm 6.8 | | |
| <i>Ictinia mississippiensis</i> | 2 | 50.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | 2.5 \pm 0.5 | 47.5 \pm 0.5 | 0.0 \pm 0.0 | | |
| <i>Otus</i> spp. | 24 | 75.2 \pm 4.8 | 1.3 \pm 0.7 | 18.9 \pm 4.6 | 0.4 \pm 0.3 | 0.2 \pm 0.2 | 1.7 \pm 0.9 | 1.0 \pm 0.6 | 1.4 \pm 0.6 | | |
| | 10 ^b | 42.0 \pm 7.7 | 6.0 \pm 2.6 | 37.5 \pm 8.2 | 5.0 \pm 3.0 | 2.0 \pm 1.2 | 5.0 \pm 3.0 | 0.0 \pm 0.0 | 2.0 \pm 1.2 | | |
| <i>Strix varia</i> | 15 | 45.5 \pm 5.7 | 24.0 \pm 5.0 | 21.8 \pm 5.1 | 0.0 \pm 0.0 | 1.7 \pm 0.7 | 6.0 \pm 2.9 | 0.0 \pm 0.0 | 1.0 \pm 0.4 | | |
| | 13 ^b | 16.9 \pm 4.6 | 28.5 \pm 7.4 | 28.8 \pm 7.5 | 19.7 \pm 6.8 | 2.7 \pm 1.2 | 3.1 \pm 1.4 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | | |
| <i>Tyto alba</i> | 14 | 38.9 \pm 4.3 | 21.4 \pm 3.8 | 28.6 \pm 4.6 | 0.0 \pm 0.0 | 1.1 \pm 0.4 | 2.9 \pm 1.0 | 0.0 \pm 0.0 | 6.4 \pm 2.2 | | |
| | 7 ^b | 22.1 \pm 6.9 | 32.1 \pm 7.4 | 33.6 \pm 8.2 | 7.1 \pm 3.6 | 0.7 \pm 0.4 | 2.9 \pm 1.5 | 0.0 \pm 0.0 | 0.0 \pm 0.0 | | |

^a BOP = commercial bird of prey diet.^b Data from Georgia survey.

popular and published beliefs about generalization of certain species' behavior. Accipiters are generally considered nervous birds that are difficult to keep in captivity and undesirable as educational birds (Arent and Martell 1996). Therefore, they are not a commonly utilized species. Most hawks, such as Red-tailed Hawks (*Buteo jamaicensis*), are regarded by falconers as a "beginner's bird" and are recommended as educational birds (Parry-Jones 1994, Arent and Martell 1996). American Kestrels and owls are other birds that adapt well to captivity and use in educational programs. Golden Eagles (*Aquila chrysaetos*), Bald Eagles, Peregrine Falcons (*Falco peregrinus*), and Prairie Falcons (*F. mexicanus*) are recommended for experienced handlers only. Ospreys are considered to be one of the most difficult raptors to maintain in captivity (Arent and Martell 1996). Despite these generalizations, each bird should be evaluated individually.

Differences between species used in Georgia and throughout the United States can, in many cases, be attributed to regional species abundance. Since many birds used in educational programs are injured migrants or resident species, a disparity of species used between regions of the United States was expected. Even though American Kestrels are Georgia residents and considered to be excellent program birds (Arent and Martell 1996), they are rarely used in environmental education programs in Georgia.

When deciding upon the minimum recommended enclosure sizes, median enclosure areas may be of more use than mean enclosure areas. Several centers reported having enclosures much larger than the mean enclosure area, which caused the mean to be skewed toward larger cages. This may be due in part to large numbers of birds being housed together, though this was not determined through the survey. Centers with birds used for display only were asked to participate if these birds were part of educational programs, such as walk-by lectures, which may account for some of the variation. From on-site inspections made in Georgia, larger enclosures were often used as static displays rather than for housing birds that are routinely "manned" (held on a glove during programs) for educational programs. These larger enclosures often held multiple birds.

Providing additional width or length may be more important in nonreleasable raptor housing than providing additional height. Many nonreleasable raptors have damaged wings or reduced vision

and do not need tall cages. Perches set high in a tall cage may injure a raptor with an amputated wing if the bird falls (Gibson 1996). Nonreleasable raptors used for educational programs must also be accessible while providing the bird with a non-stressful environment. A bird can be difficult to retrieve if the cage is much higher than a person's head. The space above the caretaker's reach is either wasted or utilized by the bird to escape the caretaker. The highest perch should be no higher than the caretaker can comfortably reach to capture the bird (Arent and Martell 1996). Gibson (1996) recommends that perches be set no higher than 1.2 m for amputee birds. Texas Parks and Wildlife Department's 1998 regulations regarding captive raptors (69.305-d-1) require a minimum height of 3.7 m, which, based on current USFWS regulations and surveyed management practices, is too high to efficiently retrieve flightless raptors utilized for educational programs. Not only does it make it difficult to retrieve birds, but a high ceiling may cause stress to a bird if the perch is set far below it, as would be necessary with amputee birds (Gibson 1996).

Perhaps the most serious deviation from accepted management practices and current USFWS regulations is the use of pine needles and similar substrates for floor covering. Floor substrates that appear to give the birds a natural setting are aesthetically pleasing to visitors at facilities. In Georgia, pine needles are abundant and can often be obtained for little or no cost. Unfortunately, pine needles and other unacceptable floor substrates may pose health hazards to birds. Pine needles and similar materials are hard to clean on a daily basis and are ideal growth media for fungi, such as *Aspergillus fumigatus*, the causative agent of aspergillosis (Parry-Jones 1994, Gibson 1996). Brushed concrete floors can injure the raptors' feet when landing or pacing. Birds with reduced flight capability seem to be especially prone to this type of injury (B. Kessner pers. comm.). However, improper substrate can be easily changed with little impact to facilities. From our inspections and consultations in Georgia, caretakers did not seem to mind making minor changes, such as using different substrates. Often, they did not know of the potential health risk to their birds or their staff from using pine needles or similar substrate. Most caretakers were receptive to changes where benefits to the birds were apparent and the cost to the facility was minor.

Few medical problems were reported. Since many raptor facilities have few or infrequent visits from veterinarians, problems that are difficult to diagnose or have clinical signs that slowly manifest over several months or years may go unnoticed by handlers. However, there were no apparent differences between facilities that had veterinarians visit the facilities on a regular basis and those that did not. There was also no reference in the survey as to how these reported problems were diagnosed. This may affect the accuracy of the data. Some diagnoses are fairly obvious, such as bumblefoot or physical injuries, and can be made by experienced handlers. Others, such as bacterial infections or *Salmonellas*, require a veterinarian to diagnose. Detailed information regarding infections, diseases, and injuries was not obtained through our survey. This area of nonreleasable raptor management deserves further attention. A survey of veterinarians who commonly handle raptor medicine and management may provide further insight into common problems.

Nonreleasable raptor management practices from throughout the United States and Georgia, current USFWS regulations, management practices in print from respected raptor centers (Arent and Martell 1996, Weaver and Cade 1991), falconry publications (Parry-Jones 1994, Fox 1995), veterinary manuals (Beynon et al. 1996, Enderson 1986, Fraser 1991), and scientific publications were combined to create a set of best management practices for captive raptors in Georgia (Caudell and Riddleberger 2000). Our approach used the best available information on which to base acceptable management practices.

An unexpected benefit from our research was that the majority of the facilities inspected appreciated our interest in their program. Most wanted an opportunity to interact with knowledgeable professionals and to showcase their facility. Suggestions for improvements were also taken well, especially in regard to the health of their birds. Caretakers were also pleased to learn that our manual would not only be a compilation of published management techniques, but would also include techniques used at their facilities.

The type and amount of formal training of the primary caretaker varied considerably. However, this did not appear to impact the level of care provided to the birds. Most facility management practices followed suggestions from the literature, as evident from enclosure construction and design,

feeding strategies, and other aspects of management surveyed in our study. Providing continuing education is an area where wildlife agencies can become involved. By providing a time where caretakers, wildlife officials, and guest lecturers can meet and discuss current trends in management and regulations, permit holders will become better informed and feel as if they have a stake in the permitting and regulatory process.

Even though our sample was not random, it did provide an indicator of common management practices used throughout the United States. In general, caretakers who responded to the survey appeared to be practicing sound management of captive raptors. Most facilities already met or exceeded the recent USFWS changes to the regulations regarding the use and management of captive raptors before they were implemented. The most apparent deviation from accepted practices (i.e., floor substrate) was one of the simplest aspects of facility management to modify. Additional surveys followed by random inspections may prove to be an accurate, cost effective alternative to inspecting all facilities throughout the United States. Whether surveys or inspections or both are utilized, we recommend that regulatory officials maintain regular contact with caretakers.

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SHORT COMMUNICATIONS

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WINTER ROOSTING BEHAVIOR OF AMERICAN KESTRELS

DANIEL R. ARDIA¹

Department of Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210 U.S.A.

KEY WORDS: *American Kestrel*; *Falco sparverius*; *nest boxes*; *roosting behavior*; *sex differences*; *winter behavior*.

During the nonbreeding season, a protected nightly roost site can be critical to maintaining a positive energy balance and reducing predation risk (Walsberg 1986, Atkinson 1993). American Kestrels (*Falco sparverius*) winter across much of North America (Root 1988); however, little is known about their roosting behavior, especially in the portion of their range where climatic conditions may be stressful (Bird 1988). Mills (1975) suggested that the presence of a suitable roost may be a critical part of a nonbreeding territory. Kestrels readily adopt nest boxes for breeding and frequently use breeding habitats during the nonbreeding season (Balgooyen 1976, Bird 1988).

How frequently kestrels use nest boxes as winter roosts is currently unknown, although Eastern Screech Owls (*Otus asio*) will frequently use them as winter roosts (Duguay et al. 1997) as will European Starlings (*Sturnus vulgaris*, Kessel 1951). Toland and Elder (1987) reported that their nest boxes in Missouri (38°98'N, 92°30'W) were used as roosts by American Kestrels during one winter during a 3-yr study. Bortolotti and Wiebe (1993) reported migrating kestrels roosting in spruce trees (*Picea* spp.) in Saskatchewan (52°07'N, 106°38'W) and Doody (1994) reported wintering female kestrels using predominately man-made structures in Louisiana (30°22'N, 91°11'W); apparently, no nest boxes were available at either site.

At my study site in southeastern Pennsylvania, winter conditions can be harsh (mean winter temperature = 5.3°C, wind speed = 4.4 m/sec, min temp = -8°C, National Climatic Data Center 1994–95 nndc.noaa.gov). As a result, a protected winter roost site might be an important component of a kestrel territory. The main objective of this study was to determine the importance of nest boxes as winter roosting sites. Given that males and females differ in the ability to occupy high quality sites during winter (Ardia and Bildstein 1997), as do permanent

and winter residents (Smallwood 1988), I sought to compare roosting behavior between males and females and between year-round residents and winter residents.

