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Names for birds should follow the A.O.U. Checklist of North American Birds (7th ed., 1998) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1999).

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COVER: Osprey (*Pandion haliaetus*). Painting by Gib Pulley, P.O. Box 430, Grimstead, VA 23064; e-mail address: pulleys@inna.net

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AN URBAN OSPREY POPULATION ESTABLISHED BY TRANSLOCATION

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Abstract.—We evaluated the success of an Osprey (*Pandion haliaetus*) translocation program which released, by hacking, 143 juveniles into the Minneapolis-St. Paul, Minnesota area from 1984–95. All of the released, and 80% of 194 wild-fledged birds, were banded and color-marked as nestlings. The first nesting attempt occurred in 1986 and the first successful nest was in 1988. By the end of the 2000 nesting season, we had documented 131 nesting attempts, 90 (69%) of which were successful. The greatest number of occupied sites in any year (19) was in 2000, while the most productive sites documented in any year (13) was in 1999. From 1987–2000, 194 wild-fledged chicks were produced in the Twin Cities area. Mean number of young fledged per occupied nest during this period was 1.57 (range = 0–2.3) and mean number of young fledged per successful nest was 2.17 (range = 1–2.7). Overall nest success was 69% with a small number of sites and individuals responsible for a disproportionate number of fledglings. Released birds were more likely to return to nest than wild-fledged birds, and more males than females returned to nest. Mean female dispersal distance (384 km) was greater than that of males (27 km). We conclude that this translocation was successful and with proper management this population will remain stable or continue to grow.

Key Words: *Osprey*; Pandion haliaetus; *productivity*; *translocation*; *urban wildlife*; *Minnesota*.

Una poblacion urbana de aguilas pescadoras establecidas su traslado

Resumen.—Evaluamos el exito de un programa del traslado de águilas pescadoras (*Pandion haliaetus*) el cual liberó, 143 juveniles dentro de Minneapolis-St. Paul, área de Minnesota de 1984–95. Todos los liberados, y 80% de las 194 aves volantonas, fueron anilladas y marcadas con color cuando eran polluelos. El primer intento de anidación ocurrió en 1986 y el primer nido exitoso fue en 1988. Para el final de la temporada de anidación del 2000, hemos documentado 131 intentos de anidación, 90 (69%) de los cuales tuvieron éxito. El numero mas grande de sitios ocupados en cualquier año (19) fue en el 2000, mientras que la mayoría de sitios productivos documentados en cualquier año (13) fue en 1999. De 1987–2000, 194 polluelos emplumados en vida silvestre fueron producidos en 1 área de las ciudades gemelas. El numero promedio de juveniles emplumados por nido ocupado durante este periodo fue 1.57 (rango = 0–2.3) y el numero promedio de juveniles emplumados por nido exitoso fue 2.17 (rango = 1–2.7). En conjunto el éxito de anidación fue 69% con un pequeño numero de sitios e individuos responsables de un numero desproporcionado de volantones. Las aves liberadas probablemente retornaron mas al nido que las aves emplumadas en vida silvestre, y retornaron al nido mas machos que hembras. La distancia media de dispersión de las hembras (384 km) fue mas grande que la de los machos (27 km). Concluimos que este traslado fue exitos y con un manejo adecuado esta población permanecerá estable continuara creciendo.

[Traducción de César Márquez]

Translocation, the movement of eggs, young, or adults from a wild population to a new location, has become a widely used conservation management tool for many species of wildlife. Recently, Cade (2000) reviewed 52 translocation projects involving 25 species of diurnal birds of prey. Osprey

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(*Pandion haliaetus*) translocations have been successful in Pennsylvania (Rymon 1989), Tennessee (Hammer and Hatcher 1983), and North Carolina (R. Bierregaard pers. comm.). Currently, Osprey translocations are ongoing in the United Kingdom (H. Dixon and R. Dennis pers. comm.), Missouri, Ohio, Colorado, and Iowa U.S.A. The success of translocations is often evaluated by the number of released animals and their offspring that establish a self-sustaining population (Griffith et al. 1989, Cade 2000). In long-lived species like the Osprey, reproductive effort and population stability, important factors in determining success, can take many years to measure. Maintaining the support and interest necessary to monitor these parameters over time can be more difficult than the initial translocation effort.

In Minnesota, Ospreys historically nested in the east-central portion of the state (Roberts 1932), which now includes the Minneapolis-St. Paul urban area. By 1900, this population had disappeared due to persecution and loss of suitable nest sites (Roberts 1932, Gillette and Voigt Englund 1985, Coffin and Pfannmuller 1988). Although Ospreys continued nesting in northern Minnesota even through the DDT era in the mid-1900s, there was no nesting recorded in the southern part of the state, partially due to the species' reluctance to colonize new areas (Poole 1989). In 1984, a program to restore a nesting population of Ospreys in the Twin Cities area was initiated (Gillette and Voigt Englund 1985). The effort focused on hacking translocated nestlings from northern Minnesota and erecting artificial nest platforms (Martell et al. 1994, Martell 1995). Using techniques similar to those employed in Tennessee (Hammer and Hatcher 1983) and Pennsylvania (Rymon 1989), we released 143 translocated Osprey nestlings at eight sites in the Twin Cities area from 1984–95. Here, we examine the characteristics of this new urban population established by translocation.

METHODS

The study area included a seven-county region in east-central Minnesota centered around the cities of Minneapolis and St. Paul, here referred to as the Twin Cities. From 1984–2000 we banded all 143 released nestlings, and 156 of 194 wild-fledged chicks (80%) from the study area. Ospreys released in the first 3 yr of the program (35 birds) were banded with a standard aluminum U.S. Fish and Wildlife Service (USFWS) band that was anodized blue (1984) or gold (1985–86). Ospreys released after 1986, and all wild-fledged young, were banded with a silver USFWS band and a black, lock-on, aluminum, al-

phanumeric coded-color band. We also banded and color-marked six nesting adults. More than 30 nest platforms were erected in the area, some under our direction, others independently.

Previously-occupied nest sites and other nesting platforms were visited several times annually, and reports of other Osprey nesting activity in the area were checked. We monitored nest sites throughout the breeding season to determine occupancy (defined as the presence of an adult pair), and productivity (number of young at banding), and to identify nesting adults where possible. We calculated annual survival through 74 territorial years defined as: "the record of one territorial adult from one breeding season to the next" (Tordoff and Redig 1997) Dispersal distances between fledging and first-time nest sites were calculated by mapping sites using a Global Positioning System (GPS) receiver, then entering coordinates and calculating straight-line distances on ArcView Geographic Information System (GIS) (Environmental Systems Research Institute, Inc. [ESRI], Redlands, CA) Statistical tests were done using Statistix 7 (Analytical Software, Tallahassee, FL).

RESULTS

Nesting and Productivity. The first nesting attempt occurred in 1986 by a translocated male and two unbanded females less than 3 km from where the male was released in 1984. Although eggs were laid, no young were produced. In 1987, after eggs again failed to hatch, a translocated chick was placed in that nest resulting in the first parent-raised Osprey fledgling in the Twin Cities area since the late 1800s. The number of territories and production of young increased in the following years (Fig. 1) so that by the end of the 2000 nesting season we documented 131 nesting attempts, 90 (69%) of which were successful. The highest number of occupied sites in any year (19) was in 2000, whereas the greatest number of productive sites in any year (13) was in 1999 (Fig. 1).

We calculated the change in the number of nesting pairs (lambda) for the years 1986–2000 and found the change to be one or higher for all years except one (1996). We used a simple regression of the log of lambda against the number of pairs and found a density dependent decrease ($F = 2.82$, $P = 0.1192$, $df = 13$) over time, consistent with the growth of a new population.

A total of 194 wild-fledged chicks were produced in the Twin Cities area from 1987–2000, in addition to the 108 chicks released during that time (35 were released from 1984–86) (Fig. 1). During this period the number of wild young fledged per occupied nest was 1.57 (yearly range = 0–2.3) and the number of young fledged per successful nest was 2.17 (yearly range = 1.00–2.7).
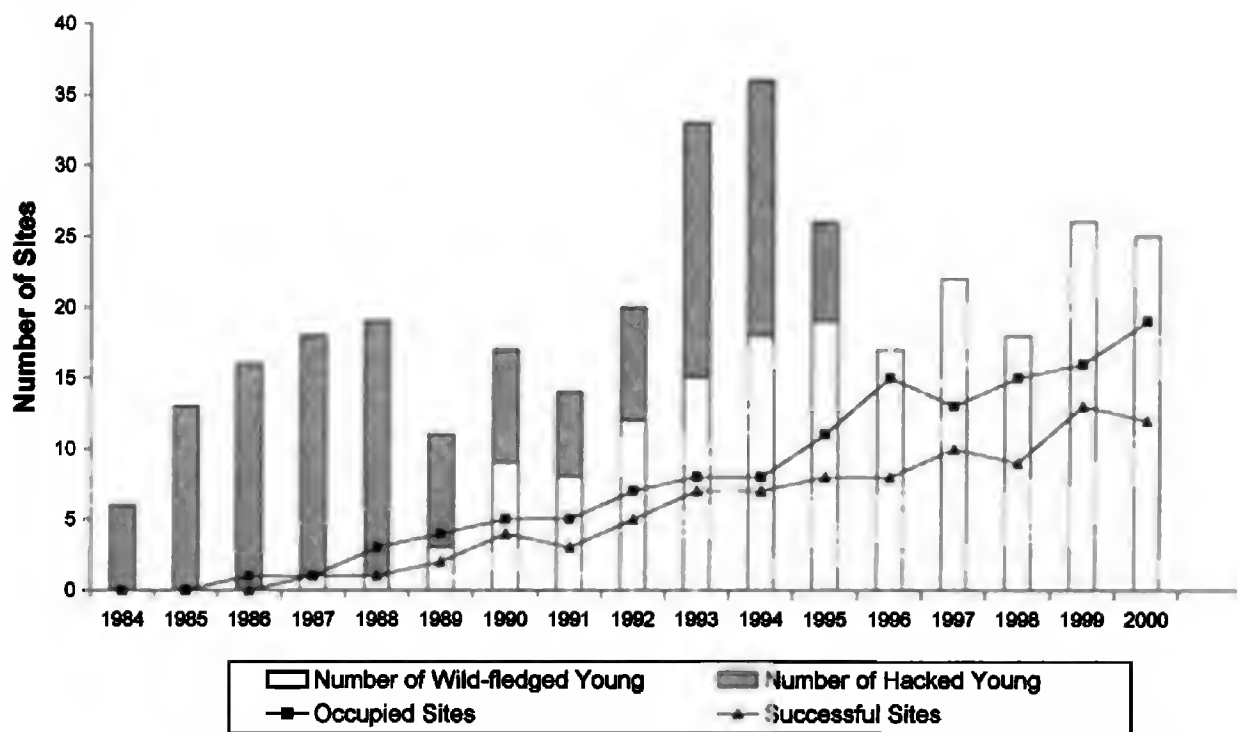
Figure 1. Number of hacked young, number of occupied sites, successful sites, and wild young Ospreys produced in the Twin Cities, Minnesota area, 1986–2000.

Individual Site Characteristics. From 1986–2000 nesting was attempted at 26 sites, 20 (77%) of which produced young. Fourteen sites (54%) were initiated in the last 5 yr of the study; nine were productive (45% of the productive sites). Only two sites have been occupied continuously since 1988. Adults at four sites produced young successfully every year since they became occupied (8, 6, 3, and 2 yr). Three productive nests (15%) were abandoned and not occupied in subsequent years. One site was abandoned after 2 yr of successful nesting due to usurpation of the nest by Great-horned Owls (*Bubo virginianus*), forcing the pair to move 2.5 km to a nearby nest where they have fledged young successfully for the past 3 yr.

Of 20 productive nests, 13 (65%) were in a park or protected park-like habitat, four (20%) were in backyards of private residences, and three (15%) were in industrial areas. All but three of the nests that Ospreys attempted to use were on platforms erected for them; the only non-platform site where young were produced successfully was a nest built by Ospreys on the top of a water tower. The other two non-platform nests were built on power transmission poles and destroyed by lightning or removed by the utility company.

Five sites accounted for 48% of the young produced and four of seven local second-generation breeders. Four of these sites are among the oldest in the study area, having been occupied since at least 1992. Three sites are within 4.5 km of each

other in Carver Park Reserve and produced 32% of the wild-fledged young during this period.

Fidelity, Dispersal, and Nesting Age. We were able to identify at least one adult at 21 (81%) nest sites, representing 94 (72%) nesting attempts. We identified 23 marked individuals (16 released, 7 wild; 2 females, 21 males) nesting in the area from 1986–2000. Additionally, five female Ospreys banded as nestlings in the Twin Cities (four released, one wild) were reported nesting outside the study area in Dickinson County, Iowa (P. Schlarbaum pers. comm.); Benzie County, Michigan (S. Postupalsky pers. comm.); Cook County, Illinois (S. Fejt pers. comm.); Stark County, Ohio (S. Peters pers. comm.); and Crow Wing County, Minnesota (M. Martell pers. observ.). The Minnesota female was nesting in the same county from which she was translocated.

Released birds (20 of 143) seemed more likely to return to the study area to nest than wild-fledged Ospreys (8 of 125) through 1997, although this pattern was not significant (χ^2 = 3.35, df = 1, P = 0.0674). Released birds were also responsible for more nesting attempts (62% of total) than banded wild-fledged birds (13% of total). Twenty-five percent of nesting attempts involved no locally banded birds.