METHODS

Study Site. I conducted this study between November 1994 and February 1995 in Berks and Lehigh counties, southeastern Pennsylvania (40°55'N, 75°75'W). November was considered the start of winter because wintering kestrels have established areas of use by this time (Ardia 1997). The study area (approximately 800 km²) is a patchwork of rolling hills and farmlands, which consists primarily of open agricultural land (pasture and fields of corn [*Zea mays*], soybean [*Glycine max*], and alfalfa [*Medicago sativa*]) separated by small woodlots and orchards. Between 70–100 pr of kestrels nest in the area each year in nest boxes (Rohrbaugh and Yahner 1997). Nest boxes at the site are cleaned and repaired in March prior to the breeding season and wood shavings are placed in the boxes. The orientation of the nest boxes varies (Rohrbaugh and Yahner 1997).

Nest Box Use. As a part of another study, I determined all occupied kestrel wintering territories along 153 km of survey route (Ardia 1997). From 59 occupied territories, I selected 20 territories at random (10 male and 10 female) and within each of these 20 territories, I chose a nest box randomly from those available (16 territories contained only one nest box, range = 1–3, \bar{x} = 1.3).

Between 12 December 1994 and 27 January 1995, I visited each box twice between 2000–2400 H to determine whether it was occupied. I also conducted two 60-min observations at each nest box: for 30 min prior to sunrise until 30 min following sunrise, and for 30 min before sunset until 30 min following sunset. Each observation was conducted from a car at a distance of about 100 m using 8× binoculars. For all observations, daylight was sufficient to observe the box opening and any movement that might have occurred.

Roosting Behavior. I conducted 25 focal observations of 13 male and 12 female kestrels going to roost. For these observations, I chose kestrels randomly from all territory holders. Each kestrel was located 30 min prior to sunset and observed until it went to roost; observations were conducted with 8× binoculars from a car at a distance of about 100 m. The time of roost selection and the type of roost were recorded for each observation. I measured roost-site height (m) using a clinometer and

¹ Present address: Department of Ecology and Evolutionary Biology, Corson Hall, Cornell University, Ithaca, NY 14853-2701 U.S.A.

Table 1. Roost sites used by 13 male and 12 female American Kestrels wintering in southeastern Pennsylvania in 1994–95.

| | TREE BRANCHES N (%) | TREE CAVITY N (%) | EAVE N (%) | BUILDING N (%) |
|-----------------------|---------------------------|-------------------------|---------------|-------------------|
| All obser- vations | 6 (24%) | 2 (8%) | 11 (44%) | 6 (24%) |
| Male | 3 (23%) | 2 (15%) | 6 (47%) | 2 (15%) |
| Female | 3 (25%) | 0 (0%) | 5 (42%) | 4 (33%) |

the distance flown to the roost from the last pre-roost perch to the roost with either a Ranging 50–1000 m rangefinder (for distances >50 m) or a measuring tape (for distances <50 m). I revisited each roost site during daylight hours to verify roost type.

I placed roost sites into four classes: tree branches, natural cavity, eave (a human-made structure where kestrels were not inside a structure but were protected from the elements) and building (a human-made structure such as a barn or silo where kestrels physically entered the structure). All kestrels classified as year-round residents were color-banded birds observed on winter territories before 15 September. Any bird that arrived after 15 September and was not previously color-banded was classified as a winter resident.

RESULTS

Nest Box Use. I encountered no American Kestrels using nest boxes either during nest box observations or during visits to boxes. A majority of nest boxes were empty (65%); boxes were used by eastern gray squirrels (*Sciurus carolinensis*; 20%), mice (*Peromyscus* spp.; 10%), and an Eastern Screech Owl (5%).

Roosting Behavior. Wintering kestrels used human structures, tree branches, and tree cavities as roosts (Table 1). Kestrels roosted in maples (*Acer* spp.; $N = 4$), eastern white pines (*Pinus strobus*; $N = 1$), and oaks (*Quercus* spp.; $N = 3$). A majority of roost sites were human-made (68%). There was no difference between natural and human-made roosts in roost height, time before sunset that kestrels entered the roost, nor in the distance that kestrels moved from their last perch to the roost (Table 2).

I detected no difference between male and female kestrels in roost-site types ($\chi^2 = 2.72$, $df = 3$, $P = 0.43$), nor in roost height, time to roost, and distance traveled from their last perch to roost (Table 2). I also detected no difference between year-round residents and winter residents in roost-site types ($\chi^2 = 2.78$, $df = 3$, $P = 0.41$), roost height, time to roost, and distance traveled from last perch to roost (Table 2). There was no interaction between sex and residency status for roost height, time to roost, and distance traveled from last perch to roost ($F_{s,21} < 2.56$, $P_s > 0.12$).

Table 2. Characteristics of roost sites ($\bar{x} \pm SD$) used by American Kestrels wintering in southeastern Pennsylvania

| | HEIGHT OF ROOST SITE (m) | TIME TO ROOST (MIN BEFORE SUNSET) | DISTANCE TRAVELED FROM LAST PERCH TO ROOST SITE (m) |
|--|--|---|--|
| All observations ($N = 25$) | 5.7 ± 2.4 | 3.4 ± 1.3 | 34.4 ± 20.5 |
| Natural roost sites ($N = 8$) | 6.4 ± 1.5 | 3.3 ± 1.5 | 40.7 ± 27.6 |
| Human-made roost sites ($N = 17$) | 5.4 ± 2.7 | 3.5 ± 1.3 | 31.5 ± 16.3 |
| <i>t</i> -value | $F_{1,21} = 0.99$, $P = 0.32$ | $F_{1,21} = 0.25$, $P = 0.62$ | $F_{1,21} = 1.08$, $P = 0.31$ |
| Male kestrels ($N = 13$) | 5.0 ± 1.4 | 3.6 ± 1.0 | 37.7 ± 27.2 |
| Female kestrels ($N = 12$) | 6.4 ± 3.1 $F_{1,21} = 2.34$, $P = 0.14$ | 3.3 ± 1.5 $F_{1,21} = 0.45$, $P = 0.51$ | 30.9 ± 9.2 $F_{1,21} = 0.70$, $P = 0.42$ |
| Year-round residents ($N = 11$) | 6.2 ± 3.1 | 3.3 ± 1.3 | 31.5 ± 16.7 |
| Winter residents ($N = 14$) | 5.1 ± 1.08 $F_{1,21} = 1.13$, $P = 0.3$ | 3.6 ± 1.31 $F_{1,21} = 0.18$, $P = 0.67$ | 37.6 ± 24.3 $F_{1,21} = 0.42$, $P = 0.52$ |

DISCUSSION

Patterns of kestrel roost use at my southeastern Pennsylvania site were similar to those reported for a similar latitude (Mills 1975) and a more southerly site (Doody 1994). My results suggested that wintering kestrels at my study site may not use nest boxes as roost sites even though they are available. There is year-to-year variation in whether kestrels use nest boxes as winter roosts (Carpenter pers. comm.), and in some areas, nest boxes are never used as winter roosts (Bortolotti pers. comm.). Given that my data are limited to a few observations in one season, it is premature to conclude that kestrels never use nest boxes at my study site; however, my results suggest that other roost sites may be more important to kestrels than nest boxes.

Because the winter energetics of kestrels are strongly influenced by convective heat loss (Hayes and Gessaman 1980, Ardia 1997), the lack of use of nest boxes is somewhat surprising if the use of boxes has thermal benefits. Therefore, that nest boxes are not used suggested that nest boxes may provide no better thermal benefit than either natural or human-made roosts, or, more likely, that benefits of nest boxes are outweighed by potential costs. A possible cost of nest boxes may be increased risk of predation (Orell 1989); one cause of mortality in breeding kestrels is predation on females incubating or brooding at night (Kellner and Ritchison 1988, C.J. and S. Robertson, D. Ardia unpubl. data). In winter, without the need to enter nest boxes to breed, females may avoid exposure to predation. Also, nest boxes may increase exposure to ectoparasites (Merila and Allander 1995), although winter weather conditions are often harsh enough to reduce ectoparasite activity.

In my site and others, kestrels have readily adopted human-made roosts and use these sites over natural locations, both of which were readily available. I observed no differences between males and females nor between year-round and winter residents, suggesting that if trade-offs exist in roost site selection, they may be similar for all kestrels. Further observations on winter roosting behavior, especially the role of nest boxes, is needed across the range of the American Kestrel.

RESUMEN.—Las perchas nocturnas pueden ser críticas para reducir la pérdida de energía y los riesgos de depredación de las aves rapaces. Estudie el comportamiento de *Falco sparverius* en las perchas de invierno en Pennsylvania, para evaluar si utilizaron las cajas de anidación como perchas nocturnas. No encontré evidencia que los cernícalos utilizaron las cajas. Sin embargo, al observar los individuos desplazarse a las perchas ($N = 25$), encontré que ambos machos y hembras tendían a utilizar estructuras humanas (68% utilizaron cocheras y aleros como sitios de descanso en lugar de árboles y cavidades de árboles). No encontré diferencias entre machos y hembras en la altura de las perchas, hora antes del atardecer para utilizar las perchas, o en la distancia de la

última percha antes de utilizar la percha nocturna. Tampoco encontré diferencias entre los residentes anuales y los de invierno en estas variables. Aunque los datos son limitados fue sorprendente encontrar que los cernícalos no utilizaron las cajas de anidación como perchas nocturnas. El posible incremento de los riesgos de depredación y la exposición a ectoparásitos pueden sobrepasar a los beneficios "termales" que proveen las cajas de anidación.

[Traducción de César Márquez]

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DIET AND PREY SELECTION OF NONBREEDING PEREGRINE FALCONS IN AN URBAN HABITAT OF ITALY

GIANLUCA SERRA

Istituto Nazionale Fauna Selvatica (INFS), via Ca' Fornacetta 9, 50064 Ozzano d'Emilia (Bologna), Italy

MARIA LUCENTINI

Dipartimento di Biologia Animale e Genetica (Università di Firenze), via Romana 17, 50121 Firenze, Italy

SIMONA ROMANO

Lega Italiana Protezione Uccelli (LIPU), Delegazione Toscana, Firenze, Italy

KEY WORDS: *Peregrine Falcon; Falco peregrinus brookei; prey selection; urban habitat; seasonal variation of diet; prey vulnerability; flight height of prey.*

The Peregrine Falcon (*Falco peregrinus*) has been described to opportunistically capture a broad spectrum of prey species according to their abundance, its diet reflecting the seasonal composition of the local avian community (Cramp and Simmons 1989, Ratcliffe 1993, Cade et al. 1994). However, little information is available about quantitative assessment of prey selection by peregrines outside of the breeding season. Hunter et al. (1988) and Rosenfield et al. (1995) have shown prey selection by breeding peregrines according to species, but selection by weight class of prey has been investigated only for *Accipiter* spp. (Cresswell 1995, Tornberg 1997). There is also very little quantitative information on how the vulnerability of prey differs according to their behavior (Thiollay 1988, Cresswell 1995).