Differences in natal dispersal distances (log-transformed) were not affected by whether they were released or wild ($F_{1,24}$ = 2.02, P = 0.17), but were significantly different by sex ($F_{1,24}$ = 16.48, P
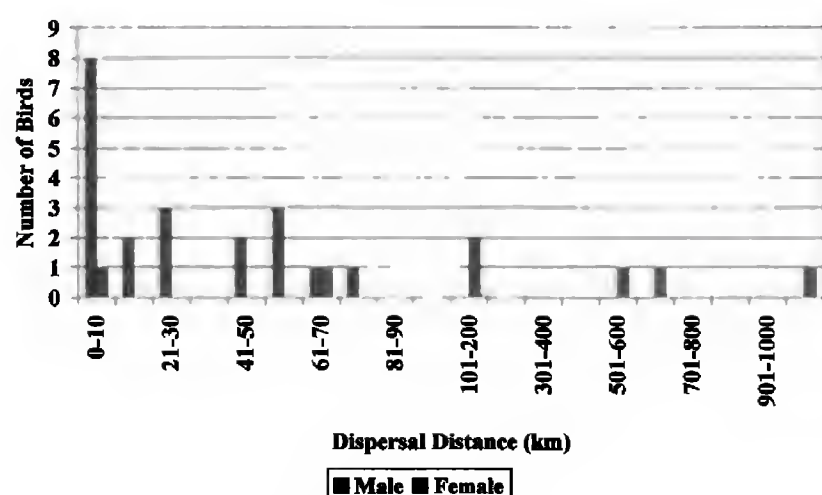
Figure 2. Natal-dispersal distance of male and female Ospreys fledged in the Twin Cities, Minnesota, 1986–2000.

Figure 3. Age at first nesting for male Ospreys in the Twin Cities, Minnesota, 1986–2000.

= 0.0005). Females dispersed a mean distance of 384 km (SE = 146, N = 7, range = 8–1075 km) from their fledge site, significantly farther than the males (N = 20), whose mean dispersal distance was 27 km (SE = 5.5, N = 20, range = 1–65 km; Fig. 2).

Median age of males at first known nesting was 4 yr, and varied from 2–8 yr (Fig. 3). In 2000, the median age of all marked Ospreys nesting in the Twin Cities was 8 yr. Using territorial years (Tordoff and Redig 1997), we calculated the annual survival rate of marked territorial males as 91%. The oldest banded Osprey nesting in the Twin Cities was a male released in 1984 and was still nesting in 2000 at age 16. The oldest female recorded was a released bird who was 10-yr old in 2000.

Band Returns. Seven band returns from outside the study area have been reported, four from released birds, three from wild birds. All returns involved juveniles, presumably on their wintering grounds, from Colombia, Costa Rica, Ecuador, Panama (2), and Peru (2).

DISCUSSION

Translocations are considered successful if they result in "a self-sustaining population" (Griffith et al. 1989). Population viability analysis and other modeling techniques can be used to determine success objectively, although more often subjective criteria are used (Cade 2000). We believe that this translocation effort was successful, at least in the near term, as indicated by the continued growth of the local population, high reproductive rates, and the longevity of individuals coupled with the return of breeding second-generation birds.

Productivity in the Twin Cities population ($\bar{x}$ =

1.57 young/occupied nest) is above the 0.9–1.3 young/occupied nest necessary for population stability (Henny and Wight 1969), and at the high end of the range for North American Ospreys (Poole 1989). While many factors influence productivity, in our study population the use of artificial nest platforms, which have been shown to increase nesting success (Seymour and Bancroft 1983, Westall 1983), seems important.

Early dependence on a small number of highly-productive individuals and sites is probably to be expected in a translocated population of this size. Studies of established populations of Ospreys and other raptors show that a small number of pairs usually are disproportionately responsible for producing successive generations (Poole 1989, Postupalsky 1989). Breeding success in Ospreys has been shown to be positively affected by experience and by retention of mates from one year to the next (Poole 1989); similarly, our most productive sites were among the oldest and had little or no turnover of males (females were not marked and thus their turnover rate was not known).

The greater number of released birds returning to the study area to breed when compared to wild-fledged young is an interesting, and unexpected, feature of this new population. We expected that juveniles raised by their parents with no human interference would be better equipped to survive to breeding age. Two possible explanations for the greater representation of released birds occur to us. First, the released birds were able to return to an area devoid of competition for prime nest sites. As the translocated population increased, their offspring may have been forced into less desirable sites because of local competition. The second possibility is that, contrary to expectations, released birds may have had a higher survival rate during their first year. Released Peregrine Falcons (*Falco peregrinus*) in the midwestern U.S. had greater sur-

vival to breeding than wild-fledged falcons (Tordoff and Redig 1997), presumably because of the greater amount of food available to released birds, food available until they are fully independent (Tordoff et al. 2000). This same factor may have been at work here; our site attendants made sure that food was available twice a day until the young birds had left the area, perhaps resulting in heavier birds with a greater chance of first-year survival.

Another striking feature of this population was the tendency of males to return to the study area to breed, as opposed to the almost total lack of returning females. The greater dispersal distance we found for females ($\bar{x}$ = 384 km) vs. males ($\bar{x}$ = 27 km) has been noted in other Osprey populations (Poole 1989, Postupalsky 1989). These sex-influenced dispersal patterns are also found in other birds (Newton 1979, Greenwood 1980, Restani and Mattox 2000) and may be related to the amount of effort each sex spends on territory competition versus raising young (Greenwood 1980). A differential dispersal pattern has implications for translocation projects, in that releasing males, rather than females, may have a greater impact on establishing a population. However, it can be argued that releasing only males results in a drain of females from donor populations, while this is balanced by exported females if both sexes are released. Also, it may be helpful for young males to have social discourse with young females.

As a long-distance migrant, an individual Osprey's survival depends on its ability to cope with habitats other than the breeding grounds. Thus, it is important that translocated Ospreys develop appropriate migration patterns and find suitable wintering areas. Band returns and satellite telemetry (Martell et al. 2001) indicate that birds from this Twin Cities population use migration routes and wintering areas similar to those used by other Ospreys from the region (Henny and Van Velzen 1972, Poole and Agler 1987, Martell et al. 1998).

The Osprey population in the Twin Cities should continue to grow, limited mostly by available nest sites. As Osprey populations in northern Minnesota and western Wisconsin continue to increase and spread, this new urban population will likely merge with the regional population. The most important management factor will be to maintain existing nesting platforms and continue the appropriate placement of new ones. It is unlikely that urban-forestry practices will allow for the development of enough super-canopy trees or snags for such sites to become a factor in the management of the Twin Cities Osprey population.

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BREEDING GROUNDS, WINTER RANGES, AND MIGRATORY ROUTES OF RAPTORS IN THE MOUNTAIN WEST

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ABSTRACT.—We report band-encounter locations accumulated between 1980 and April 2001 for five species of North American raptors (Sharp-shinned Hawk, *Accipiter striatus;* Cooper's Hawk, *A. cooperii;* Northern Goshawk, *A. gentilis;* Red-tailed Hawk, *Buteo jamaicensis;* and American Kestrel, *Falco sparverius*) banded or recaptured during migration in northern Oregon ($N = 14$), northeastern Nevada ($N = 325$), and north-central New Mexico ($N = 136$). Based on a discriminant function analysis of the encounter locations and comparisons of intra- and inter-flyway recapture rates, migrants passing through these areas travel along three distinct regional flyways: Pacific Coast, Intermountain, and Rocky Mountain. Encounter locations of Pacific Coast migrants were generally restricted to west of the Sierra Nevada and Cascade ranges from southern British Columbia through California. Intermountain migrants were encountered from interior Alaska to southwestern Mexico, usually east of the Sierra Nevada–Cascade ranges and west of the Rocky Mountains and Sierra Madre Occidental. Rocky Mountain migrants were found from interior Alaska to southern Mexico, usually within or east of the latter two ranges. Because encounter distributions tended to converge in the far northwest and southern Mexico, the delineation of regional flyways in western North America is probably most relevant for distinguishing subpopulations of birds that originate south of mainland Alaska and winter north of Central America. During summer and migration seasons, most encounters away from the banding sites resulted from death due to collisions with human structures or unknown causes. In contrast, most winter encounters involved birds shot in Mexico. We also examined the Nevada encounter data for evidence of differential migration distances among age and sex classes, and found a consistent but nonsignificant pattern for four species. Mean winter latitude tended to increase with age within sexes and to be higher for males than females within age classes. These patterns are most consistent with predictions of foraging-efficiency and arrival-time hypotheses proposed to explain differential migration.

KEY WORDS: *band encounters; band recoveries; differential migration; migration; flyways; western North America.*

Campos de anidacion, rangos invernales, y rutas migratorias de Las Rapaces en la Montaña Oeste

RESUMEN.—Reportamos las localidades de encuentros de individuos marcados acumulados entre 1980 y abril de 2001 para cinco especies de rapaces norteamericanas (*Accipiter striatus, A. cooperii, A. gentilis, Buteo jamaicensis,* y *Falco sparverius*) anilladas o recapturadas durante la migración en el norte de Oregon ($N = 14$), noreste de Nevada ($N = 325$), y Nuevo Méjico Norcentral ($N = 136$). Con base en un análisis de función discriminante de las localidades de encuentros y comparaciones de las tasas de recaptura intra- e inter-corredores de vuelo, los migrantes pasan a través de estas áreas de viaje a lo largo de tres distintos corredores regionales de vuelo: costa pacifica, ínter montañoso y por las montañas rocosas. Las localidades de encuentro de los migrantes de la costa pacifica estaban generalmente restringidos al oeste de la Sierra Nevada y Cascade ranges desde el sur de British Columbia hasta California. Los migrantes ínter montanos fueron encontrados desde el interior de Alaska hasta el suroeste de Méjico, usualmente al oriente de la Sierra Nevada y Cascade ranges y el oeste de las montañas rocosas y la Sierra Madre Occidental. Los migrantes de las montañas rocosas fueron encontrados desde el interior de Alaska al sur de Méjico, usualmente dentro o al este de los dos últimos rangos. Debido a que las distribuciones de los encuentros tendían a convergir en el lejano noroeste y sur de Méjico, la delineación de corredores de vuelo regionales en el occidente de Norteamérica es probablemente mas relevante para distinguir subpoblaciones de aves originarias del sur de Alaska continental y que invernan al norte

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de Centroamérica. Durante el verano y las estaciones migratorias, la mayoría de encuentros lejos de los sitios de marcaje fueron resultado de la muerte por colisiones con estructuras humanas o por causas desconocidas. En contraste, la mayoría de encuentros invernales involucraron aves impactadas en Méjico. Examinamos además los datos de encuentros de Nevada buscando evidencia de distancias de migración diferenciales entre edad y clases de sexo, y encontramos un consistente pero no significante patrón para cuatro especies. La latitud media invernal tendió a incrementarse con la edad dentro de sexos y a ser mas alta para los machos que para las hembras dentro de clases de edad. Estos patrones son mas consistentes con las predicciones de eficiencia del forrajeo y la hipótesis del tiempo de arribo propuesta para explicar la migración diferencial.

[Traducción de César Márquez]

Linking summer and winter ranges and migratory or dispersal routes of bird populations is necessary before effective year-round and location-specific conservation strategies can be designed (Myers et al. 1987, Sherry and Holmes 1995). Establishing such linkage, thus defining migration flyways, also ensures the proper geographic context for interpreting trends observed at count sites (Senner and Fuller 1989). Assessing the status of raptor populations is difficult using breeding-season census methods, because most species are secretive, occupy large home ranges, and occur at low breeding densities (Fuller and Mosher 1981). For this reason, researchers have turned to estimating population trends by counting migrating raptors as they pass concentration points (Zalles and Bildstein 2000).

HawkWatch International, Inc. (HWI) and its organizational precursors have been banding raptors at migration sites since 1980 to help identify source populations and migration routes of western raptors (Smith and Hoffman 2000). Herein, we describe the breeding areas, wintering grounds, and migratory routes of raptors encountered as migrants at four long-term monitoring sites in New Mexico, Nevada, and Oregon. Our analyses concern five species (Sharp-shinned Hawk, *Accipiter striatus*; Cooper's Hawk, *A. cooperii*; Northern Goshawk, *A. gentilis*; American Kestrel, *Falco sparverius*; Red-tailed Hawk, *Buteo jamaicensis*) and derive from 475 encounters with previously banded birds recorded between autumn 1980 and April 2001 (Table 1).

With these data, we also examined variation in migration distances among age and sex classes, commonly referred to as differential migration. Several hypotheses have been offered to explain this phenomenon (see Ketterson and Nolan 1983, Kerlinger 1989).

When discussing raptor migration, it is important to recognize that migrants recorded at concentration points may be involved in at least six different types of movements: complete migration, partial migration, natal dispersal, and irruptive, nomadic, and local movements, including altitudinal migration (Dingle 1980, Kerlinger 1989). Worldwide, 70% of all migratory falconiform species are considered partial migrants, which involves seasonal movements between breeding and non-breeding ranges by some but not all members of a population or a seasonal departure from only a portion of the breeding range (Kerlinger 1989). Herein, we consider the migratory movements of five species of partial migrants.

While species such as Sharp-shinned and Cooper's Hawks routinely follow largely north–south migration pathways, other species (e.g., Prairie Falcons, *Falco mexicanus*; Red-tailed Hawks; Ferruginous Hawks, *Buteo regalis*; and Golden Eagles, *Aquila chrysaetos*) often migrate or disperse from natal territories in many directions (Steenhof et al. 1984, Bloom 1985, Watson and Pierce 2000). Moreover, as one moves south, especially along the coast of California (A. Fish pers. comm.), patterns of movement become increasingly complex and populations include permanent residents and wintering birds, as well as actual migrants. Thus, although herein we adopt the classic terminology of "flyways" to describe relatively distinct regional movement corridors, we caution readers to recognize that movements within flyways can be multi-directional and complex and that the model we articulate may not apply to all species or populations.

METHODS

Study Sites. The Goshute banding site (Hoffman 1985) is located on a ridgetop near the southern end of the Goshute Mountains in northeastern Nevada (40°25.46′N, 114°16.26′W; Fig. 1). Annual autumn migration counts, begun in 1983, currently range from about 16 000–25 000 migrants of up to 18 species (Sherrington 1999). From one to six banding stations were operated each year since 1980 ($\bar{x}$ elevation = 2695 m). Annual capture totals average about 2100 raptors of up to 13 species.

Table 1. Banding totals and encounters with previously banded birds through spring 2001 by species and migration site. "Foreign encounters" indicate birds observed elsewhere after banding; "foreign recaptures" indicate birds recaptured after being banded elsewhere; and "recaptures" indicate birds banded and recaptured at the same migration site.

| SPECIES	NEVADA (SINCE 1980)				NEW MEXICO (SINCE 1990)				OREGON (SINCE 1995)		
	CAP-TURED	FOR-EIGN ENCOUN-TERS	FOR-EIGN RECAP-TURES	RECAP-TURES	CAP-TURED	FOR-EIGN ENCOUN-TERS	FOR-EIGN RECAP-TURES	RECAP-TURES	CAP-TURED	FOR-EIGN ENCOUN-TERS	FOR-EIGN RECAP-TURES
Sharp-shinned Hawk	24 698	87	8	32	6229	19	0	13	643	5	2
Cooper's Hawk	12 050	101	6	32	5964	21	4	64	173	2	0
Northern Goshawk	615	9	3	2	80	1	1	1	27	0	0
Red-tailed Hawk	1201	29	2	0	714	9	0	0	186	5	0
American Kestrel	2797	9	5	0	524	3	0	0	1	0	0
Total	41 361	235	24	66	13 511	53	5	78	1030	12	2
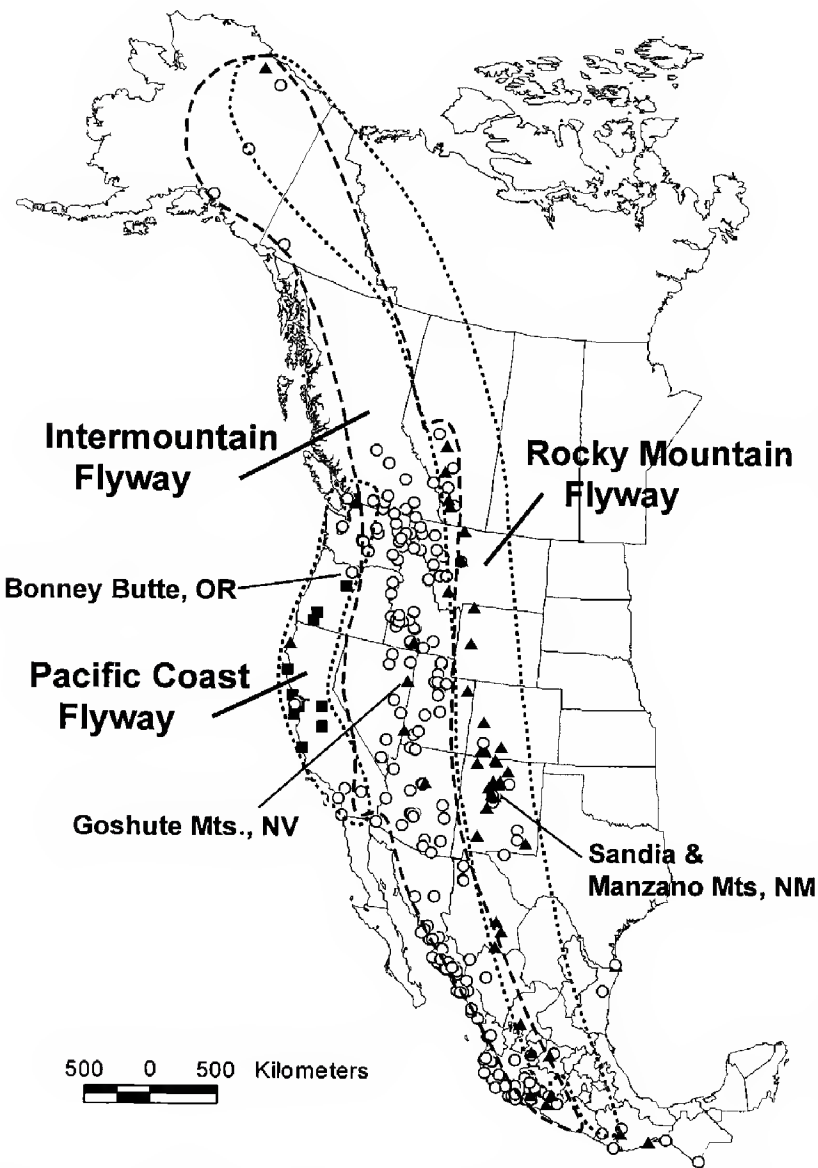
Figure 1. Distribution of foreign encounters and foreign-recapture banding locations associated with raptor migration-banding sites in New Mexico (triangles), Nevada (circles), and Oregon (squares), and the associated regional flyways in western North America.

The Manzano banding site (DeLong and Hoffman 1999) is located on a ridgetop in the Manzano Mountains of central New Mexico (34°42.25′N, 106°24.67′W; Fig. 1). Annual autumn migration counts, begun in 1985, range from about 4500–6000 migrants of up to 19 species (Sherrington 1999). From one to four banding stations were operated each year since 1990 ($\bar{x}$ elevation = 2730 m). Annual capture totals average about 1000 raptors of up to 12 species.

The Sandia banding site is located on a ridgetop near the southern end of the Sandia Mountains (41-km long, north-south range) ca. 34 km north of the Manzano site and 18 km east of Albuquerque, New Mexico (35°05.21′N, 106°25.93′W; Fig. 1). The vegetation around the site is similar to that described for the Manzano site in DeLong and Hoffman (1999), typical of the Upper Sonoran life zone. Annual spring migration counts, begun in 1985, range from about 3700–5500 migrants of up to 20 species (Sherrington 2000). Banding has occurred each year since 1990, except in 1992, mostly at a single station (elevation = 2235 m). Annual capture totals average about 265 raptors of up to 12 species.

The Bonney Butte banding site is located in the eastern Cascade Mountains of north-central Oregon (45°16.08′N, 121°59.72′W; Fig. 1). Bonney Butte is a mostly bald knoll (summit elevation = 1754 m) at the southern terminus of Surveyor's Ridge, which originates near the town of Hood River and terminates southeast of Mt. Hood. With the exception of scattered montane meadows and forest clearcuts, mixed conifer forest covers the immediate area surrounding Bonney Butte. Autumn migration counts, begun in 1994, range from about 2200–2800 migrants of up to 18 species (McDermott 1999). Banding has occurred each year since 1995 at a single station at the north end of Bonney Butte. Annual capture totals currently range from about 150–350 raptors of up to 12 species.

Capture and Processing Methods. Migrant raptors were captured between March and April in the Sandia Mountains and between mid-August and early November at the autumn sites. The number of stations and variety of cap-

ture devices used at each site differed, but the basic capture and processing methods used were consistent across all sites. Trappers attracted raptors using live, non-native, avian lures manipulated from camouflaged blinds. Capture devices included bow nets, dho-gaza nets, and mist nets (Bloom 1987). Unless already banded, all birds were fitted with a uniquely-numbered, U.S. Fish and Wildlife Service/U.S. Geological Survey aluminum leg band. Processors identified species, subspecies, sexes, and ages using morphological characteristics described in the U.S. Bird Banding Laboratory (BBL) manual, Wheeler and Clark (1995), and Hoffman et al. (1990).

Data Classification. We considered three types of encounters with banded birds. "Foreign encounters" included birds originally banded as migrants at one of the four banding sites that were subsequently encountered elsewhere. "Foreign recaptures" included birds originally banded by other researchers that we later recaptured as migrants. For analytical purposes, we pooled foreign-encounter locations and foreign-recapture banding locations associated with each migration site. "Recaptures" included individuals banded and later recaptured at the same migration site.

Between 1990 and April 2001, 34 between-site recaptures of banded birds occurred at the Manzano and Sandia sites, which is similar to the number of same-site recaptures that occurred at the two sites during this period (44). We consider this strong confirmation that the two sites lay within the same flyway, which we expected given their proximity and situation along a north–south line of relatively isolated mountain ranges. Hence, we treated data from the two New Mexico sites as representing a single migration site.

We classified foreign encounters/recaptures by season based on dates that foreign encounters occurred or foreign recaptures were originally banded: (1) summer, 15 May–19 August; (2) winter, 15 November–14 March; and (3) migration, 15 March–14 May or 20 August–14 November. We chose these dates based on knowledge of primary passage periods for migrants observed during standardized western counts (HWI unpubl. data). After we classified cases strictly by the reported BBL encounter date, it quickly became apparent that some assignments were not reasonable. Twenty-five cases warranted a change from migration to winter status because the foreign encounter location was in the southern portion of the species' wintering range (i.e., Nayarit, Mexico and farther south). Two cases warranted a change from summer to spring-migration status because the location was in Mexico where breeding was improbable.

Data Analysis. We analyzed the encounter data in two ways to determine if the three migration sites could be classified as located along different flyways. First, we used discriminant function and classification analysis (Afifi and Clark 1996) to determine whether foreign encounters/recaptures could be classified according to migration site based on the latitude and longitude (lat–long) of the encounters (Nichols and Kaiser 1999). For this analysis, we withheld one foreign encounter from Massachusetts, because inclusion of this extreme outlier skewed the bivariate distribution of lat-longs. Discriminant function analysis resulted in a two-way table of predicted versus actual migration-site associations. Second,

Table 2. A comparison of actual and predicted migration-site associations based on a discriminant function analysis using latitudes and longitudes of foreign encounters and original banding locations of foreign recaptures.

ACTUAL	PREDICTED			
	OREGON	NEVADA	NEW MEXICO	PERCENT CORRECT
Oregon	13	1	0	93
Nevada	10	202	41	80
New Mexico	1	6	50	88
Total	24	209	91	82

we compared the number of intra- and inter-site recaptures across the three migration sites.

To examine differential migration distances, we conducted one-way or two-way factorial analysis of variance (ANOVA) on the winter latitudes of different sex–age classes of Sharp-shinned, Cooper's, and Red-tailed Hawks associated with the Nevada site. Smaller sample sizes precluded such analyses for other sites and species. We also compared sex ratios at banding and among foreign encounters using G-tests of independence with William's correction (Sokal and Rohlf 1981:737–738). We conducted all statistical analyses using Systat (SPSS 1998).

RESULTS

Flyway Delineation. The discriminant function correctly classified 77% of the Nevada birds, 82% of the New Mexico birds, and 93% of the Oregon birds (Wilks's lambda = 0.65, $F_{4,646}$ = 39.51, $P <$ 0.001). However, when we eliminated from the analysis several foreign encounters/recaptures from Alaska and the Yukon Territory (Fig. 1), which improved the bivariate normality of the lat-long dataset, our classification efficiency improved to 80% of the Nevada birds, 88% of the New Mexico birds, and 93% of the Oregon birds (Wilks's lambda = 0.53, $F_{4,640}$ = 59.04, $P <$ 0.001; Table 2).

Recapture data (Table 1) also confirmed that the probability of a same-site recapture (66 Nevada recaptures, 78 New Mexico recaptures, no Oregon recaptures) was much greater than the probability of a flyway crossover (only one Manzano–Goshute crossover encounter since 1990).

Sharp-shinned Hawk. Females comprised 82% of the foreign encounters, which is significantly higher than the proportion of females banded at the three migration sites through 2000 (51%; G_{adj} = 46.5, $P <$ 0.001).

A two-way incomplete factorial ANOVA with SEX and AGE as the main effects and winter-location latitudes of Nevada migrants as the dependent var-

Table 3.   Mean latitude of winter foreign encounters by sex and age for selected species banded in the Goshute Mountains, Nevada. Except for Sharp-shinned Hawks, means were not significantly different based on analysis of variance.

SPECIES	SEX	HATCH-YEAR MEAN ± SE	(N)	SECOND-YEAR MEAN ± SE	(N)	AFTER-SECOND-YEAR MEAN ± SE	(N)
Sharp-shinned Hawk	Female	22.61 ± 1.87	(8)	26.11 ± 1.60	(11)	23.64 ± 1.87	(8)
	Male	—		16.33	(1)	39.67 ± 3.74	(2)
Cooper's Hawk	Female	22.28 ± 2.63	(6)	21.56 ± 2.43	(7)	24.21 ± 1.29	(25)
	Male	22.54 ± 3.72	(3)	23.58 ± 3.72	(3)	26.52 ± 2.43	(7)
American Kestrel	Female	18.33 ± 1.33	(2)	18.53 ± 0.07	(2)	19.03	(1)
	Male	19.83	(1)	—		—	
Red-tailed Hawk	Unknown	30.40 ± 3.39	(5)	30.65 ± 3.79	(4)	31.77 ± 2.68	(8)

Figure 2.   Distribution of foreign encounters and foreign-recapture banding locations for Sharp-shinned Hawks associated with migration-banding sites in New Mexico (triangles), Nevada (circles), and Oregon (squares) during summer (solid fill), winter (filled with a dot), and migration seasons (no fill).

iable revealed a significant overall model ($F_{4,25}$ = 5.43, P = 0.003); however, close examination of group means revealed a complex pattern (Table 3). Planned post-hoc contrasts indicated significant differences ($P < 0.05$) for second-year (SY) versus after-second-year (ASY) males (higher latitudes for ASY birds) and for ASY males versus ASY females (higher latitudes for males). However, due to small sample sizes for males, these results must be considered tentative. There were no significant age-related differences for females. Moreover, although HY females averaged the most southerly winter latitudes, SY females averaged more northerly latitudes than ASY females. Similarly, although two ASY males averaged more northerly latitudes than ASY females, the opposite appeared true for SY birds. Thus, our results are equivocal concerning sex-related differences within age groups, but suggest that older birds generally winter farther north than younger birds, with the difference perhaps less pronounced for females than for males.

Two summer locations of New Mexico migrants were in northeastern Utah and west-central Wyoming (Fig. 2). Six other encounters during late spring migration (late April–mid-May), which may represent summer locations, extended along the eastern Rocky Mountains from western Colorado to western Alberta. Summer locations of Nevada migrants were in the Intermountain West and northwestern Rocky Mountains from northern Utah to central and eastern British Columbia and western Alberta (N = 12). However, two autumn locations were in central Alaska, indicating that the breeding-ground origins of Nevada migrants extend at least that far north. No summer records were available for Oregon migrants.