Our study focused on a single pair of Peregrine Falcons that occurred regularly in urban habitat outside the breeding season. Our goal was to describe seasonal variations in the composition of the diet relative to changes in the availability of prey and to assess prey selection according to the different heights at which prey typically flew.

METHODS

Two adult Peregrine Falcons have regularly occurred during the nonbreeding season (from late May to beginning of February) within the historical center of Florence, Italy, since at least 1993. Each year, they use the same habitual perches located on tops of the three historical monuments that tower over the city center. Using individual variations in morphological characters, we were able to distinguish the two individuals through a 60× spotting scope. Observations on frequency with which they roosted close together at the same perches and their behavioral interactions, indicated that they were an established pair.

A total of 26 monthly samples of prey remains and pellets were collected below the peregrine roost sites between January 1997–February 1999. We analyzed the prey remains and pellets according to Oro and Tella (1995) and Rosenfield et al. (1995) and identified a total of 46 different prey items taken by the falcons. Bird species identification was made through comparisons with specimens of the zoological collection of Istituto Nazionale Fauna Selvatica (INFS, Bologna, Italy). Bat hairs were identified through 40 \times microscope analysis (Keller 1986). The number of prey individuals identified for each species represented the minimum number consumed by the falcons. The composition of the diet over the two nonbreeding seasons May 1997–February 1998 and May 1998–February 1999 was determined either as the relative frequency of capture or as the relative biomass consumed of each species over the total of individuals captured/biomass consumed by falcons. Average weights of bird species (Cramp and Simmons 1989) and bat species (Schober and Grimberger 1993) were used as approximations for biomass consumed by falcons. The Friedman test for paired data was used to test for difference in the rank of prey types (i.e., resident breeder, migrant breeder, passage migrant, and winter visitor) consumed during the three periods from May–July 1997 and 1998, August–November 1997 and 1998, December–February 1997–98 and 1998–99. An α level of 0.05 was used in all statistical tests.

Selection of diurnal avian prey breeding within a 3-km radius of peregrine perches was also analyzed from May–July 1997 and 1998 according to Baker (1967), Treleven (1977), Hunter et al. (1988), and Cramp and Simmons (1989). Hereinafter, this circular area is simply referred to as “Florence center.” Prey selection was assessed according to the following categories: (1) flight height – 162 hr of observations from elevated points enabled us to rank the bird community breeding within Florence center as either commonly observed flying high above the roof level of Florence center (high-fliers), sometimes observed flying high above the roof level (mid-fliers), birds rarely or never observed flying high above the roof level (low fliers); (2) species—the five most abundant high-flying species with relative abundance estimates > 10 % of the total breeding pairs counted within Florence center, $N = 9533$ (House Martin [*Delichon urbica*], Swift [*Apus apus*], European Starling [*Sturnus vulgaris*], Jackdaw [*Corvus monedula*], and Pigeon [*Columba livia*]); (3) weight—we recognized three weight classes (1–100, 101–200, and >201 g) within the five most abundant high-flying species, whose average weight ranged between 35–300 g.

We tested two null hypotheses: that relative prey consumption (expressed either by frequency and by biomass) occurred in proportion to prey abundance, considering all the prey classes simultaneously and that prey consumption occurred in proportion to prey abundance within the same prey class. To test the former hypothesis, we used either Chi-squared goodness-of-fit or Kolmogorov-Smirnov goodness-of-fit tests according to data and to test the latter hypothesis we used a Bonferroni’s test. An α level of 0.05 was adopted as the minimum value for rejection the null hypotheses.

RESULTS

We identified a total of 18 species of prey in the nonbreeding diet of the peregrine pair we studied. Pigeons were the most important prey both by frequency of capture (30.4%) and by biomass (54.0%). Two species of bats (Savi’s pipistrelle [*Hypsugo savii*] and Kuhl’s pipistrelle [*Pipistrellus kuhlii*]) and Swifts were also frequently-captured prey (15.1 and 8.7% of total prey, respectively). Wintering Black-headed Gulls (*Larus ridibundus*) were also important prey both by frequency (8.7%) and biomass (13.1%). The average weight of prey taken ranged from 7 g (Savi’s pipistrelle) to 305 g (Woodcock [*Scolopax rusticola*]), but 53% were <150 g.

Prey taken by the peregrines varied seasonally, although this variation was not statistically significant either by frequency or biomass (Friedman test = 0.37 and 0.87, respectively, $N = 3$, $P > 0.1$). During May–July, the pair fed mainly on resident breeders (70% by frequency and 88% by biomass) and to a lesser extent on migrant breeders (30% by frequency and 12% by biomass). The percent of resident breeders in the diet decreased progressively during August–November and December–February (53 and 43% by frequency, 58 and 39% by biomass), while winter visitors increased to 16 and 57% by frequency and 20 and 61% by biomass. Moreover, during August–November passage migrants became a considerable component of the diet (31% by frequency and 22% by biomass).

Among the 54 bird species breeding in Florence center (both resident and migrant), those that we commonly observed flying high above roof level were taken by peregrines significantly more frequently (frequency of capture = 0.800) than expected based on their relative frequency of occurrence (0.512). The opposite was true for those species sometimes or rarely observed flying high above roof level which were far less frequently captured than expected (χ^2 with Yates’s correction = 4.56, $df = 1$, $P < 0.05$). Likewise, consumption of prey types within categories differed from that which was expected with more high-flying species taken than mid- to low-flying species Bonferroni confidence interval = 0.569–1.0 vs. an expected frequency of 0.512 for high-flying prey and Bonferroni confidence interval = 0–0.431 vs. an expected frequency of 0.489 for mid- to low-flying species. Among most abundant bird species commonly flying high above the roof level of Florence, peregrines showed no significant preference for any species (Kolmogorov-Smirnov goodness-of-fit test = 0.06, $N = 5$, $P > 0.1$) or weight (Kolmogorov-Smirnov goodness-of-fit test = 0.06, $N = 3$, $P > 0.2$). Our results were the same when we analyzed the data expressed as biomass of prey consumed.

DISCUSSION

There is little information about the diet of Peregrine Falcons outside the breeding season (Baker 1967, Mearns 1982), mainly due to its variable use of numerous perch-

es and roosts during this period (Ratcliffe 1993). Despite the relatively small size of the sample of prey that we collected, we felt that it was representative of the non-breeding diet of Florentine peregrines. We identified a total of 18 prey species and this fell within the range of 10–22 species in the diets of other European Peregrine Falcons in urban habitats which were based on larger sample sizes (Mocci Demartis and Murgia 1986, Ranazzi 1995). Our study confirmed that peregrines fed opportunistically during the nonbreeding season adjusting their diet in accordance with season variations in prey abundance and the height at which they flew in the Florence city center.

Although not significantly different and likely due to our small sample size, the proportion of prey captures characterized by different residence status did not vary from that which was expected. Resident breeders were important prey, especially during the period May–July, both by frequency and by biomass. During this period, the migrant breeder, the Swift, was an important prey species by frequency (Ranazzi 1995). Between August and January, resident breeders were conspicuously replaced by passage migrants and winter visitors in the diet. In particular, between December and January, the proportion of winter visitors was greater than that of resident breeders, especially when captures of Black-headed Gulls increased.

Considering all the bird species breeding in Florence center and their relative abundance, high-fliers appeared to be significantly more vulnerable to peregrine predation than mid- and low-fliers. Among high-flying birds, no significant preference for any one prey species was found. Even prey that were most important in peregrine diets were captured in proportion to their relative abundance. Our findings were not consistent with findings of Hunter et al. (1988) and Rosenfield et al. (1995) who found significant preferences of breeding peregrines for certain taxa. We also found no significant preference according to weight classes of prey. Nutritional requirements of young and daily temporal constraints may force Peregrine Falcons to be more selective with respect to prey classes during the breeding rather than the non-breeding season.

RESUMEN.—La dieta de una pareja de halcones peregrinos (*Falco peregrinus brookei*) que estacionalmente habitan en el centro de Florencia, Italia, fue investigada durante la época no reproductiva (desde finales de mayo hasta principios de febrero). Los halcones peregrinos ajustaron su dieta en forma oportunista de acuerdo a la variación estacional en la disponibilidad de presas. Las comparaciones entre el consumo y la disponibilidad relativa de las diferentes clases de presas desde mayo–julio mostraron que en un habitat urbano con construcciones altas la altura a la cual volaban las presas fue la mayor limitante en la dieta de este cazador aéreo. Las aves que típicamente volaban por encima del nivel del techo de Flo-

rencia fueron capturadas mas frecuentemente que lo esperado de acuerdo con su abundancia relativa. Lo contrario sucedió con las aves que ocasionalmente volaban mucho mas alto que el nivel del techo. Los halcones peregrinos no mostraron ninguna preferencia entre clases y pesos de clases.

[Traducción de César Márquez]

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BALD EAGLES KILLED BY TRAINS IN NEW YORK STATE

WARD B. STONE

Wildlife Pathology Unit, New York State Department of Environmental Conservation, 108 Game Farm Road, Delmar, NY 12054 U.S.A.

PETER E. NYE

Endangered Species Unit, New York State Department of Environmental Conservation, 108 Game Farm Road, Delmar, NY 12054 U.S.A.

JOSEPH C. OKONIEWSKI

Wildlife Pathology Unit, New York State Department of Environmental Conservation, 108 Game Farm Road, Delmar, NY 12054 U.S.A.

KEY WORDS: *Bald Eagle*, *Haliaeetus leucocephalus*; mortality; trains.

High-speed passenger trains were first introduced into the Hudson River valley rail corridor in eastern New York State in 1980. As of October 2000, there were 20 train trips per day during daylight hours between Albany and New York City on a set of tracks along the eastern shore of the river. Over the same period, use of the lower Hudson River valley by nesting, migrating, or overwintering Bald Eagles (*Haliaeetus leucocephalus*) greatly increased. Sightings of Bald Eagles during annual January aerial surveys of the lower Hudson River have risen from none in the early 1980s to 28 in 2000 (Nye unpubl. data). These two developments have resulted in the deaths of Bald Eagles killed by high-speed trains. Between 1986 and October 2000, we examined the carcasses of 10 Bald Eagles apparently struck and killed by trains, eight in the last four years. At least eight of the incidents occurred on the Albany–New York City tracks in the mid-to-lower Hudson River valley. A ninth bird was recovered from the front of a high-speed locomotive which traveled this route, but which also traveled to and from Vermont during the period in question. The tenth eagle was killed along a railbed that parallels the western shore of Lake Champlain and supports high-speed train traffic to Montreal, Canada. Based on two reports by rail personnel, it is likely that

one other eagle (an adult) was struck (presumed killed) in the lower Hudson River valley in August 1996.