Table 4. Disposition of foreign encounters by species.

DISPOSITION	SPECIES				
	SHARP-SHINNED HAWK	COOPER'S HAWK	NORTHERN GOSHAWK	RED-TAILED HAWK	AMERICAN KESTREL
Captured and released	6	6	2	2	3
Collision w/ human structure	33	11	2	6	0
Shot	25	47	0	4	3
Held in captivity	2	2	1	1	2
Injured or sick	3	9	0	7	0
Poisoned	1	2	0	1	0
Cat/dog kill	1	0	0	0	1
Electrocuted	0	0	0	1	0
Caught in coyote leg-hold trap	0	0	0	1	0
Starved	1	0	0	0	0
Found dead—cause unknown	33	43	5	17	2
No reported reason	7	3	0	3	1
Total	112	123	10	43	12

Three winter locations of New Mexico migrants were in southwestern Mexico, but another was on the northern California coast (Fig. 2). Nevada migrants wintered primarily from the southwestern U.S. to Oaxaca, with concentrations in Sinaloa and Michoacán ($N = 30$). The only true winter locations of Oregon migrants were in southern Oregon ($N = 2$); however, three migration locations were in northern California.

Migration locations of New Mexico migrants were along the eastern Rocky Mountains from Alberta to Chihuahua ($N = 13$; Fig. 2). Most migration locations of Nevada migrants extended from central Alaska, through the Intermountain West and Great Basin, and down the Sierra Madre Occidental into southwestern Mexico ($N = 51$). However, one SY female was recovered during September near San Francisco, California, and one adult male was captured and released during October after it landed on a ship from Guyana somewhere at sea. Since 1995, our Goshute project and Idaho Bird Observatory's (IBO) Boise Ridge migration-banding project (340 km north-northwest of the Goshutes) have recorded seven between-site encounters. Migration locations of Oregon migrants ($N = 5$) were in northern California (3) and the eastern Cascades of Oregon and Washington.

The most common reason for summer and migration foreign encounters was injury or mortality due to collisions with human structures such as windows, buildings, and cars (56% of summer encounters, 38% of migration encounters, 30% over-

all; Table 4). In contrast, the most common cause of winter encounters was shooting (43%), with 96% of all reported shootings in Mexico.

Cooper's Hawk. Females comprised 71% of the foreign encounters, which was significantly higher than the proportion of females banded at the three migration sites through 2000 (56%; $G_{adj} = 10.6$, $P < 0.005$).

There were no significant differences in the mean winter latitudes of different sex–age classes of Nevada migrants (two-way factorial ANOVA: Sex—$F_{1,45} = 0.44$, $P = 0.51$; Age—$F_{2,45} = 0.94$, $P = 0.40$; Interaction—$F_{2,45} = 0.08$, $P = 0.93$). However, the mean winter latitudes of males were slightly farther north than for females of the same age group, and within sexes, mean winter latitudes increased with age except for HY versus SY females (Table 3).

Most summer locations of New Mexico migrants were in the southern Rocky Mountains of New Mexico and Colorado ($N = 10$; Fig. 3). However, one summer location was in southwestern Alberta and another individual, banded as a HY bird in the Manzano Mountains, was reportedly found dead five years later during summer in Massachusetts (extreme outlier; maybe transcription error?). The summer locations of Nevada migrants were concentrated in the Intermountain West from Nevada to western Alberta ($N = 8$). No summer records were available for Oregon migrants.

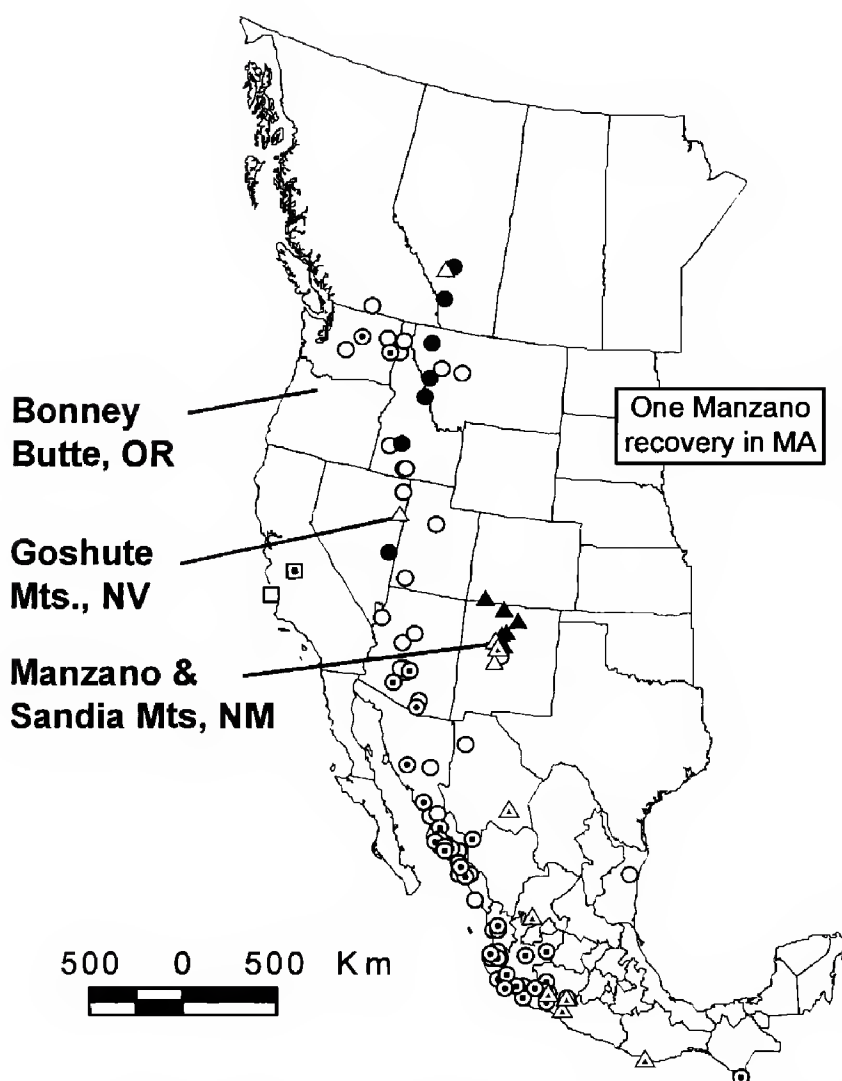Winter locations of New Mexico migrants extended from central New Mexico south through

Figure 3. Distribution of foreign encounters and foreign-recapture banding locations for Cooper's Hawks associated with migration-banding sites in New Mexico (triangles), Nevada (circles), and Oregon (squares) during summer (solid fill), winter (filled with a dot), and migration seasons (no fill).

Chihuahua and San Luis Potosí, remaining east of the Sierra Madre Occidental, and along the southwestern coast of Mexico from Michoacán to Oaxaca ($N = 9$; Fig. 3). Most winter locations of Nevada migrants extended from Arizona south along primarily the western flanks of the Sierra Madre Occidental and into the Pacific coastal states of Mexico from Sinaloa to the Guatemala border, with concentrations in Sinaloa and Michoacán ($N = 49$). However, two other Nevada migrants were recovered as adults during January in central and eastern Washington after cars hit them. One Oregon migrant was recovered during winter in the southern Central Valley of California near Fresno.

Three migration locations of New Mexico migrants were in south-central New Mexico, but another was recaptured in the Goshute Mountains (Fig. 3). Migration locations of Nevada migrants extended from central British Columbia through the Great Basin and western Arizona, and south into the Pacific coastal states of Mexico ($N = 46$). This includes four between-site encounters of birds banded in the Goshutes and at IBO's Boise Ridge site. One migration location of an Oregon migrant was along the south coast of California.

Most summer foreign encounters (81%) were birds found dead—cause unknown (35% of all encounters; Table 4). Most winter encounters (56%) were due to shooting (38% overall). During migration, common reasons for encounters included shooting (27%) and collisions with fences and windows (11%).

Northern Goshawk. Females comprised 60% of the foreign encounters, which is only slightly higher than the proportion of females banded at the three migration sites through 2000 (50%; $G_{adj} = 0.3, P > 0.50$).

A single New Mexico autumn foreign recapture was banded as a nestling the previous spring in the Jemez Mountains, ca. 105 km northwest of the Manzano site (Fig. 4). A single New Mexico foreign encounter (found dead—cause unknown) occurred 28 km north of the Manzano site the spring after banding as a HY bird. A single New Mexico recapture occurred seven years after banding as a HY bird in the Manzano Mountains. Ten of 12 goshawk foreign encounters/recaptures associated with the Nevada migration site were clustered in the Great Basin or adjacent portions of the northwestern Rocky Mountains in Utah, Nevada, Idaho, and Oregon, most within 300 km of the project site. These include five between-site encounters involving our Goshute site and a long-term nesting study in the Independence Mountains of Nevada (209 km northwest of the Goshutes; M. Bechard pers. comm.). The latter included three birds banded as nestlings and later recaptured in the Goshutes the same year, and two birds banded in the Goshutes (one HY and one SY) that were later resighted as breeding adults (both as 3-yr birds). The two exceptions to the Great Basin/northern Rockies foreign-encounter locations were birds recovered during summer in the Gila Mountains of southeastern Arizona (found dead—cause unknown) and during spring in central Alberta (released after striking unknown object). Three of the remaining five Nevada birds recovered in the Great Basin were found dead—cause unknown; another died when it hit a barbed wire fence; and the last was simply reported as in captivity (Table 4).

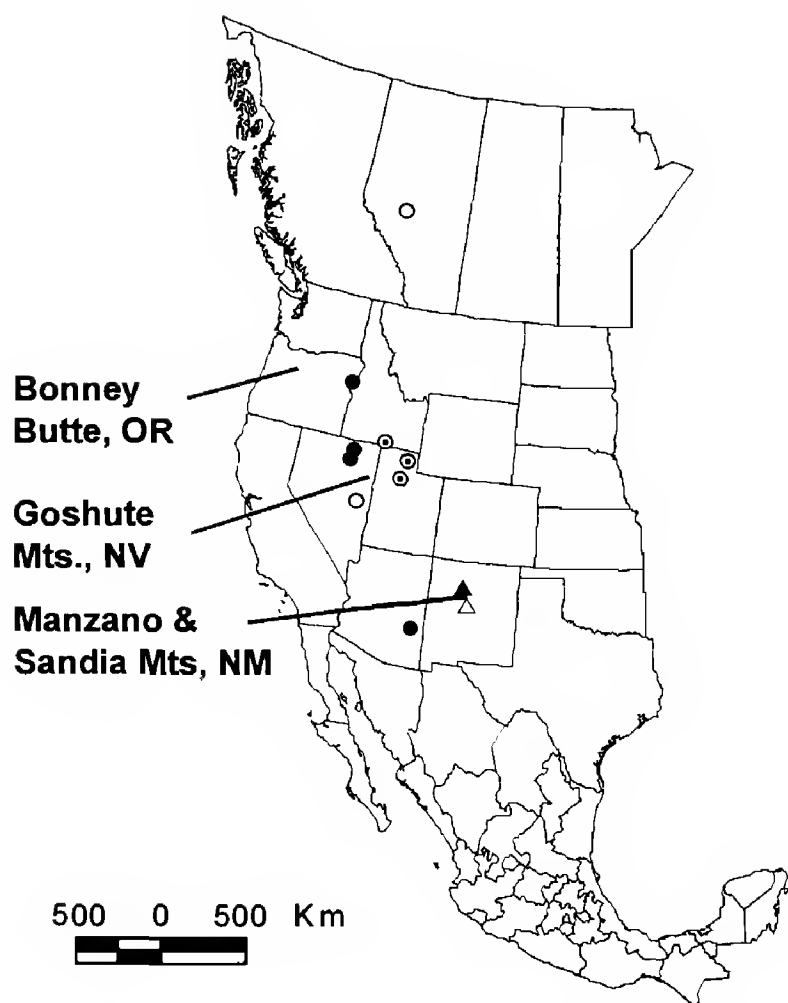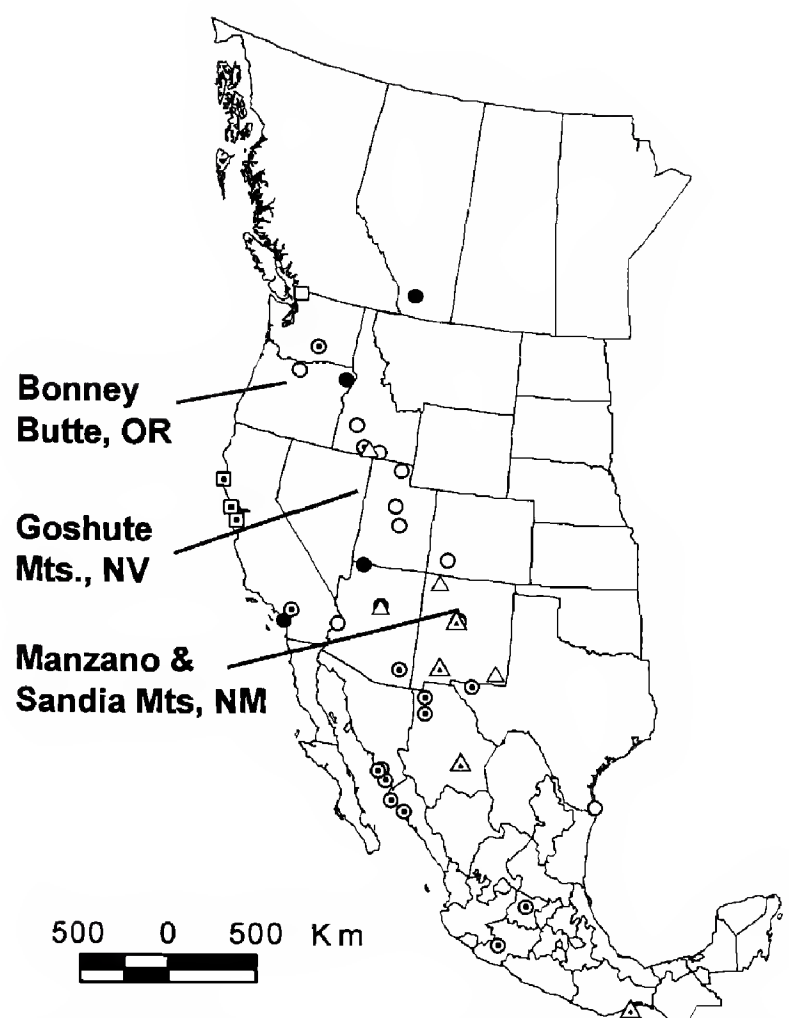**Red-tailed Hawk.** There were no significant age-

Figure 4. Distribution of foreign encounters and foreign-recapture banding locations for Northern Goshawks associated with migration-banding sites in New Mexico (triangles), Nevada (circles), and Oregon (squares) during summer (solid fill), winter (filled with a dot), and migration seasons (no fill).

Figure 5. Distribution of foreign encounters and foreign-recapture banding locations for Red-tailed Hawks associated with migration-banding sites in New Mexico (triangles), Nevada (circles), and Oregon (squares) during summer (solid fill), winter (filled with a dot), and migration seasons (no fill).

related differences in the mean winter latitudes of Nevada migrants (ANOVA: $F_{2,14} = 0.06$, $P = 0.942$); however, the means showed a consistent pattern of increasing latitude with increasing age (Table 3).

No summer locations were available for New Mexico or Oregon migrants. Two foreign recaptures in Nevada were originally banded as nestlings in the Wallowa Mountains of northeastern Oregon and in the coastal foothills of southern California (Fig. 5). Two other summer locations of Nevada migrants were in southwestern Alberta and near the Utah–Arizona border. Based on satellite tracking, three other Nevada migrants summered in central British Columbia, northwestern Montana, and southeastern Idaho (HWI unpubl. data).

Winter encounters of New Mexico migrants were in central New Mexico, Chihuahua, and Oaxaca ($N = 4$; Fig. 5). Based on satellite tracking, six other New Mexico migrants wintered from northern Sinaloa and western Tamaulipas south through southern Oaxaca and east-central Veracruz (HWI

unpubl. data). Winter encounters of Nevada migrants extended from south-central Washington to Guanajuato and Michoacán, including one in southern California and one near the southern tip of Texas ($N = 17$). Based on satellite tracking, five other Nevada migrants wintered from Baja California and northwestern Chihuahua south to the Nayarit/Jalisco area (HWI unpubl. data). Four winter locations of Oregon migrants were near the coast of northern California.

Migration locations of New Mexico migrants were in northern New Mexico, Arizona, and southern Idaho ($N = 5$; Fig. 5). Migration locations of Nevada migrants extended from the northeastern Cascade Mountains of Oregon, through the western Rocky Mountains of Idaho and Utah, into southwestern Arizona, and as far as coastal Texas ($N = 9$). One migration location of an Oregon migrant was in southwestern British Columbia.

No specific causes of mortality were reported for three Red-tailed Hawks found during summer.

Common reasons for winter encounters included shooting (12%), collisions with cars and human structures (12%), and other unspecified injury or illness (12%; Table 4). Common reasons for migration encounters included unspecified injury or illness (29%) and collisions with human structures (14%).

American Kestrel. Females comprised 92% of the foreign encounters, which is significantly higher than the proportion of females banded at the three migration sites through 2000 (48%; G_{adj} = 10.7, $P < 0.005$).

The sample of winter locations for kestrels was too small to warrant statistical analysis of differential migration distances; however, like for Red-tailed and Cooper's Hawks, consistent patterns emerged. The winter latitudes of females increased with age and the winter latitude of the single male encounter was farther north than for any female (Table 3).

One New Mexico migrant was found dead (cause unknown) during summer in central Alberta (Fig. 6). All summer locations of Nevada migrants reflect encounters with breeding adults (N = 3) or nestlings (N = 5) in artificial nest boxes. Six were birds from two nest-box studies near Boise and Fairfield, Idaho. The other two were banded as nestlings in north-central Washington and the southwestern Yukon Territory.

Winter locations of Nevada (N = 6) and New Mexico (N = 2) migrants were in similar areas in Jalisco, Michoacán, and Oaxaca (Fig. 6). Common reasons for these encounters included shooting (37.5%), died in captivity (25%), and killed by a dog (12.5%; Table 4).

DISCUSSION

Flyway Delineation. Results from the flyway-classification analyses suggest that raptors monitored at the three migration sites travel within three definable, regional flyways: Rocky Mountain, Intermountain, and Pacific Coast (Fig. 1). Only two birds banded in Nevada or New Mexico were recovered west of the Sierra Nevada–Cascade ranges in Oregon or California (Fig. 1). Data from IBO's Boise Ridge site also indicate infrequent crossing of the Sierra Nevada–Cascade boundary (2 of 30 [6%] encounters since 1995; G. Kaltenecker unpubl. data). However, the distribution of encounters with Oregon and Nevada migrants overlapped in Washington and southern British Columbia, and south of the Sierra Nevada range in southern Cal-
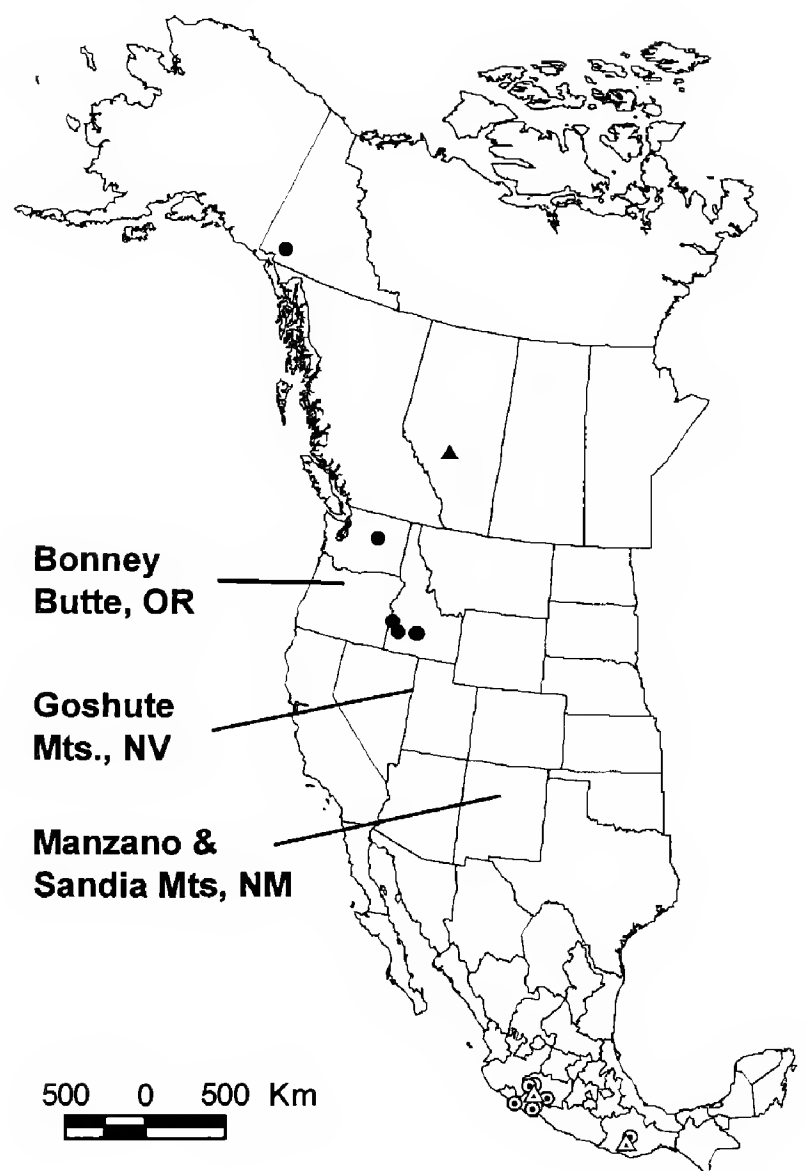

Figure 6. Distribution of foreign encounters and foreign-recapture banding locations for American Kestrels associated with migration-banding sites in New Mexico (triangles) and Nevada (circles) during summer (solid fill) and winter (filled with a dot).

ifornia and northwestern Mexico. Our encounter sample sizes for Oregon migrants were small; therefore, the minimal overlap in the distributions of Oregon and Nevada/New Mexico migrants may be misleading. However, the limited Oregon data are consistent with long-term, band-return data from coastal California, which indicate distribution west of the Cascade and Sierra Nevada ranges from southwestern British Columbia to northern Baja California (Scheuermann 1996, 1997, Acuff 1998, 1999).

The largest geographic overlap (15%) in encounter locations occurred among migrants using the Rocky Mountain and Intermountain flyways. Nevertheless, Intermountain migrants were usually encountered west of the Rocky Mountains and Sierra Madre Occidental, whereas Rocky Mountain migrants were usually found within or east of these ranges. The zones of greatest overlap were on sum-

mer ranges in southwestern Alberta and on win-
tering ranges in the coastal states of southwestern
Mexico. Thirty foreign encounters of birds banded
at IBO's Boise Ridge site also were all west of the
Rocky Mountains (G. Kaltenecker unpubl. data).

The recapture analyses also suggested high fi-
delity to the Intermountain and Rocky Mountain
flyways. The single recapture of a Manzano-banded
bird in Nevada, as well as several other outlier en-
counters, show that Intermountain–Rocky Moun-
tain flyway crossovers do occur, but such events
were rare compared to the frequency of within-fly-
way recaptures and foreign encounters.

Thus, both the Sierra Nevada–Cascade and
Rocky Mountain ranges could be considered bio-
geographic boundaries, albeit permeable, that gen-
erally separate individuals inhabiting the three
western flyways. This also means that, for most spe-
cies, migration counts in the three regions repre-
sent largely distinct subpopulations. However, sig-
nificant overlap occurred at the southern and
northern extents of the encounter distributions for
each flyway. Moreover, limited encounter data
from two long-term banding sites in mainland Alas-
ka (mostly Sharp-shinned Hawks) suggest that au-
tumn migrants originating in the state ultimately
may travel along any one of the three flyways de-
scribed herein, with most such birds wintering in
the northwestern U.S. (T. Swem and C. McIntyre
pers. comm.). Similarly, for those species that mi-
grate into Central and South America (e.g., Pere-
grine Falcons, *F. peregrinus* or Swainson's Hawks, *B.
swainsoni*) all flyways essentially merge in southern
Mexico near the Isthmus of Tehuantepec (Bilds-
tein and Zalles 2001). Thus, the delineation of re-
gional flyways in western North America is proba-
bly most relevant for distinguishing subpopulations
of birds that originate south of mainland Alaska
and that winter north of Central America. Further-
more, while migration counts along the three fly-
ways may generally reflect the dynamics of distinct
subpopulations responding to unique sets of envi-
ronmental factors, large landscape-scale events in
southern Mexico or the far northwest may influ-
ence counts along multiple flyways.

Our description of regional flyways is based pri-
marily on data for Sharp-shinned and Cooper's
Hawks, which together comprised 77% of the for-
eign encounters/recaptures and 91% of the recap-
tures considered. Nevertheless, the results for our
other three study species indicated conformity to
the patterns shown for the two accipiters; there-

fore, we believe the flyway descriptions we propose
also apply to other species.

Sharp-shinned Hawk. The range of summer and
winter latitudes of Rocky Mountain and Inter-
mountain Sharp-shinned Hawks were most similar
to those of migrants encountered at other inland
as opposed to coastal migration sites. Rocky Moun-
tain and Intermountain migrants summered as far
north as Alaska and wintered primarily along the
west coast of Mexico. Migrants from the western
Great Lakes region also frequently wintered in
southern Mexico (Evans and Rosenfield 1985, Car-
penter et al. 1990). Thus, prominent factors op-
erating in southern Mexico (e.g., large-scale habi-
tat changes or heavy shooting pressure) could
conceivably affect breeding Sharp-shinned Hawks
from across much of interior North America.

Oregon migrants showed similar latitudinal
ranges as birds from other coastal states. For ex-
ample, migrants from the Marin Headlands of Cal-
ifornia typically traveled relatively short distances
from breeding areas in the Pacific Northwest to
wintering areas in Oregon and California
(Scheuermann 1996, 1997, Acuff 1998, 1999). Sim-
ilarly, Atlantic Coast (Clark 1985) and eastern
Great Lakes (Duncan 1982, Holt 1991) migrants
tended to winter in the southeastern U.S.

Cooper's Hawk. Rocky Mountain and Inter-
mountain migrants wintered in concentrations
along the Pacific Coast from Sinaloa to Jalisco.
Breeding birds from eastern Oregon showed a sim-
ilar winter range (Henny 1990), whereas migrants
banded in coastal California generally remained
north of Baja California (Scheuermann 1997) and
migrants from the eastern Great Lakes tended to
remain in the southern Midwest and southeastern
U.S. (Duncan 1981, Holt 1991). Thus, Rocky
Mountain and Intermountain Cooper's Hawks like-
ly respond to different environmental factors than
Pacific Coast or eastern birds. For example, shoot-
ing was a commonly reported cause of winter en-
counters in our study and that of Henny (1990),
whereas Scheuermann (1996, 1997), Acuff (1998,
1999), and Holt (1991) rarely reported shooting as
a cause of mortality.

Northern Goshawk. The few foreign encounters
we documented corroborate the notion that gos-
hawk movements typically are restricted to dispers-
al and short-distance migration (Squires and Reyn-
olds 1997). This suggests that migration counts of
Northern Goshawks generally reflect relatively lo-
calized movements (i.e., 400–500 km or less) and

that counts of HY birds may therefore serve as an indicator of regional productivity. This possibility must be tempered, however, with recognition that about every 10 years, goshawks from the northern part of the species' range migrate *en masse* much farther south than usual due to crashes of available prey (Mueller et al. 1977). In fact, our most distant foreign encounter (1200 km from the banding site near Shining Bank, Alberta) involved a Nevada migrant banded as an adult during the 1983 irruption episode.