Most of the train mortalities we examined occurred during periods of fall migration or overwintering in September (1 mortality), October (2), November (1), December (1), and January (3). The two exceptions were immatures killed in late June 1997 and late July 2000. Nine of the eagles were immatures (five female, three male, one unknown sex), and one was an adult male. All were in good nutritional condition except for one immature struck in September.

Analyses for organochlorine pesticides and polychlorinated biphenyls (PCBs) completed at Hazleton Labs, Madison, WI U.S.A.; EnChem, Inc., Madison WI U.S.A.; Illinois Animal Disease Laboratory, Centralia, IL U.S.A., and University of Mississippi, MS U.S.A. on various tissues from eight eagles (brain [4 birds], liver [3], subcutaneous fat [3]) did not reveal levels that might implicate them as predisposing factors in these train mortalities. DDE was detected in seven birds (0.02–0.73 ug/g in brain, 0.13–0.19 ug/g in liver, 1.4–3.73 ug/g in fat). PCBs were present in six birds (0.13–13.8 ug/g in brain, 0.45–4.3 ug/g in liver, 3.7–71 ug/g in fat). Highest levels were found in the immature from June 1997 supporting suspicions that it fledged from a nest near the PCB-contaminated Hudson River. Other organochlorines detected less frequently and at much lower levels included DDD

(max = 0.084 ug/g in brain, 0.023 ug/g in liver, and 1.2 ug/g in fat), DDT (max = 0.04 ug/g in brain, 0.52 in fat), and chlordane-related compounds (max = 0.92 ug/g cis-nonachlor in fat, 0.019 ug/g in liver).

Analyses for lead and mercury in the livers of seven of the eagles similarly excluded those contaminants as predisposing factors with the possible exception of an immature male that showed 23 ug/g mercury. This bird was in excellent nutritional condition, in contrast to what might be expected in an animal overtly intoxicated with mercury. Levels of mercury in the other six eagles ranged from 0.76–6.0 ug/g. Levels of lead (0.03–0.42 ug/g) were not notably elevated.

Rail hazards to wildlife have almost certainly been greatly increased by the newer high-speed passenger trains. Traveling at speeds up to 200 km/h, these trains are also remarkably quiet, further increasing the hazard. Eagles and other wildlife may have difficulty in effectively responding to objects moving at speeds greatly exceeding those ordinarily encountered in nature. Animals killed by trains attract scavengers that are subsequently imperiled. Two of the eagles in this report were observed standing near carrion before they flew into the path of the train, and it is likely that most of the others were struck in similar circumstances.

The preponderance of immature birds among the train casualties contrasts with the frequency of adults (63%, $N = 141$) observed during the January aerial surveys of the lower Hudson over the past 14 yr (Nye unpubl. data). This suggests that immatures are more vulnerable to this hazard, possibly because young eagles are more dependent on scavenging (Stalmaster 1987). Winter trapping efforts in the same region using deer or duck carcasses consistently attract more immatures (Nye unpubl. data). Young eagles may be further jeopardized by being both less wary and less agile than adult birds.

The significance of these train mortalities for eagles utilizing resources near these high-speed rail corridors is uncertain. The casualties reported here comprise 10 of 16 post fledged eagles examined from this part of New York State since 1986 (24% of 41 examined statewide). It has been suggested (Harmata pers. comm.) that high-speed trains, by providing a food base at critical periods (post fledging, first winter), might actually promote overall eagle survival and production despite causing occasional collision losses. At present, there are no data on amounts of carrion provided by the trains or use of the carrion by eagles that can be used to quantitatively evaluate this hypothesis. However, given the abundance and availability of fish in certain stretches of the lower Hudson River, the substantial amount of carrion linked to highway traffic in this region, and the frequency of collisions in relation to the number of eagles in this area,

we suspect that the net effect of the high-speed trains is most likely to be decidedly negative. In any event, the greatest impact, positive or negative, will probably be on fledglings of local nesting pairs. Five nesting territories have become established in the lower Hudson River valley since 1992, and at least one of the train casualties was believed to have been a local juvenile.

The immediate proximity of this high-speed rail corridor to one of New York's most important eagle habitats suggests that the number of eagle-train collisions can be expected to increase if eagle use of the lower Hudson Valley continues to rise, or if there are further increases in train speed or trip frequency. As faster passenger trains appear to be expanding in both numbers and destinations nationwide, further investigation of their importance to Bald Eagles and other scavengers is warranted. In the interim, ways to possibly reduce the hazards of these high-speed trains to scavengers, or to wildlife in general, should be explored. Carcass removal in certain locations and seasons might be beneficial, as might some sort of audible or visual signal that would scare avian scavengers well ahead of the train. Such signals might be more effectively located along the track than on the train itself.

RESUMEN.—La parte baja del Valle del Río Hudson ha crecido en importancia en las dos últimas décadas como sitio de invierno y de anidación de las águilas calvas (*Haliaeetus leucocephalus*). Al mismo tiempo ha habido una introducción y expansión de los trenes rápidos de pasajeros en el corredor férreo a lo largo del Río Hudson. La introducción de trenes de alta velocidad ha estado acompañada de colisiones con águilas calvas. Entre 1986–2000, 10 águilas calvas fueron golpeadas y muertas por los trenes, ocho en los últimos cuatro años. Nueve de estas eran águilas juveniles. Estos accidentes representaron 10 de las 16 águilas emplumadas a las que se les practicó el post-mortem y que pertenecían a esta región durante este período de tiempo. El aumento en el uso de trenes de alta velocidad a nivel nacional puede aumentar la mortalidad de águilas calvas y otras aves rapaces atraídas a la carroña ocasionada por los trenes.

[Traducción de César Márquez]

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EARLY NESTING BY GREAT HORNED OWLS IN MONTANA

DENVER W. HOLT AND STACY DRASEN

Owl Research Institute, P.O. Box 39, Charlo, MT 59824 U.S.A.

KEY WORDS: *Early nesting, Great Horned Owl, Bubo virginianus, Montana.*

Great Horned Owls (*Bubo virginianus*) begin nesting earlier than any other owl species across its range in the United States and Canada (Austing and Holt 1966, Houston et al. 1998). A correlation is evident between egg laying and latitude, with northern populations laying eggs later than southern ones (Houston et al. 1998). For example, in southern Florida, eggs are often laid in December and rarely in November (Bailey 1925). In North and South Carolina, Great Horned Owls lay eggs in late December (Houston et al. 1998). In Ohio, a total of 903 breeding owls began nesting in January and February (Holt 1996). Craighead and Craighead (1956) found that the earliest egg laying occurred in Michigan was 12 February. In Saskatchewan and the Yukon Territory, Great Horned Owls lay eggs from late February through mid-May (Houston et al. 1998). In west-central Montana, Great Horned Owls lay eggs from mid-February to early April (Baumgartner 1938, Holt pers. obs.). In addition to their latitudinal variation in the timing of laying, it seems that Great Horned Owls may also lay their eggs later at higher elevations.

Occasionally Great Horned Owls lay earlier than normal in a given location. Watson (1933) reported finding a Great Horned Owl nest with one egg at Andover, New York on 29 January 1933, and, on 20 January 1935, Elder (1935) found a female incubating one egg near Madison, Wisconsin. Herein, we describe an unprecedented early nest record for the Great Horned Owl in Montana.

OBSERVATIONS

We have monitored nesting sites of Great Horned Owls near Missoula, Montana, to determine breeding since 1985. Monitoring begins in February, and only once have we seen evidence that nesting began before February. On 19 February 1996, while checking for nesting Great Horned Owls, we observed a nest with a female and two well-developed nestlings at the entrance to the Missoula International Airport, Missoula, MT (46°54'48"N, 114°05'02"W; elevation 960 m). The nest was a platform 7 m above the ground, and was originally constructed by a Black-billed Magpie (*Pica pica*). The nest was in the middle tree of three, medium-sized Russian olive (*Elaeagnus angustifolia*) trees, which were 7.5 m from each other. The trees lined the entrance to the

airport, bordering a highway. The male owl was 74 m away in a densely-twigged Norway spruce (*Picea abies*). The surrounding area is relatively flat, and consisted of a mixture of open lands used for ranching, agriculture, and the airport. There were few trees in the area and it was exposed to winds. Thereafter, the nest was monitored daily until the nestlings moved onto nearby branches in the nest tree.

The nestlings were almost identical in size, suggesting similar ages. Great Horned Owls usually hatch two days apart (Houston et al. 1998). After comparing our observations with descriptions and photographs of known-aged Great Horned Owl nestlings (Hoffmeister and Setzer 1947, Austing and Holt 1966), we estimated the nestlings to be 4 wk old on 19 February. Considering a mean incubation period of 33 d (range = 30–37) (Hoffmeister and Setzer 1947, Austing and Holt 1966, Peck and James 1983), then egg laying occurred approximately 22 December and hatching likely occurred about 22 January. The young fledged on 11 and 14 March, almost two months earlier than usual for Montana (D. Holt pers. obs.). In fact, all of the breeding pairs that we monitored began to breed in mid-to-late February in 1996 ($N = 17$). Most Great Horned Owls in west-central Montana typically lay their eggs from mid-February to early April (Baumgartner 1938).

The adult Great Horned Owls successfully fledged their young, even though the winter of 1996 was unusually cold. Shortly after the eggs would have hatched on about 22 January, there were bitter Arctic winds in Missoula and the average daily temperatures and wind chills (in parentheses) were -1°C (-1°C); -2°C (-4°C); -4°C (-12°C), -8°C (-18°C); -10°C (-12°C); -9°C (-23°C); -15°C (-30°C); -18°C (-23°C); -23°C (-23°C); -25°C (-25°) for 22–31 January and -24°C (-25°C); -26°C (-26°C); -25°C (-26°C); -15°C (-16°C) for 1–4 February. These data were calculated from readings of temperatures and wind speeds taken hourly 800 m from the nest by the National Weather Service.

DISCUSSION

As in all owls, Great Horned Owl nestlings are ptilopadic (covered in white protoptile down), semi-altricial, and nidicolous (Holt et al. 1999). They are essentially poikilothermic for the first five days after hatching, and are unable to maintain a body temperature $>3^{\circ}\text{C}$ above ambient temperature (Turner and McClanahan 1981)

In comparison with adults, the capacity of nestlings to regulate body temperature is 25% at 15 d, 69% at 20 d, 90% at 25 d, and 95% at 47 d (Turner and McClanahan 1981). During the cold period the owls were forced to endure in January and February 1996, nestlings were dependent on the female for thermoregulation. Female Great Horned Owls brood almost continuously for the first two weeks of the brood period (Houston et al. 1998) while males provide most of the food.

Pakpahan et al. (1989) reported that Great Horned Owls have a low standard metabolic rate (SMR) relative to sympatric raptor species, and that female Great Horned Owls have a lower SMR than males. This low SMR undoubtedly maximizes the efficient use of energy by female Great Horned Owls allowing them to begin nesting earlier than other raptor species. Although our observations help in our understanding of how early nesting can occur in the Great Horned Owl, they leave us wondering what might have influenced this pair to begin nesting two months earlier than the species' usual initiation date in Montana.

Both ultimate and proximate factors interact to influence the onset of breeding; ultimate factors tune a species phenology to the best average time for reproduction while proximate factors act as cues during any one season. Temperature and photoperiod are purported to be important modifiers of annual gonadal cycles (Farner and Mewaldt 1952, Gwinner 1996). The months of November and December had average monthly temperatures of 2.6 and -2.8°C , which were 2.3 and 2.1°C above normal, respectively. It is conceivable that such warm weather could have influenced early gonadal and ovarian development; however, if temperature alone was responsible, then it seems other pairs should have also bred early. Artificial lighting for the airport and its entrance may have influenced the effective photoperiod, but whether this was a contributing cause is not known.

Analysis of the pellets found around the nest and the male roost indicated that the pair relied on voles (*Microtus montanus* and *M. pennsylvanicus*), European Starlings (*Sturnus vulgaris*), and House Sparrows (*Passer domesticus*) for food. Unfortunately, we did not have local population estimates of the prey species. Still, small mammal snap-trapping results in the Mission Valley, approximately 80 km away, resulted in no trapped voles in 500 trapnights (100 traps \times 5 nights). Although we are unable to adequately answer the question why this pair initiated its nest so early, the fact that it successfully raised young provides compelling evidence for the hardiness of the Great Horned Owl.

RESUMEN.—Observé un nido de *Bubo virginianus* con pichones de cuatro semanas en febrero 19 de 1996. Los buhos estaban utilizando un nido viejo de *Pica pica* en un árbol de un olivo ruso (*Elaeagnus angustifolia*). La postura de huevos y la eclosión ocurrieron en este nido entre diciembre 20 y enero 22, dos meses antes de lo que usualmente ocurre en Montana. El promedio de temperaturas mensuales en noviembre y diciembre fué de

2.3 y 2.1°C por encima de lo normal, quizás el clima más caliente pudo haber influenciado el desarrollo gonadal temprano en esta pareja.

[Traducción de César Márquez]

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DIET OF THE SHORT-EARED OWL IN NORTHWESTERN ARGENTINA

SEBASTIÁN CIRIGNOLI AND DARÍO H. PODESTÁ

*Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque s/n,
1900 La Plata, Argentina*

ULYSES F.J. PARDIÑAS

Departamento Científico Paleontología Vertebrados, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina

KEY WORDS: *Short-eared Owl*; *Asio flammeus*; diet; northwestern Argentina.

Despite its widespread distribution of the Short-eared Owl (*Asio flammeus*) in South America, there is very little known about its feeding habits (Martínez et al. 1998). In Argentina, there is very little dietary information (see Dalby 1975, Massoia 1985, Diéguez 1996). Here, we report on the results of an analysis of Short-eared Owl pellets from northwestern Argentina and compare our results to those from other areas of South America.

We collected the Short-eared owl pellets in April 1993 at Cerrito Leones, near Pan de Azúcar mine, in the Man and Biosphere Reserve in Laguna de Pozuelos (22°15'–22°27'S, 65°56'–66°03'W; 3600–4800 m elevation) in the Province of Jujuy, Argentina. The reserve is an endorheic basin with a central lake surrounded by two ridges. The landscape includes a complex mosaic of mountain and highland systems with grasslands and shrublands belonging to the Puna Phytogeographic Province (Cabrera 1971) and slopes of bare rocks. The climate is cold and dry with a mean annual precipitation of 350 mm.

The 72 fresh pellets that we collected averaged 44.4 ± 7.8 mm (\pm SD) in length (range = 29–62 mm) and 26.1 ± 3.4 mm in width (range = 16–35 mm). The mean number of prey in each pellet was 3.11 ± 1.12 individuals (range = 1–6) and it was not correlated with pellet length ($r = 0.03$, $P > 0.50$). The diet consisted mainly of native sigmodontine rodents (97.7%) with very low frequencies of marsupials, birds, and insects (Table 1). Two small rodents (*Calomys lepidus* and *Eligmodontia puerulus*) accounted for >90% of the prey. Levins' index of food-niche breadth (NB, after Marti 1988) was 2.30 for all prey categories and 2.20 for mammals. The geometric mean prey weight was 20.1 g.

A one year trapping study of the rodents in Laguna de Pozuelos found that the community was dominated by *Phyllotis darwini*, *C. lepidus*, and *Akodon albiventer* (Bonaventura et al. 1999; Table 1). *P. darwini* inhabits rocky slopes with shrubs of *Fabiana densa* and *Baccharis bolivien-sis*, while *C. lepidus* is restricted to shrub areas of *Parastrephia lepidophylla* on less rocky slopes. *A. albiventer* is found ubiquitously throughout the study area. According to

Marks et al. (1999), the daily activity pattern of the Short-eared Owl is likely dictated by the activity of its main prey. In Laguna de Pozuelos, high predation on crepuscular and nocturnal rodents such as *C. lepidus* and *E. puerulus* and the underrepresentation of diurnal rodents such as *A. albiventer*, suggested that the Short-eared Owls we studied had mainly a crepuscular to nocturnal hunting period. Low frequencies of *Phyllotis* in our pellet sample were probably due to its large size and not its availability since it does occur commonly in the diet of sympatric Great Horned Owls (*Bubo virginianus*) (Massoia 1994).

Our results agreed with those of Massoia (1985) who studied the diet of Short-eared Owls in temperate and humid Pampean grasslands. There, small native sigmodontine rodents also dominated the diet of Short-eared Owls and birds and marsupials were negligible. Nevertheless, his measure of NB was much higher (5.86 for all categories, 5.60 for mammals) and his geometric mean weight was even higher still (24.0 g). The harsh environmental conditions of Laguna de Pozuelos may have caused the apparent lower species richness of the Short-eared Owl diet there. Analyses of Short-eared Owl diets in continental Chile were also similar to our results. Rau et al. (1992) and Martínez et al. (1998) found that mice (*Abrothrix olivaceus*) were the most important prey of Short-eared Owls in northern Chile.

RESUMEN.—Se documentan los primeros datos sobre la dieta de *Asio flammeus* en el noroeste de Argentina, sobre la base de 72 egagrópilas recolectadas en la Reserva del Hombre y la Biosfera Laguna de Pozuelos (22°15'–22°27'S, 65°56'–66°03'W, 3600–4800 m, Jujuy, Argentina). Más del 90% de las presas consumidas fueron roedores sigmodontinos nativos de pequeño tamaño (*Calomys* y *Eligmodontia*). Los resultados obtenidos concuerdan con los registros previos para Argentina y Chile que indican una depredación centrada en micromamíferos de <30 g.

[Traducción de Autores]

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Table 1. Diet of the Short-eared Owl in Man and the Biosphere Reserve in Laguna de Pozuelos, Province of Jujuy, Argentina.

| PREY | NUMBER | PERCENT BY NUMBER | ADULT BODY MASS ^a | PERCENT BY BIOMASS | PERCENT IN THE FIELD ^b |
|------------------------------|------------|-------------------|------------------------------|--------------------|-----------------------------------|
| Rodents | | | | | |
| <i>Calomys lepidus</i> | 122 | 54.7 | 15.1 | 43.9 | 22.5 |
| <i>Eligmodontia puerulus</i> | 81 | 36.3 | 21.4 | 41.3 | — |
| <i>Auliscomys sublimis</i> | 10 | 4.5 | 38.5 | 9.2 | — |
| <i>Phyllotis</i> spp. | 2 | 0.9 | 57.0 | 2.7 | 26.8 |
| <i>Cavia</i> spp. | 0 | 0.0 | nd | 0.0 | 1.4 |
| <i>Akodon albiventer</i> | 3 | 1.3 | 25.3 | 1.8 | 47.9 |
| Marsupials | | | | | |
| <i>Thylamys</i> spp. | 2 | 0.9 | 23.0 | 1.1 | 1.4 |
| Birds | 2 | 0.9 | — | — | — |
| Coleopterans | 1 | 0.5 | — | — | — |
| Total | 223 | | | | |

^a Mean adult masses in g were obtained from Redford and Eisenberg (1992).

^b Data from Bonaventura et al. (1999).

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A SURVEY OF RAPTORS ON RHODES: AN EXAMPLE OF HUMAN IMPACTS ON RAPTORS ABUNDANCE AND DISTRIBUTION

ARIANNA ARADIS AND GIUSEPPE M. CARPANETO

Università degli Studi "Roma Tre," Dipartimento di Biologia, Viale G. Marconi, 446, 00146 Roma, Italy

KEY WORDS: *raptor survey, Rhodes, human impacts.*

The Dodecanese includes more than 200 relatively-undisturbed islands, only 27 of which are inhabited by people (de Grissac et al. 1994). Rhodes Island is a strategic area for bird conservation because it is close to important migration routes along the Turkish coast and may be a stopover for spring and autumn migrants. Because locations on the island have experienced varying degrees of human exploitation, it is also a place where the impacts of human activities on raptor populations can be evaluated. The aim of our research was to verify the impact of high levels of tourism on raptor abundance and to determine the effects of road building and settlements on raptor abundance. We hoped to provide documentation for the impacts of people on raptor abundance in the Mediterranean region, where raptors and people are frequently in conflict.

STUDY AREA AND METHODS

Rhodes is located in the southeastern part of the Aegean Sea, <20 km from the Turkish coast. The island is 80 km long and has a surface area of about 1400 km². There are four habitat types on the island: coniferous forest (*Cupressus sempervirens*, *Pinus brutia*, *Pinus halepensis*), maquis (*Arbutus andrachne*, *Erica arborea*, *Quercus coccifera*), phrygana (*Thymus capitatus*, *Erica manipuliflora*, *Sarcopoterium spinosum*, *Cistus* spp., *Lithodora hispidula*), and wetlands (de Grissac et al. 1994).