American Kestrel. Rocky Mountain and Intermountain migrants summered as far north as the Yukon Territory and wintered primarily in far southwestern Mexico. Similar winter ranges were documented for birds banded in the Sierra Nevada range and farther east (Bloom 1985) and for breeding birds from Idaho and eastern Oregon and Washington (Henny and Brady 1994). In contrast, 90% of foreign encounters with birds banded in coastal California were located within 16 km of the original banding location, regardless of season (Bloom 1985). These patterns lend additional support for the hypothesis that the Sierra Nevada and Cascade ranges constitute a biogeographic boundary between the relatively constrained Pacific Coast Flyway and extensive interior flyways.

Similar to Cooper's Hawks, Rocky Mountain and Intermountain kestrels wintered substantially farther south than conspecifics migrating through the eastern Great Lakes (Duncan 1985) and along the Atlantic Coast (Layne 1982). Thus, American Kestrels from the western and eastern halves of the continent likely respond to different sets of environmental pressures.

Red-tailed Hawk. Attempts to partition populations into Rocky Mountain, Intermountain, and Pacific Coast migrants were the most problematic for this species. The summer and winter ranges and migration/dispersal routes of migrants from New Mexico, Nevada, and Oregon often overlapped. For example, Nevada migrants wintered in central New Mexico and along the Texas coast, while New Mexico migrants were later encountered in northern Nevada. Bloom (1985) also documented several cases of extensive juvenile dispersal to the north and east from southern California. Similarly, nestlings banded in southern Idaho dispersed in many directions, including toward southern California, northeastern Idaho, southeastern New Mexico, and southern Guatemala (Steenhof et al. 1984). Nevertheless, satellite tracking has shown

that 12 Red-tailed Hawks (one HY, 11 SY or older) outfitted during autumn migration in New Mexico and Nevada all followed southerly routes to wintering grounds in Mexico (HWI unpubl. data). Moreover, three adult birds outfitted in Nevada showed high fidelity to individual migration pathways, winter locations, and summer territories in British Columbia, Montana, and Idaho over a 2.5-yr period. Thus, it appears that Red-tailed Hawks banded in the Rocky Mountains and Intermountain West tend to migrate/disperse south in autumn, but specific bearings and distances may vary, especially with regard to the first-year dispersal of juvenile birds. Similarly, although Bloom (1985) showed that juvenile dispersal from southern California could be extensive, Red-tailed Hawks banded during autumn migration along the central coast of California may subsequently move in almost any direction but tend to remain along the Pacific Coast (Scheuermann 1996, 1997, Acuff 1998, 1999).

Similar to Cooper's Hawks and kestrels, Rocky Mountain and Intermountain Red-tailed Hawks tended to winter farther south and show little longitudinal overlap with migrants from the Great Plains and farther east (Houston 1967, Holt and Frock 1980, Brinker and Erdman 1985).

Sex-biased Encounter Probabilities. For four sexually-dimorphic species, foreign encounters of females occurred more often than expected given sex ratios at banding. The same pattern applied to migrant Sharp-shinned and Cooper's Hawks from the Great Lakes (Duncan 1981, 1982, Evans and Rosenfield 1985, Holt 1991) and to Sharp-shinned Hawks along the Atlantic Coast (Clark 1985). Clark (1985) and Duncan (1982) suggested that this pattern results from competitively dominant females occupying more open habitats than males during winter, a pattern documented for Eurasian Sparrowhawks (*A. nisus*; Newton 1979). These tendencies may cause females to encounter human-related trouble more often and increase the probability that humans will discover dead or injured females. This scenario may apply to kestrels also (Ardia and Bildstein 1997).

Differential Migration Distance. Small sample sizes limited our ability to detect significant differential migration. Nevertheless, winter latitude tended to increase with age for four species, and male Cooper's Hawks and American Kestrels tended to winter farther north than females of the same age. Moreover, the winter distribution pattern for

Cooper's Hawks appeared consistent with the pattern of differential timing documented by DeLong and Hoffman (1999) for Manzano and Goshute migrants (i.e., autumn passage sequence: juvenile females, juvenile males, adult females, and adult males). Thus, our results appear most consistent with predictions of the foraging-efficiency (Rosenfield and Evans 1980) and arrival-time (Myers 1981) hypotheses, but not consistent with predictions of the body-size hypothesis (Ketterson and Nolan 1976). The apparent inconsistency in results for SY versus ASY female Sharp-shinned Hawks may reflect the fact that, compared to Cooper's and Red-tailed Hawks, sharp-shins often begin breeding in their second year (Johnsgard 1990). Thus, this apparent anomaly may favor the arrival-time hypothesis over the foraging-efficiency hypothesis for this species. Relative to the behavioral or social-dominance hypothesis (Gauthreaux 1978, 1985, Newton 1979, Clark 1985), our results appear equivocal. They are consistent with the age-related prediction of the hypothesis (dominant adults winter closer than immature birds of the same sex), but not the sex-related prediction (larger, dominant females should winter closer to the breeding grounds than smaller males of the same age).

Potential Biases. There are several potential biases associated with describing raptor movements based on band encounters. One potential bias may derive from species, sex, or age-related variation in susceptibility of migrants to be captured using live lures (Gorney et al. 1999). Another concerns the higher probability of recovering females; however, if females indeed tend to migrate farther south than males, this factor would not bias delineations of overall flyway dimensions. A third may derive from the positive correlation between the probability of recovery and the density of human habitation (Nichols and Kaiser 1999), which the dearth of summer recoveries, especially north of southern Canada, clearly illustrates (Fig. 1). Thus, we look forward to advances in methodology such as satellite telemetry (Brodeur et al. 1996) and stable-isotope analysis (Meehan et al. 2001), which should further improve our understanding of raptor movements in the western hemisphere and elsewhere.

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CIRCUITOUS AUTUMN MIGRATION IN THE SHORT-TOED EAGLE (*CIRCAETUS GALLICUS*)

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Abstract.—The Short-toed Eagle (*Circaetus gallicus*) uses mainly soaring flight during migration and avoids long water crossings between Italy and Africa by crossing at the Strait of Gibraltar. Observations were made 15–26 September 2000 at four sites in the central Mediterranean area: Arenzano (Ligurian Apennines, northwest Italy), Circeo promontory (central Italy), Marettimo (southern Italy) and Malta. In addition, 68 hr of observations were made 18–24 September 1998, 1999, and 2000 over the Apuane Alps along the western slope of central Italy. At Arenzano, 476 Short-toed Eagles were counted (5.4/hr) consisting of 368 adults, 6 immatures, and 102 juveniles, with an overlap in the migration periods of age classes. The Short-toed Eagles migrated in flocks averaging 4.3 ± 0.9 (SE) birds. Over the Apuane Alps, 289 Short-toed Eagles, all migrating northwest, were counted (4.3/hr). Few birds were seen at the other three sites, with a maximum of eight individuals recorded at Marettimo. These results confirm the circuitous autumn migration around the Mediterranean of Short-toed Eagles breeding in central Italy and suggest that at least some juveniles learn this route by following the adults.

Key Words: *Short-toed Eagle; Circaetus gallicus; migration; orientation; flocking; navigation.*

Circuito de migracion de otoño de *Circaetus gallicus*

Resumen.—*Circaetus gallicus* usa principalmente el vuelo de planeo durante la migración y evita los largos cruces sobre el agua entre Italia y África cruzando por el estrecho de Gibraltar. Se hicieron observaciones entre 15–26 de septiembre de 2000 en cuatro sitios en el área mediterránea central: Arenzano (Apeninos Ligurianos, noroeste de Italia), promontorio de Circeo (Italia central), Marettimo (sur de Italia) y Malta. Además, 68 horas de observaciones fueron entre 18–24 de septiembre de 1998, 1999, y 2000 sobre los Alpes de Apuane a lo largo de la vertiente oeste de Italia central. En Arenzano, 476 águilas de pies cortos fueron contadas (5.4/hr) incluyendo 368 adultos, 6 inmaduros, y 102 juveniles, con un traslape en los periodos de migración en las clases de edades. Las águilas de pies cortos migran en bandadas que promedian 4.3 ± 0.9 (SE) aves. Sobre los Alpes de Apuane, fueron contadas 289 *Circaetus gallicus* (4.3/hr), todas emigrantes del noroeste. Pocas aves fueron vistas en los otros tres sitios, con un máximo de ocho individuos registrados en Marettimo. Estos resultados confirman el circuito migratorio de otoño alrededor del mediterráneo de *Circaetus gallicus* que anidan en Italia central y sugiere que al menos algunos juveniles aprenden esta ruta siguiendo los adultos.

[Traducción de César Márquez]

The Short-toed Eagle (*Circaetus gallicus*) is a summer resident in Europe, wintering in tropical North Africa (Cramp and Simmons 1980). Italy has a breeding population of 380–415 pairs, most of them in the Ligurian Apennines (northwest Italy) and along the western slope of central Italy (Cattaneo and Petretti 1992; Fig. 1). A small number of pairs breed in southern continental Italy and

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Figure 1. The study area (A = Arenzano, MC = Mount Colegno, C = Circeo promontory, P = Ponza, M = Marettimo; the breeding areas of the Short-toed Eagle in the Ligurian Apennines and central Italy are shown in gray).

probably winter in Sicily (Mascara 1985, Cattaneo and Petretti 1992, Cattaneo 1997, Agostini and Logozzo 1997). In the Mediterranean basin, the greatest concentration of individuals has been observed at the Strait of Gibraltar both during autumn and spring movements (Finlayson 1992).

Information in support of a circuitous migration route for Short-toed Eagles has been circumstantial to date. In the central Mediterranean, passage of these birds is virtually non-existent during spring (Beaman and Galea 1974, Agostini and Malara 1997, Agostini and Logozzo 1998, Agostini 2001). Individuals breeding in both northern and central Italy are expected to cross the Mediterranean at the Strait of Gibraltar, traveling along the Ligurian Apennines (northwest Italy, Agostini and Malara 1997), where their greatest concentration in Italy occurs during spring migration (Baghino and Leugio 1989, 1990,

Baghino 1996). In autumn, a few birds are recorded in southern continental Italy and over the islands of Malta and Capri (Beaman and Galea 1974, Sultana and Gauci 1982, Agostini and Logozzo 1995a, 1995b, 1997, Jonzén and Pettersson 1999), although over Malta, Short-toed Eagles are occasionally recorded in November (Coleiro 1999). These results suggested the hypothesis that Short-toed Eagles breeding in central Italy avoid the long water crossing between Italy and Africa and that they move across the Mediterranean at the Strait of Gibraltar rather than via southern Italy (Agostini and Logozzo 1997). Because this route involves circuitous migration (Fig. 1), it suggests information transmission and, thus, a contemporaneous migration of adults (experienced individuals) and juveniles (inexperienced individuals). The aim of this study was to verify these hypotheses through observations at five sites of the central Mediterranean: the Ligurian Apennines, the Apuane Alps (central Italy), the Circeo promontory (central Italy), the islands of Marettimo (western Sicily, southern Italy) and Malta. At the last three sites, remarkable concentrations of raptors occur in autumn (Beaman and Galea 1974, Corbi et al. 1999, Agostini et al. 2000), while, to date, on the Ligurian Apennines and on the Apuane Alps observations of migrating individuals in this period were lacking.

STUDY AREA AND METHODS

With the exception of those observations made in the Apuane Alps, we collected our data from 15–26 September 2000, the peak of the autumn migration of the Short-toed Eagle in the Mediterranean basin (Cramp and Simmons 1980). The entire observation period was divided into four 3-d periods for recording the migration of adult, immature, and juvenile individuals. Observations were aided with binoculars and telescopes. Age determination was possible only when birds flew very close (<150 m) overhead. An estimated total of adults, immatures, and juveniles was derived by multiplying their proportions in the sample of identified individuals during each period, following the method used by Kjellén (1992) in his study on the autumn migration of raptors at the Falsterbo peninsula (Sweden). Characters used in separating age were those given by Forsman (1999).

In the Ligurian Apennines, the observation post was at the northernmost point of the midwestern Mediterranean basin, near Arenzano (Fig. 1), where the ridge of Apennines, after running parallel to the coast, reaches its closest proximity to the sea (6 km) as well as the minimum transverse width for the entire Italian peninsula. The observation post was on the closest culmination to the sea at 500 masl.