Based on previous surveys, we divided the island into two zones of human impact: the northern zone with high levels of habitat degradation caused by touristic exploitation, and by the presence of an electric power station, and the southwestern zone which is still not impacted by tourism. Ten survey routes, five in the northern zone and five in the southern zone, were selected and each route was surveyed in August for three years (1997–99). The routes were approximately 20 km in length and each route was treated as a line transect (Fuller and Mosher 1987) to estimate the relative abundance of each species of raptor. Carriage roads were driven at 20–40 km/hr during the morning (0730–1230 H) and afternoon (1500–1930 H), alternating the time period in order to not bias the data. Relative abundance indexes were computed (Woffinden and Murphy 1977) as follows:

$$\text{R.A.} = \left[\frac{\text{Number of species}}{\text{total individuals observed}} \div \text{Number of km traveled} \right] \times 1000$$

Data for the northern and southern zones were analyzed separately for each year using Mann-Whitney *U*-tests. A Kruskal-Wallis test was used to compare the mean number of each species of raptor observed in the two areas each year. All tests were two-tailed.

RESULTS

A total of eight species of raptors was observed. Four species, Eurasian Kestrel (*Falco tinnunculus*), Long-legged Buzzard (*Buteo rufinus*), Eurasian Buzzard (*Buteo buteo*), and Eurasian Sparrowhawk (*Accipiter nisus*) were residents of the island. Eleonora's Falcon (*Falco eleonora*) was a summer resident, and there were three migrants: Northern Hobby (*Falco subbuteo*), Merlin (*Falco columbarius*), and Booted Eagle (*Hieraaetus pennatus*). In all, 165 individuals were observed over the 600 km driven. In the northern zone, relative abundance estimates for raptors were similar (R.A. = 20) for all three years. The only raptors observed were Eurasian Kestrels (70.3%, *N* = 27) and Eurasian Buzzards (29.6%, *N* = 27). In the southern zone, eight species of raptors, Eurasian Kestrels, Eleonora's Falcons, Northern Hobbies, Merlins, Booted Eagles, Long-legged Buzzards, Eurasian Buzzards, and Eurasian Sparrowhawks, were observed (R.A. = 80). Kestrels and Eleonora's Falcons were the most frequently observed (R.A. = 180 and 150, respectively). Long-legged Buzzards were more common (R.A. = 100) than Eurasian Buzzards (R.A. = 76), and Eurasian Sparrowhawks were infrequently observed (R.A. = 20).

We detected a difference in the relative abundances of raptors between the northern and the southern zones in each year of our surveys (*U* = 0, *P* < 0.05), but no significant differences were detected in the number of raptor sightings between northern and southern portions of the island.

DISCUSSION

Our results indicated that the two zones of human impact on Rhodes have resulted in a differential distribution of raptors on the island. Only kestrels and buzzards, species that are highly adaptable to humans (Newton 1979), were observed in the northern part of the island where development has been the greatest. Those species were observed in the southern portion of the island are uncommon in areas with large amounts of human development. Southern portions of the island are not as at-

tractive for tourism because the rocky seashore is often inaccessible and the sea is always rough owing to dominant easterly winds. Nevertheless, there was two potential threats to the area's future suitability for raptors. The southern part of the island was increasingly being settled by people and there were projects designed to build new residences and several villages. Perhaps the greatest threat was a project to build a second electric power station on the island. The project would involve the destruction of 8 ha of native habitat along the coast where the majority of raptor sightings were made.

Because we observed so many migratory raptors during our surveys, Rhodes seems to play an important role in the migration of several raptor species. Rhodes is probably important because it offers undisturbed resting areas, water, and food resources. Due to this, future developments on the island should take into consideration the importance of native habitats on the island to migratory species of raptors.

RESUMEN.—En agosto desde 1997–99, censamos las aves rapaces en la Isla de Rodas para determinar los impactos de carreteras y construcciones asociadas al aumento de turismo en su abundancia. Hubo dos zonas diferentes de impacto, la zona norte con altos niveles de turismo y la zona sur con impacto relativamente poco de la gente. Diez rutas de investigación, cinco en cada zona de impacto fueron utilizadas. Un total de ocho especies de aves rapaces fueron observadas: Cuatro especies residentes *Falco tinnunculus*, *Buteo rufinus*, *Buteo buteo*, *Accipiter nisus*, un residente de verano *Falco eleonora* y tres migratorios

Falco subbuteo, *Falco columbarius* y *Hieraaetus pennatus*. Las especies ocurrieron en forma desigual con especies asociadas a la gente (*Falco tinnunculus* y *Buteo buteo*) mas frecuentemente observadas en la parte norte mas altamente impactada de la isla.

[Traducción de César Márquez]

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THE INCIDENCE OF INTESTINAL PARASITES IN BRITISH BIRDS OF PREY

NIGEL W.H. BARTON¹ AND DAVID C. HOUSTON

Ornithology Group, Institute of Biomedical and Life Sciences, Graham Kerr Building, Glasgow University, Glasgow, G12 8QQ, Scotland, U.K.

KEY WORDS: *raptors; intestinal parasites; Britain.*

During studies on the comparative morphology of the digestive tract of British birds of prey, we examined the gut contents of 379 individuals of six raptor species. Methods of *postmortem* examination and the sources of these birds are given in Barton and Houston (1991, 1992,

1993a, 1993b, 1994, 1996). To obtain weights and measurements of empty digestive tracts, we removed the digesta from the whole gut by cutting the gut open along its entire length and carefully scraping out the gut contents, followed by washing. We took this opportunity to examine carefully the gut wall and gut contents for parasitic worms. We only recorded those clearly visible to the naked eye, and some species or microscopic individuals too small to be seen may have been missed. We counted the total number of worms removed from each individual. All those recovered were nematodes. This group of

¹ Present address: The Falcon Facility, Penllynin Farm, College Road, Carmarthen, SA33 5EH, U.K.

worms are extremely difficult to identify. Because their taxonomy is still very poorly known (D.W.T. Crompton and J.D. Ewald pers. comm.), we were not able to identify them further. Most of the carcasses examined had been found dead and submitted for pesticide analysis. The cause of death was assessed during the dissection and based on criteria routinely used by the Institute of Terrestrial Ecology (Newton et al. 1982). Many birds had died from starvation or collisions. The body condition of all birds was estimated from pectoral muscle weight by dissecting the muscles, drying them to constant weight at 60°C, and extracting the fat by chloroform Soxhlet extraction to determine the fat-free dry muscle weight and fat content. A condition index, which accounted for the body size differences, was calculated from the residuals of the regression of dry muscle weight against a body size factor developed from factor loadings derived from Principal Components Analysis of five body measurements (Barton and Houston 1994). In this note, we report on the incidence of intestinal parasites and consider whether there was any correlation between the number of parasitic worms and the body condition of the birds.

We examined 135 Sparrowhawks (*Accipiter nisus*), 23 Peregrine Falcons (*Falco peregrinus*), 76 Eurasian Kestrels (*Falco tinnunculus*), 77 Common Buzzards (*Buteo buteo*), 9 Red Kites (*Milvus milvus*), and 59 Goshawks (*Accipiter gentilis*). The incidence of intestinal parasites was low, with only 20% of individuals having one or more parasites. There was no significant difference between species in the incidence of parasitic infection. The number of worms per individual was very variable, with up to 70 recorded from some individuals. It might be expected that birds in poor condition would have the greatest number of parasites and there was some slight evidence for this. Goshawks showed a significant negative correlation between the amount of pectoral fat and parasite numbers ($r_{13} = -50$, $P < 0.05$), so birds with the least fat reserves had the greatest parasite load. There were no significant relationships between pectoral fat and parasites for the other species. Our small sample sizes might have accounted for this, so we also examined whether those individuals with no parasites were in better condition than those individuals with parasites. In buzzards, those individuals with little fat were also likely to be individuals with parasites ($U = 76.0$, $N = 39$, $P < 0.005$, Mann-Whitney U -test) as were those with the smallest lean dry muscle weights ($U = 71.0$, $N = 39$, $P < 0.003$), but there was no significant relationship for the other species.

We were surprised that the incidence of parasite infection was so low. Our sample may have been biased because we discarded all birds that had not been freshly killed but, even with this precaution, most birds would have been dead for a day or so before collection, and frozen and thawed before examination. Few tapeworms were found. This may have been due to the fact that they disintegrated before the digesta was examined. Neverthe-

less, the cuticle of nematodes is remarkably resilient (Bird 1971, Lee 1972) and all of the nematodes removed from the gut were in good condition. Therefore, we think it likely that most nematodes were recovered.

There was some weak evidence of a correlation between body condition and parasite load, although it is impossible to establish cause and effect. Birds in poor condition might have been more susceptible to parasitism. Alternatively, parasites could have been the cause of the poor condition. There is very little literature on the incidence of intestinal parasites in birds of prey. They appear uncommon in captive birds (Greenwood et al. 1984) but, apart from some references to unusual individual case histories (Simpson and Harris 1992), there have been few surveys of wild birds. McInnes et al. (1994) surveyed 109 Tawny Owls (*Strix aluco*) and found nematodes were present in the small intestine of only 18% of individuals, although 68% were infected with an Acanthocephalan worm, and Houston and Cooper (1975) examined the intestines of 18 Rueppell's Griffon Vultures (*Gyps rueppellii*) and found nematode infections in 16 individuals. Parasites often use predators at the top of food chains as definitive hosts (Crompton and Nickol 1985). There is a considerable lack of information about the role of birds of prey in parasite transmission and this is an area of study which might repay further examination for those with the opportunity to carry out *post-mortem* examinations.

RESUMEN.—Examinamos 379 individuos de seis especies de aves rapaces británicas de las cuales sólo el 20% tenían nematodos intestinales. Hubo una pequeña evidencia que los individuos de *Accipiter gentilis* y *Buteo buteo* en condiciones físicas pobres tuvieron una carga mayor de parásitos.

[Traducción de César Márquez]

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LETTERS

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FIRST SIGHT RECORD OF THE KING VULTURE IN BAJA CALIFORNIA, MEXICO

On 31 October 1999 from 0900–1130 H, we observed a solitary adult King Vulture (*Sarcoramphus papa*) at San José del Cabo Estuary, Baja California Sur, Mexico (23°03'N, 109°41'W; elevation just above sea level). The estuary is located just east of the Presidente Forum Los Cabos resort about 1.0 km southeast of San José del Cabo and is in a tropical and semiarid portion of the Baja California peninsula where the Río San José meets the Pacific Ocean. Maya et al. (1997, pages 5–25 in L. Arriaga and R.R. Estrella [Eds.], *Los oasis de la Península de Baja California*. Centro de Investigaciones Biológicas del Noroeste, S.C., La Paz, B.C.S., México) provides a more complete description of this estuary.