The Circeo promontory is at the southernmost point of the Pianura Pontina (Fig. 1) reaching 541 masl. In autumn 1998, hundreds of Marsh Harriers (*Circus aeruginosus*) and juvenile Honey Buzzards (*Pernis apivorus*)
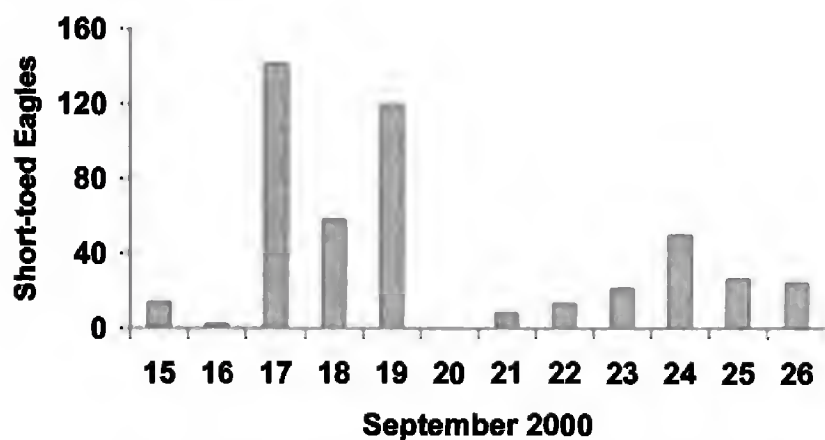
Figure 2. Occurrence of migrating Short-toed Eagles in the Ligurian Apennines between 15–26 September 2000.
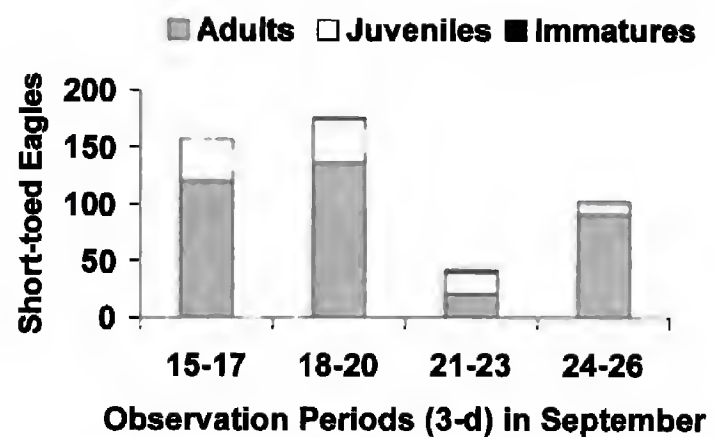

Figure 3. Adult, juvenile, and immature Short-toed Eagles estimated in the four 3-d periods, according to their proportion among the identified individuals.

were seen leaving the coast toward the island of Ponza from this point (Corbi et al. 1999; Fig. 1), but only five Short-toed Eagles. The observation post was along the southern slope nearly at its highest point.

Marettimo is a small mountainous island (12 km²) about 30 km off western Sicily (Fig. 1). Monte Falcone is its highest relief at 686 m. At this site, observations were made between the end of August and the first half of September 1997 and 1998 when a maximum of 5227 raptors were counted, nearly all Black Kites (*Milvus migrans*) and adult Honey Buzzards; only one Short-toed Eagle was reported in 1997 (Agostini et al. 2000). To date no observations have been carried out after mid-September. The observation post was located at the altitude of ca. 500 m.

The Maltese Islands are ca. 90 km south of Sicily and 335 km north of Libya (Fig. 1). Raptors, mostly Marsh Harriers and juvenile Honey Buzzards (Agostini and Logozzo 1995c), concentrate along the cliffs (Beaman and Galea 1974). The observation post was on the western side of the island of Malta, at one of the highest points of the island (250 masl). At the Ligurian Apennines and at the Circeo promontory, no monitoring was done on 20 September because of heavy rainfalls.

At the Apuane Alps site, observations were made between 18–24 September 1998 (16 hr), 1999 (20 hr), and 2000 (32 hr). The observation post was located on the slope of Mount Colegno, about 370 km NW of the Circeo promontory and 130 km SE of Arenzano (Fig. 1), at the altitude of ca. 200 m. This site was used to detect the direction of Short-toed Eagles migrating along the western slope of central Italy.

RESULTS AND DISCUSSION

On the Ligurian Apennines (Arenzano), we counted a total of 476 Short-toed Eagles (5.4/hr) with about 55% of birds seen in two days (Fig. 2). This species was the most abundant at this site (79.6%, $N = 598$). During the four 3-d periods, a total of 368 adults, six immatures, and 102 juveniles was estimated, with an overlap in the migration periods of individuals belonging to different age classes (Fig. 3). The Short-toed Eagles showed a strong tendency to migrate in flocks of two or more ($N = 96$), although 62 (13.1%) individuals were seen alone. On average, groups consisted of 4.3 ± 0.9 (SE) individuals and 64% (61 of 96) of flocks contained two or three birds. It was possible to age all birds migrating together in 23 (24%) cases, seven of these groups consisted of juveniles and adults while 16 comprised only adults. In at least four of the remaining 73 flocks recorded, juveniles and adults were seen migrating together. Few Short-toed Eagles were counted at the other three sites. However, three birds were seen on the Circeo promontory (0.4%, $N = 832$), two over Malta (0.2%, $N = 957$) and eight over Marettimo (2.8%, $N = 286$). Finally, over the Apuane Alps, a total of 289 Short-toed Eagles was counted (4.3/hr) and all individuals were seen migrating northwest toward the Ligurian Apennines (Fig. 1).

Our observations are consistent with the predictions based on the circuitous migration hypothesis. During autumn migration, Short-toed Eagles breeding in central Italy migrate over the Ligurian Apennines en route to the Strait of Gibraltar, thus avoiding a longer sea crossing between Italy and Africa. Flights suggestive of circuitous migration during autumn have been recorded in genera such as *Hirundo* and *Motacilla* (Alerstam 1990) and, among raptors, in Griffon Vultures (*Gyps fulvus*) breeding in the island of Cres (Croatia; Susic, in Zalles and Bildstein 2000, p. 220). Along the coastal zone in southern Sweden, many birds are seen regularly migrating north or northeast. However, these movements seem to be made in order to find suitable stop-over sites inland before crossing the sea (Alerstam 1990) and they are not the result of a true migration movement. In the case of our study, both the strong tendency of Short-toed Eagles to migrate together and flocks containing in-

dividuals belonging to different age classes, are consistent with the prediction that at least some juveniles belonging to the population breeding in central Italy are able to learn this circuitous route by following the adults (Agostini and Logozzo 1997). Before this study, among migrating raptors, information transmission concerning orientation and navigation has been recorded in Black Kites and, occasionally, Honey Buzzards migrating across the central Mediterranean (Agostini and Logozzo 1997, Agostini et al. 1999, 2000).

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SPRING MIGRATION OF ADULT AND IMMATURE BUZZARDS (*BUTEO BUTEO*) THROUGH ELAT, ISRAEL: TIMING AND BODY SIZE

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ABSTRACT.—More than 300 000 Common Buzzards (*Buteo buteo*), particularly steppe buzzards (*B. b. vulpinus*), are counted at the northern end of the Gulf of Aqaba (a.k.a. Gulf of Elat) each spring (Shirihai et al. 2000). In 1996–2000 we captured, banded, and measured 1420 of these northbound migrants at a trapping station north of the city of Elat, Israel. We used information collected from these birds, together with information from 1472 individuals that had been trapped in 1984–88 (Gorney and Yom-Tov 1994) to examine migration timing and body sizes in juvenile (i.e., first-time spring migrants) versus adult migrants at the site. Almost all migrants trapped (>98%) were considered to be steppe buzzards by plumage; 65% were juveniles. The median date of passage for adults (9 April) preceded that of juveniles (26 April) by more than two weeks. Within both age classes, both wing chord and body mass declined significantly with date of capture. Gorney and Yom-Tov (1994) demonstrated that once they had taken overall size into account, juvenile migrants weighed less than did adult migrants. Of the birds trapped, 6.2% had oiled or tarred feathers or toes. A significantly higher proportion of juveniles than adults were oiled or tarred. Our results, together with those of Gorney and Yom-Tov (1994), lead us to conclude that juveniles on their first spring passage are less efficient migrants than are adults, and that they are more likely to succumb to both natural and human-related risks en route.

KEY WORDS: *Common Buzzard*; Buteo buteo; *spring migration*; *age differences*; *Elat*.

Migracion primaveral de Gavilanes (*Buteo buteo*) adultos e inmaduros a traves de Elat, Israel: tiempo y tamaño de cuerpo

RESUMEN.—Mas de 300 000 gavilanes comunes (*Buteo buteo*) particularmente de gavilanes de estepa (*B. b. vulpinus*), son contados en el limite norte de el golfo de Agaba (a.k.a. Golfo de Elat) cada primavera (Shirihai et al. 2000). En 1996–2000 capturamos, colocamos bandas y medimos 1420 de estos emigrantes norteños en una estación de trampeo al norte de la ciudad de Elat, Israel. Usamos información colectada a partir de estas aves, junto con información de 1472 individuos que habían sido atrapados en 1984–88 (Gorney and Yom-Tov 1994) para examinar el tiempo de migración y el tamaño del cuerpo en juveniles (p. ej., emigrantes de primavera primerizos) versus adultos migratorios en el sitio. Casi todos los emigrantes atrapados (>98%) se consideraron como migrantes de la estepa debido a su plumaje; 65% eran juveniles. La fecha promedio de paso para los adultos (9 de abril) precedió a la de los juveniles (26 de abril) por mas de dos semanas. Dentro de ambas clases de edad, tanto la cuerda alar como la masa corporal declinó significativamente con la fecha de la captura. Gorney y Yom-Tov (1994) demostraron que una vez ellos hubieron tomado en cuenta el tamaño en conjunto, los juveniles pesaron menos que los adultos migratorios. De las aves atrapadas, 6.2% habían aceitado o alquitranado las plumas o los pies. Una proporción significativamente más alta de juveniles que de adultos se habían aceitado. Nuestros resultados, junto con los de Gorney and Yom-Tov (1994), nos lleva a concluir que los juveniles en su primera travesía de primavera son unos emigrantes menos eficientes que los adultos, y que probablemente ellos sucumben tanto a amenazas naturales como humanas en la ruta.

[Traducción de César Márquez]

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The Common Buzzard (*Buteo buteo*) is a widespread breeder in Europe, Asia, and Africa. The major palearctic subspecies (of 11 described) are *B. b. buteo* (western Europe), *B. b. vulpinus* (Scandinavia east to Siberia; ca. 96°E), *B. b. menetriesi* (between the Black and Caspian seas), and *B. b. japonicus* (east Asia) (Snow and Perrins 1998). Scandinavian, Russian, and most Asian populations, which are strongly migratory, winter in southern Asia, the Middle East, and sub-Saharan Africa (Shirihai et al. 2000).

In Israel, which is a major migratory bottleneck for soaring migrants that breed in Europe and Asia and that over-winter in Africa (Zalles and Bildstein 2000), *B. b. vulpinus* is an abundant migrant in both spring and autumn (Shirihai et al. 2000). Visible migration surveys since 1977 suggest that Elat, at the southernmost tip of Israel, is an important stopover site for the species in spring. The site is at the northern edge of almost 2000 km of contiguous Sahara and Sinai desert, and in spring many northbound migrants land there to rest and roost after crossing the desert (Safriel 1968). We have trapped, banded, and measured large numbers of Common Buzzards at and around Elat in spring (mid-April–early May) 1996–2000. Here, we use the results of those efforts, together with data from an earlier program in 1984–88 (Gorney and Yom-Tov 1994, Gorney et al. 1999), to assess the extent to which immatures and adults differ in the timing of their spring migration.

STUDY AREA AND METHODS

Common Buzzards were caught and banded immediately to the north of Elat, Israel (29°33'N, 34°57'E), both at a permanent banding station in the agricultural fields of Kibbutz Elat using bow-nets, mist nets, and dho-gazas operated from two blinds (Clark 1970, 1981, Clark et al. 1986, Gorney et al. 1999), in box traps in date palm plantations (Clark and Yosef 1997), and from moving vehicles using bal-chatri traps (Berger and Mueller 1959).

All captured raptors were identified to species, aged, measured (unflattened wing chord), and weighed, and then fitted with appropriately-sized, numbered aluminum bands issued by Tel Aviv University. Common Buzzards were aged based on plumage, molt, and iris color (Clark and Yosef 1998). The length of the culmen, hallux, and tail also was noted for some birds. Common Buzzards were assigned to subspecies based on diagnostic plumages and measurements (Cramp and Simmons 1980, Shirihai and Doherty 1990, Shirihai and Forsman 1991, Clark 1999, Forsman 1999). We assumed 1:1 sex ratios in both juvenile and adult buzzards for purposes of age-class analyses and comparisons.

None of the measurements were distributed normally (Kolmogorov-Smirnov test, $P < 0.05$ in all cases). There-

fore, we used a nonparametric Mann-Whitney group test to compare age groups (Zar 1984). Even so, unless otherwise stated, all measured data are presented as mean $\pm$SD, N, and range. We chose $P = 0.05$ as the minimum acceptable level of significance.

Data Collection. Data were collected in 1984–88 (Gorney and Yom-Tov 1994, Gorney et al. 1999) as part of a joint raptor trapping and ringing project of the Society for Protection of Nature in Israel and the International Birding and Research Centre in Elat (IBRCE). Data collection, which was reinitiated in 1996 by the IBRCE, continued through 2000 (Clark and Yosef 1997, Shirihai et al. 2000).

RESULTS

Of 2892 Common Buzzards trapped and banded in 1984–88 and 1996–2000, 1880 (65%) were second-year (immature) individuals, and 1012 (35%) were after-second-year (adult) individuals. Ten buzzards that were not aged were not included in the analysis. The ratio of immature to adult birds (1.9:1) differed significantly from 1:1 ($\chi^2 = 129.7$, df = 1, $P < 0.0001$).

Almost all of the buzzards captured (2612; >90.3%) were considered to be steppe buzzards (*B. b. vulpinus*). *B. b. menetriesi* (27; 0.9%) and nominate Common Buzzards (*B. b. buteo*) (8; 0.3%), also were caught. Adult buzzards migrated significantly earlier than immatures (median day-of-year = 99 [9 April in non-leap years] versus 116 [26 April; Fig. 1]); median test, $\chi^2 = 385.3$, df = 1, $P < 0.0001$).