The King Vulture was observed roosting along with numerous Turkey Vultures (*Cathartes aura*) in a dense grove of Mexican fan palms (*Washingtonia robusta*) that bordered a part of the estuary. According to Howell and Webb (1995, *A guide to the birds of Mexico and northern Central America*. Oxford Univ. Press, Oxford, U.K.), adult King Vultures are “unmistakable” and “usually seen singly,” and the species “associates with other vultures.” Although not photographed or collected, the King Vulture that we saw was easily separable from the Turkey Vultures roosting in the area. It was definitely larger than the Turkey Vultures and was aggressive towards them, apparently to acquire better sunning sites. The white wing feathers except for the main flight feathers that were black were easily observed while the bird extended its wings to thermoregulate in the morning sun. After returning from the field and reviewing Eitniear (1996, *J. Raptor Res.* 30:35–38), we determined that the King Vulture was an adult in definitive plumage, approximately 6–7 yr old. Its multicolored head was also easily seen, especially the portions that were orange. Our viewing distance was less than 150 m with the sun to our backs, and we used 8 × 42 binoculars. It was impossible to reduce the viewing distance for photographic purposes because of an intervening wetland.

To our knowledge, this represents the first report of the King Vulture in Baja California. Brewster (1902, *Bull. Mus. Comp. Zool.* 41:1–241), Grinnell (1928, *Univ. Calif. Publ. Zool.* 32:1–300), Wilbur (1987, *Birds of Baja California*. Univ. of Calif. Press, Berkeley, CA U.S.A.), Howell and Webb (1995), and American Ornithologists' Union (1998, *Checklist of North American birds*, 7th Ed. Am. Ornithol. Union, Washington, DC U.S.A.) did not list the King Vulture from Baja California. Howell and Webb (1995) state that the King Vulture is a rare lowland species that is decreasing in numbers, and their range map depicts the species' former distribution in western Mexico to as far north as central Sinaloa near the Culiacan area. The 300 km distance between the mainland in Sinaloa, México and the Cape region of Baja California Sur is not all that far for a species with the presumed flight range of the King Vulture. We could not relocate it on a brief visit to the same site two days later and biologists from the Centro de Investigaciones Biológicas del Noroeste, La Paz, Baja California Sur did not observe it there some weeks following our initial observation (R.R. Estrella pers. comm.). It is not known whether this King Vulture observation represents a natural “accidental” record or an escapee from captivity. It seems unlikely that it could have been the latter because no one knew of a King Vulture held in captivity in the Santiago Zoo or elsewhere in Baja California (R.R. Estrella and A.C. Vera pers. comm.). It was also unlikely that it could have escaped from a zoo in California because none were reported and most are kept in “double-door” facilities and California has one of the most restrictive state wildlife regulations in the U.S. (J. Bellinger pers. comm.). It is, of course, possible the bird originated from an area in the west outside of California where wildlife regulations are less restrictive. However, we feel that this was not an escaped King Vulture that we observed in Baja California but was, in fact, a free living bird well away from its usual range in mainland Mexico.

We thank M. Bechard, J. Bellinger, J. Clinton Eitniear, R. Rodríguez Estrella, L. Kiff, S. Speich, P. Unitt, A. Castellanos Vera, and S. Wilbur for reviewing the draft manuscript and making useful suggestions.—**Russell B. Duncan and Jo Ann V. Lacroix, R.B. Duncan & Associates, Biological Consultants, 6111 Bobcat Lane, Tucson, AZ 85743 U.S.A.**

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PROBABLE REPLACEMENT CLUTCHES BY BOOTED EAGLES (*HIERAAETUS PENNATUS*)
IN THE TIETAR RIVER VALLEY OF CENTRAL SPAIN

The Booted Eagle (*Hieraaetus pennatus*) is a summer resident species in Spain whose breeding ecology is poorly known (Brown and Amadon 1968, *Eagles, hawks, and falcons of the world*, Vols. 1 and 2, McGraw-Hill Book Company, New York, NY U.S.A.; Cramp and Simmons 1980, *Handbook of the birds of Europe, the Middle East, and North Africa*, Vol. 2, Oxford Univ. Press, Oxford, U.K.; Brown et al. 1982, *The birds of Africa*, Vol. 1, Academic Press, London, U.K.). Available information is limited to scarce data on clutch sizes, laying dates, productivity, and food habits (Labitte 1955, *Alauda* 23:249–253; Suetens and Van Groenendael 1969, *Ardeola* 15:19–36; Iribarren 1975, *Ardeola* 21:305–330; Steyn and Grobler 1981, *Ostrich* 52:108–118). To my knowledge, replacement clutches have not been reported for this species. Here, I report the first records of replacement clutches in Booted Eagles.

The data were obtained during a long-term study of breeding ecology of the species in the Tietar River valley (Ávila Province, central Spain, 40°40'N, 4°42'W) from 1995–2000. This is a mountainous area (300–2594 m) with large tracts of pine forest (*Pinus pinaster*) interspersed with smaller clearings of cultivated lands and scrubland. Booted Eagles arrive from their wintering grounds in late March and early April. Known territories were checked every two days to estimate arrival dates of each pair. The rest of the study area was surveyed intensively each year during March–April to locate new pairs. Nests were checked first after the female was observed in incubation posture. Eggs were measured and marked with felt pens, and I noted if they were warm or cold. When single eggs were found in nests during the first nest visits, I made a second visit two days later, or as soon as weather conditions permitted.

Only two replacement clutches were found among 82 breeding attempts with accurately-known clutch sizes. The first replacement clutch was recorded in May 1998. This pair nested on a platform used by a pair of Black Kites (*Milvus migrans*) during the previous year. Aggressive interactions between the pair of Black Kites and the Booted Eagles were frequently observed before the first nest check on 25 April. On this first visit, I found a recently-broken Booted Eagle egg on the ground below the nest and another egg on the nest. On 29 April the female was not incubating, but was seen perched near the nest tree. I revisited the nest again on 2 May and a new Booted Eagle egg was found and marked. On that visit, I did not find remains of the original eggs. Three days later the nest was checked again, and only the marked egg was found. On 13 June, I visited the nest again, but the egg was not found.

The second replacement clutch was observed in May 1998 at a newly-occupied nesting territory. I had surveyed this area since 1995 but did not find any evidence that Booted Eagles occupied the site. On 13 April 1998, I found the nest of this pair and, on 17 April, I found the female incubating one egg in the nest. The nest was checked again two days later, and I found only the marked egg. The female was incubating when the nest was visited again 38 d later (the typical incubation period). The marked egg was in the nest, dirty and only slightly warm. Three days later, I visited the nest again. There were eggshell remains of the original egg, and a new recently-laid egg, cold, clean, and completely white was found. A Booted Eagle was flying over the nest site. On 5 July, the nest was checked again, but only eggshell remains were found.

The adult Booted Eagles were not marked, so I was not absolutely sure that these were replacement clutches. They could have been new clutches of different pairs of eagles. If these were cases of pair replacement, I would have observed more than two birds in the same territory, aggressive interactions between individuals, courtship displays, and/or territorial flights as I observed in other cases of suspected pair changes. Therefore, I concluded that these were replacement clutches laid by Booted Eagles whose initial clutches failed early in the nesting season. After failing in the early stages of the breeding cycle, Booted Eagles may produce one replacement egg, supporting the suggestion that mid-size raptors that usually lay only one clutch can lay replacement eggs if they have lost the original clutch at an early stage (Newton 1979, *Population ecology of raptors*, T. & A.D. Poyser, London, U.K.).

I am grateful to J. Gomendio who allowed me to do this study. This work could not have been carried out without the help by M. García Tornero and J. Muñoz Familiar. M. Ferrer, G. Bortolotti, C. McIntyre, and J. Viñuela made critical evaluations of previous drafts. This paper is dedicated to Warden Marcos, from the town of Guisando, as a model of what exploiting and preserving our surrounding nature should be.—**Ignacio S. García Dios, Departamento de Ecología Evolutiva, Museo Nacional de Ciencias Naturales, José Gutiérrez Abascal 2, 28006 Madrid, Spain.**

BOOK REVIEWS

EDITED BY JEFFREY S. MARKS

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Owls: A Guide to the Owls of the World. By Claus König, Friedhelm Weick, and Jan-Hendrick Becking. 1999. Yale University Press, New Haven, CT. 462 pp., 64 color plates, numerous maps and line drawings. ISBN 0-300-07920-6. Cloth, \$50.—Claus König and his team have produced an excellent book on the owls of the world. Owing to new research findings, and to the fact that Professor König strongly believes that differences in vocalizations serve to separate even closely related taxa of owls, no other book has recognized so many species of owls. This book treats 212 species, versus, for instance, the 205 species treated in volume 5 of the *Handbook of the Birds of the World* (del Hoyo et al. 1999). Burton's (1973) *Owls of the World* recognized 134 species, and in that same year Eck and Busse proposed a new taxonomic revision of the world owls with only 108 species. So, in less than 30 years we have found or created 104 new species of owls on this planet. This is a remarkable taxonomic achievement for which Professor König and his team deserve special congratulations.

Although this book has named several new owls and reclassified many old taxa, I was disappointed that it did not attempt to harmonize English names. For example, for many years in Africa we have called *Glaucidium perlatum* the Pearl-spotted Owl and *G. capense* the Barred Owl. Now, König et al. have joined others (e.g., del Hoyo et al. 1999) in calling these species Pearl-spotted Owlet and African Barred Owlet, respectively. In the *Dictionary of Birds*, Campbell and Lack (1985) define "owlet" to stand for a young owl, so to my mind no species should be called "owlet." Especially strange is that we have owlets not only in *Glaucidium* (11 species), but in *Xenoglaux* (1) and *Athene* (2). This is very confusing, to say the least.

If in the genus *Otus* (as this book does correctly) we call the Old World species "scops-owls" (41) and the New World species "screech-owls" (19),

can't we similarly rename all *Glaucidium* "pygmy-owls," all *Athene* "little-owls," and *Xenoglaux loweryi* (Long-whiskered Owlet) simply the Long-whiskered Owl? With the same logic, we should not call *Pyrroglaux podarginus* and the two species of *Ptilopsis* "scops-owls," but rather Palau Owl and white-faced owls (Northern and Southern), respectively. In the case of long tradition, and to respect the AOU's role in naming North American birds, we could make exceptions, for instance by using Burrowing Owl instead of Burrowing Little-Owl, and Pearl-spotted Owl could easily be called Pearl-spotted Pygmy-Owl. Similarly, *G. capense* should be called Barred Pygmy-Owl to distinguish it from the North American *Strix varia*, which also is well-known as the Barred Owl. My point is that a dire need exists for some entity, perhaps the Raptor Research Foundation, to organize a conference in which owl researchers could agree on the English names of owls, once and for all.

Illustrations in the book are detailed enough in line drawings, but the numerous color plates are very monotonous. The overall quality of the color plates does not help what is an otherwise largely enjoyable work. I am not sure whether the quality of the plates was dictated by the small page format, or whether the publisher was operating within a tight budget.

It is true that owls are not too colorful, but without question Great Gray Owls (*Strix nebulosa*) have very bright yellow eyes, and Milky Eagle-Owls (*Bubo lacteus*) have bright fleshy eyelids. Somehow, these two species (among several others) have lost their brightness, at least in the copy that I received. Maybe this was the fault of the color separation during printing.

Any book of this magnitude takes years to write, but still an author is bound to miss some information among the wealth of data from recent research on owls. Taxonomy and vocalizations are extremely well covered throughout, but distribution and ecology are not. Coming from northern Europe and living in Africa, it is readily apparent that the authors did not put adequate effort into get-

ting the distribution maps correct. Certainly Great Gray Owls in the north and Pharaoh Eagle-Owls (*Bubo ascalaphus*) in the south, again only as examples, occur much farther south than illustrated in the maps.

The latest research on the ecology of owls has been almost totally neglected. The most productive owl ecologist in recent years, Erkki Korpimäki, is mentioned only once in the text (under Tengmalm's Owl [*Aegolius funereus*]), but in the Bibliography none of his excellent works are listed. The converse is true in my case, in which the Bibliography lists some of my works, although the citations are not mentioned in the text; e.g., Mikkola (1986) on the Barn Owl (*Tyto alba*). My paper on the Northern Hawk Owl (*Surnia ulula*) also is in the Bibliography but not in the text, and the year should be 1971 instead of 1973. The lack of information on ecology is partly understandable given that the authors concentrated on taxonomy and vocalizations, but the focus on the latter topics should have been mentioned somewhere in the book.

Despite my negative remarks, I warmly recommend this unique taxonomic work to anyone interested in knowing more about diversification of owls on our planet. This book is a must for serious "owlers" and academic owl researchers from throughout the world. The book also points out issues for further study, such as the serious need for additional research on vocalizations of different owls, the lack of DNA samples for many taxa, and the paucity of data on the ecology of many species. Only after more studies have been conducted and synthesized can one hope to produce a truly comprehensive work on the owls of the world.—**Heimo Mikkola, Institute of Applied Biotechnology, University of Kuopio, P.O. Box 1627, FIN-70211 Kuopio, Finland.**

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First Symposium on Steller's and White-tailed Sea-Eagles in East Asia. Edited by Mutsuyuki Ueta and Michael J. McGrady. 2000. Wild Bird Society of Japan, Tokyo, Japan. 127 pp., numerous figures and tables. Paper, \$20.00.—The current offering is a proceedings of a workshop organized by the Wild Bird Society of Japan, Shiretoko Museum, and the Lead Poisoning Network of Eagles, that was held in Tokyo and Hokkaido, Japan, from 9 to 15 February 1999. Participants included specialists from Japan, Russia, and the United States. Despite its title, the proceedings focuses clearly on the Steller's Sea-Eagle (*Haliaeetus pelagicus*), the largest and one of the least-studied of the world's eight *Haliaeetus* eagles. The species, described by Pallas in 1811, was named in honor of its collector, arctic naturalist Georg Wilhelm Steller, who considered it to be "bold," "cunning," and of "savage disposition." The Steller's Sea-Eagle's massive nature, unmistakable plumage, and oversized yellow bill have long attracted the admiration of raptor biologists. Until recently, however, the species' rugged and remote breeding grounds in easternmost Russia have made it difficult to study the bird in the field. Not surprisingly, then, this proceedings offers much in the way of new information.

The work includes 11 journal-style chapters, nine of which concern Steller's Sea-Eagles, and two of which deal with lead poisoning and chlorinated hydrocarbon contamination in White-tailed Eagles (*H. albicilla*) and Steller's Sea-Eagles. Papers focusing only on the Steller's Sea-Eagle include treatments of bill structure, molt, diet, migration, post-natal development, distribution and abundance in the Magadan and Khabarovsk districts and on Sakhalin Island, and habitat use in Northern Okhota, as well as information on population trend analysis and techniques for determining sex and

age. A 95-entry reference section on Steller's Sea-Eagles is included as an appendix.

Proceedings can be notoriously uneven in places, and although this is the case here, it is so only because substantial differences in the state of our knowledge regarding various aspects of the biology of Steller's Sea-Eagles have made it necessary. Indeed, and in spite of several minor lapses, the editors are to be congratulated on a job well done, as well as on a job most rapidly done. In addition to the work's judicious editing, Michiko Shigehara's artwork conveys a welcome sense of place for the birds whose biology is described.

Alexander Ladyguin's chapter on bill structure in Steller's Sea-Eagles is particularly enlightening and well written. Having described the species' oversized bill in detail, Ladyguin goes on to discuss the function of its massive and powerful nature, arguing persuasively that both owe their origins not only to the exceptional toughness of fishes' skin, but also to the rapidity with which the species—like Old World vultures—devours its prey while feeding within groups of a dozen or more aggressive conspecifics. Thus, the Steller's Sea-Eagle is capable of consuming 900 g of fish in 3–4 min, whereas the White-tailed Eagle takes almost 18 min to accomplish this task. The complexities of molt in Steller's Sea-Eagles—the species replaces one-half to one-third of all feathers, and one-fourth to one-third of all *flight* feathers annually—are capably described by Teruaki Morioka. Vladimir Masterov's offering reveals that nestlings hatched early in the season grow more slowly than those that hatch later, and that nestling males reach adult size 7–10 days earlier than nestling females. In two exceptionally well-written papers, Potapov et al. suggest that Steller's Sea-Eagles breed almost entirely within a 100-km wide strip along

the coastline of the Sea of Okhotsk, that those breeding in regions with low sloping coastlines and broad littoral zones are more tolerant of human disturbance than those breeding along more steeply sloped coastlines, and that diets of nesting pairs differ depending on coastline structure. In yet another excellent paper by the same authors, Utekhina et al. document seasonal shifts in diet, with carrion being particularly important in spring, and fish and colonial-nesting waterbirds being more important in summer. McGrady et al.'s satellite telemetry studies of movements in the species detail fledgling dispersal to premigratory summering sites, as well as eventual migratory journeys to the south, the latter at rates of approximately 50 km per day. Most eagles from Amur and Magadan migrate down the western shorelines of the Sea of Okhotsk, whereas individuals from Kamchatka move south through the Kuril Islands. One exceptional bird undertook a minimal overwater crossing of 730 km from Magadan southeast to southern Kamchatka. Finally, and on a more poignant note, Iwata et al. detail the extent of chlorinated hydrocarbon contamination and lead poisoning in both species of eagles. Lead poisoning, in particular, appears problematic, with pellets in deer shot in wintering areas in Hokkaido, Japan, playing a major role.

Overall, the work provides a thorough and remarkably up-to-date summary of state-of-the-art knowledge of the biology of Steller's Sea-Eagles. The symposium's organizers and proceedings' editors are to be congratulated on their efforts, which should serve the region's conservation biologists and the world's sea-eagle specialists for some time. This slim volume belongs on the shelves of all raptorphiles.—**Keith L. Bildstein, Hawk Mountain Sanctuary, 1700 Hawk Mountain Road, Kempton, PA 19529 U.S.A.**

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The following people reviewed manuscripts for the Journal of Raptor Research in 2000. Peer review plays a vital role in the publishing process and in improving the quality of the Journal. The editorial staff would like to thank the following for reviewing manuscripts this past year. The names of those who reviewed two or more manuscripts are indicated with an asterisk.

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Buteo Books stocks the *Handbook of the Birds of the World*. The first five volumes of this projected 12-volume work have been published including: **Volume 2: New World Vultures to Guinea-fowl** (1994) covering the diurnal raptors and **Volume 5: Barn Owls to Hummingbirds** (1999) covering owls. These volumes are priced at \$185 each plus shipping and handling.

Usually available from Buteo Books, the classic reference on diurnal birds of prey: Brown, Leslie and Dean Amadon. *Eagles, Hawks and Falcons of the World*. Country Life Books, 1968. Two volumes. First English edition in brown cloth. Fine in slipcase. \$300.00 and other editions at lesser prices.

2001 ANNUAL MEETING

The Raptor Research Foundation, Inc. 2001 annual meeting will be held on 25–30 October in Winnipeg, Manitoba, Canada. For information about the meeting contact Jim Duncan, Biodiversity program, Wildlife Branch, Manitoba Natural Resources, Box 24, 200 Saulteaux Crescent, Winnipeg, MB R3J 3W3 Canada. Email jduncan@nr.gov.mb.ca.

Persons interested in predatory birds are invited to join The Raptor Research Foundation, Inc. Send requests for information concerning membership, subscriptions, special publications, or change of address to OSNA, P.O. Box 1897, Lawrence, KS 66044-8897, U.S.A.

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RAPTOR RESEARCH FOUNDATION, INC., AWARDS Recognition for Significant Contributions¹

The **Dean Amadon Award** recognizes an individual who has made significant contributions in the field of systematics or distribution of raptors. Contact: **Dr. Clayton White, 161 WIDB, Department of Zoology, Brigham Young University, Provo, UT 84602 U.S.A.** Deadline August 15.

The **Tom Cade Award** recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. Contact: **Dr. Brian Walton, Predatory Bird Research Group, Lower Quarry, University of California, Santa Cruz, CA 95064 U.S.A.** Deadline: August 15.

The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Contact: **Dr. David E. Andersen, Department of Fisheries and Wildlife, 200 Hodson Hall, 1980 Folwell Avenue, University of Minnesota, St. Paul, MN 55108 U.S.A.** Deadline: August 15.

Recognition and Travel Assistance

The **James R. Koplín Travel Award** is given to a student who is the senior author of the paper to be presented at the meeting for which travel funds are requested. Contact: **Patricia A. Hall, 5937 E. Abbey Road, Flagstaff, AZ 86004 U.S.A.**

The **William C. Andersen Memorial Award** is given to the student who presents the best paper at the annual Raptor Research Foundation Meeting. Contact: **Ms. Laurie Goodrich, Hawk Mountain Sanctuary, Rural Route 2, Box 191, Kempton, PA 19529-9449 U.S.A.** Deadline: Deadline established for meeting paper abstracts.

Grants²

The **Stephen R. Tully Memorial Grant** for \$500 is given to support research, management and conservation of raptors, especially to students and amateurs with limited access to alternative funding. Contact: **Dr. Kimberly Titus, Alaska Division of Wildlife Conservation, P.O. Box 20, Douglas, AK 99824 U.S.A.** Deadline: September 10.

The **Leslie Brown Memorial Grant** for \$500–\$1,000 is given to support research and/or the dissemination of information on raptors, especially to individuals carrying out work in Africa. Contact: **Dr. Jeffrey L. Lincer, 1220 Rosecrans St. #315, San Diego, CA 92106 U.S.A.** Deadline: September 15.

¹ Nominations should include: (1) the name, title and address of both nominee and nominator, (2) the names of three persons qualified to evaluate the nominee's scientific contribution, (3) a brief (one page) summary of the scientific contribution of the nominee.

² Send 5 copies of a proposal (≤5 pages) describing the applicant's background, study goals and methods, anticipated budget, and other funding.