Immatures had significantly longer tails and total body lengths than did adults (Table 1). Within individuals, all paired body measurements were significantly correlated ($r > 0.42$ and $P < 0.01$ in all cases). With this in mind, we chose wing chord as
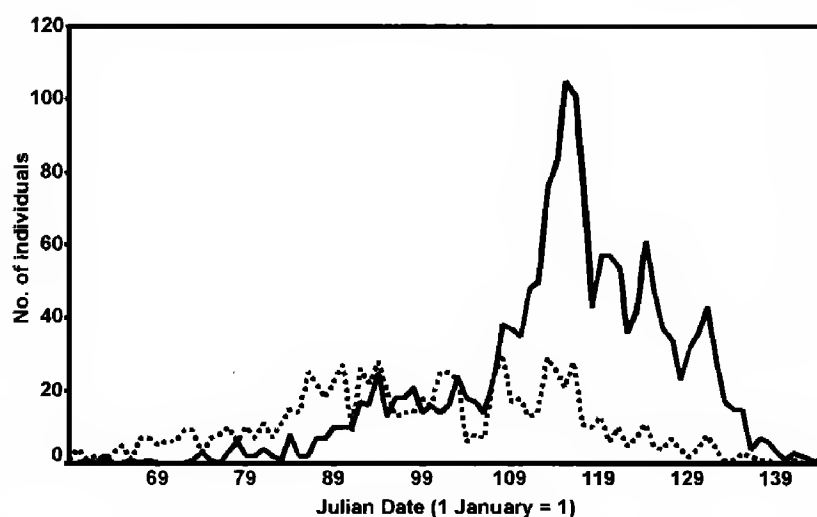

Figure 1. Phenology of migrating buzzards at Elat, Israel, as depicted from banding data. Data represent means for all years 1984–98, 1996–2000. Dashed line denotes adults and solid line immatures.

Table 1. Biometrics of adult and immature steppe buzzards banded in Elat, Israel, in 1984–88 and 1996–2000.

MEASUREMENT	N	IMMATURE MEAN ± SD	N	ADULTS MEAN ± SD	z VALUE
Body mass	1695	526 ± 75	882	578 ± 87	−14.26
Wing chord	1709	358 ± 15	906	365 ± 15	−10.13
Wingspread	810	1155 ± 43	364	1171 ± 50	−6.13
Culmen	936	21.1 ± 1.3	410	21.5 ± 1.4	−4.66
Tail	1073	189 ± 11	503	185 ± 10	−6.07
Hallux	941	21.3 ± 1.4	413	21.7 ± 1.6	−4.45
Body length	802	432 ± 20	362	429 ± 20	−2.33

All differences significant at $P < 0.001$, except body length where $P = 0.02$.

the parameter representing body size because it had the highest repeatability of features we measured, and because a Principal Component Analysis with Varimax rotation (Sokal and Rohlf 1995) indicated that although all body measurements were included in Principal Component 1, only wing chord had an eigen value higher than 1.0 (3.99), and because wing chord alone explained 57% of the variance in total body size.

A total of 73 buzzards were found dead in the area between 1996–2000. Of these, the majority were juveniles (68; 93%) and only five (7%) adults. Given the overall banding ratio, a significantly greater proportion of juveniles were found dead than banded ($\chi^2 = 25.3$, df $= 1$, $P < 0.0001$).

Wing Length and Body Mass in Relation to Date of Passage. Overall, wing chord decreased significantly with the date of arrival ($r = -0.164$, $P < 0.0001$, $N = 2615$), and differences were significant in both age classes (Fig. 2). Also, body mass changed significantly with date of passage ($r = -0.354$, $P < 0.0001$, $N = 2577$), and decreases were significant in both age classes (Fig. 3).

DISCUSSION

In many raptors, adults migrate earlier in spring than do juveniles (Newton 1979, Christensen et al. 1981, Kerlinger 1989, Gorney and Yom-Tov 1994). With an overall 10-yr median trapping date of 9 April for adults versus 26 April for juveniles, our results, which extend an earlier 5-yr study of Gorney and Yom-Tov (1994), confirm that Common Buzzards in Israel exhibit age-related differences in the timing of migration. Although a bias is known to occur in trapping of migratory raptors (Nass 1964, Weatherhead and Greenwood 1981), including of steppe buzzards at Elat (Gorney and Yom-tov 1994), we do not consider this to be a param-

eter that influences this conclusion because visual migration surveys have, independently of the trapping program, confirmed that adults migrate earlier than juveniles (Shirihai 1996, Shirihai and Christie 1992, Shirihai et al. 2000, Yosef 1996).

Although age differences in raptor migration are not completely understood, previous work suggests that such differences occur because (1) breeding
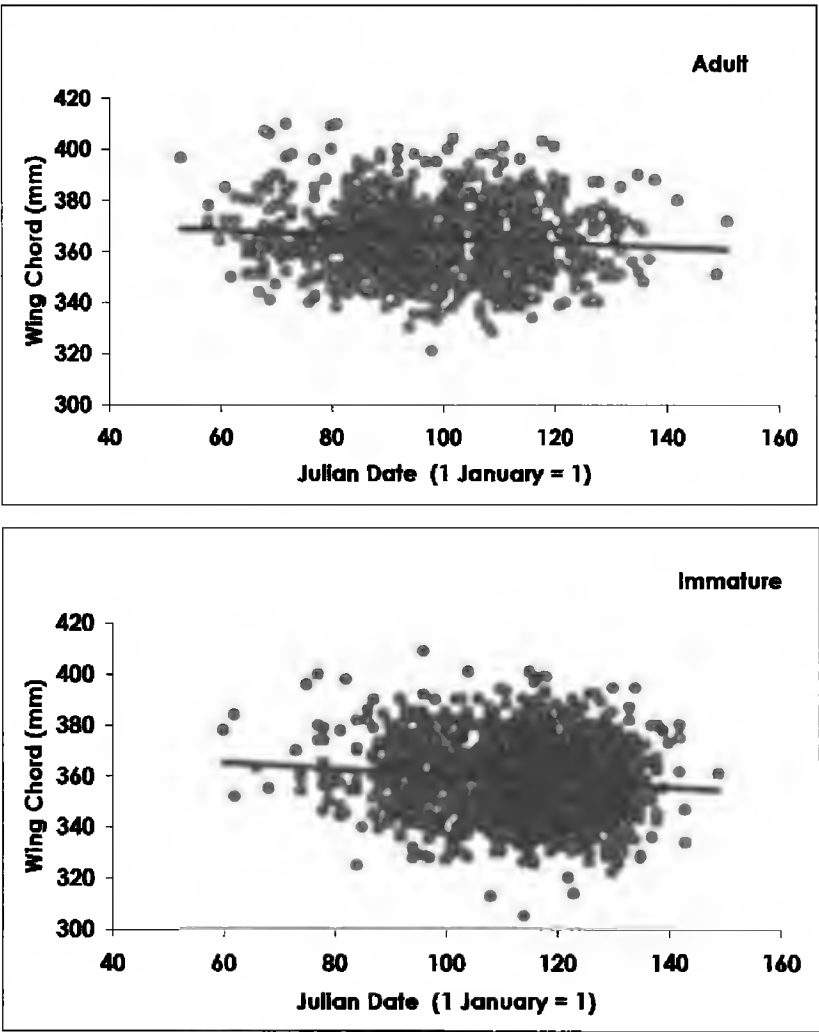

Figure 2. Wing length of adult ($r = -0.083$, $P = 0.012$, $N = 906$; regression y $= -0.078$ (± 0.031) $- 0.083$; top) and immature ($r = -0.087$, $P < 0.003$, $N = 1709$; regression y $= -0.108$ (± 0.030) $- 0.087$; bottom) buzzards in relation to date of passage and trapping at Elat.
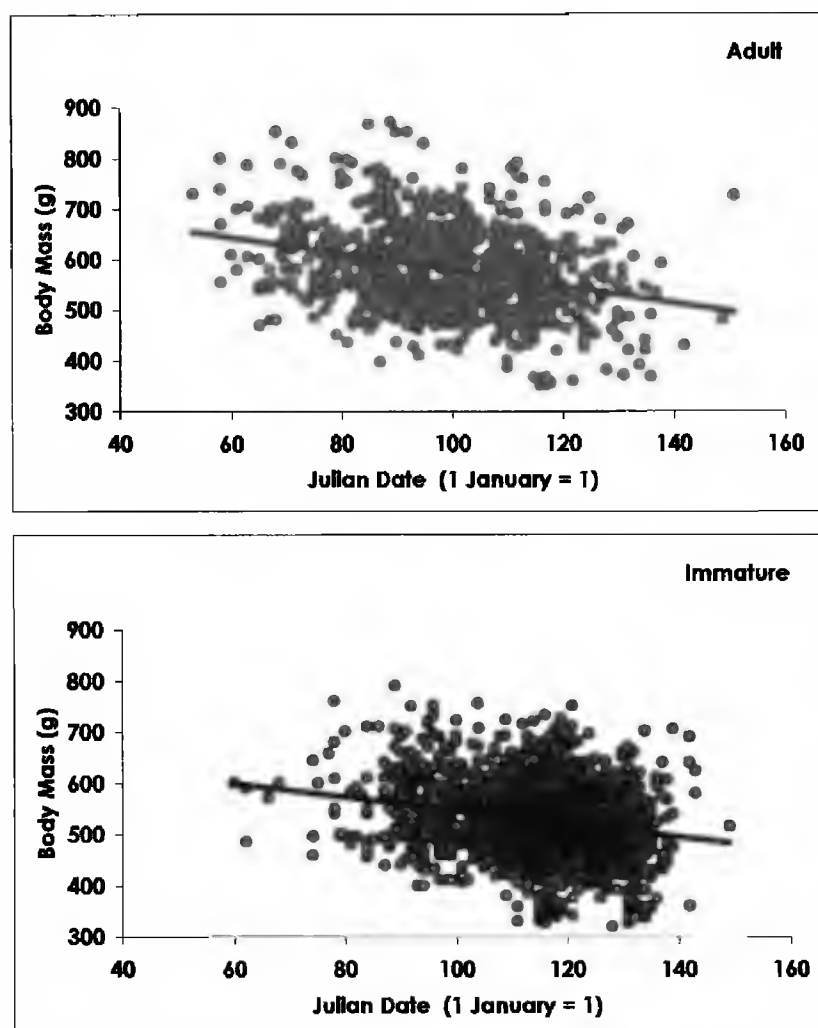
Figure 3.   Body mass of adult ($r = -0.307$, $P < 0.0001$, $N = 882$; regression $y = -1.616$ (± 0.169) $- 0.307$; top) and immature ($r = -0.215$, $P < 0.0001$, $N = 1695$; regression $y = -1.311$ (± 0.144) $- 0.215$; bottom) buzzards in relation to date of passage and trapping at Elat.

pressures on adults select for earlier arrival on the breeding grounds (Newton 1979, Gorney and Yom-Tov 1994), (2) immatures require more time either to initiate or complete their journeys (Gorney and Yom-Tov 1994), or (3) immatures over-winter farther from their breeding grounds than do adults (Król 1983). The three hypotheses are not mutually exclusive.

In an earlier paper, Gorney and Yom-Tov (1994) argued the earlier passage of adults at Elat suggested that adults were "time selected" migrants, whereas juveniles were "energy-selected" migrants. Their reasoning was based on the fact that because most second-year birds do not breed, they would not need to reach their "breeding grounds" as early in spring as adults, who were returning to breed. We offer an alternative explanation: adults precede juveniles because they are better able to prepare for migration and, therefore, start earlier, are more capable, and are faster migrants en route.

Although their general habitats are reasonably "well known," steppe buzzards have yet to be stud-

ied in detail on their wintering grounds in Africa (Brown et al. 1982). Even so, there are suggestions that adults both arrive and leave slightly earlier than immatures (Broekhuysen and Siegfried 1970, Schmidt et al. 1980). This, together with the fact that adults arrive in Elat earlier, and are heavier than juveniles (Gorney and Yom-Tov 1994), suggests that adults maintain a more positive energy balance than juveniles, rather than that the age classes are using different strategies on migration.

Soaring migrants, including steppe buzzards (Tarboton et al. 1987, Spaar 1997) typically travel in large flocks, presumably because in doing so individuals more quickly locate thermal energy needed to assist their long-distance movements (Kerlinger 1989). Observations in North America suggest that in at least one such species, immatures are less adroit at effective soaring than are adults. At Hawk Mountain Sanctuary in eastern Pennsylvania, young-of-the-year Broad-winged Hawks (*Buteo platypterus*), follow adults into and out of thermals during soaring and gliding flight, significantly more so than vice-versa (Maransky and Bildstein 2001). In addition, observations in both coastal New Jersey and peninsular Florida suggest that immature Broad-winged Hawks are more likely to be affected by wind drift and eventually find themselves off course than are more experienced adults (Hagar 1988, Hoffman and Darrow 1992). Taken together these reports suggest that immature steppe buzzards pass through Elat later than adults because they are less efficient migrants than adults, which also is supported by their lower body masses there each spring (Gorney and Yom-Tov 1994).

Juvenile inefficiencies on migration may also explain an age-related bias in the numbers of "tarred and oiled" birds trapped at Elat. Clark and Gorney (1987) reported that 7% (37 of 516) of the buzzards banded at Elat in 1985 and 1986 had oil and tar residues on their feathers or feet, or both. In a similar study in 1996–2000, we found that 86 (6.2%) of 1389 buzzards banded were tarred or oiled, and that 67 (78%) of the tarred birds were juveniles. Presumably the sources of these contaminants are oil fields in the Sahara and Arabian deserts along the Red Sea south of Elat. Given the overall banding ratio of 1.9:1 juveniles to adults, juveniles seem to be more prone to tarring ($\chi^2 = 6.3$, df $= 1$, $P < 0.05$) than adults, possibly because their migration inefficiencies make them more likely to seek drinking water and, therefore, mistakenly land in pools of spilled oil. Assuming that

(1) spring-migration counts of 350 000 steppe buzzards reported for Elat in Shirihai et al. (2000) represent the minimal numbers of northbound migrants, and (2) contaminant information collected from banded birds reflects the level of occurrence in the migratory population, overall, then more than 22 000 buzzards are contaminated and, presumably, disadvantaged (Clark and Gorney 1987) en route, with the majority being immatures.

Gorney and Yom-Tov (1994) suggest that the large proportion of immatures trapped in Elat resulted from age differences in migration routes as has been reported for several raptor species (Bildstein et al. 1983, Clark 1985, Yosef 1996, Yosef and Alon 1997). This is somewhat difficult to evaluate in the case of the steppe buzzards, however, owing to the fact that only 0.3–0.5% of the birds counted on the visible migration survey in the Elat Mountains are subsequently trapped in the fields north of Elat each spring. Even so, geography in the region (Shirihai et al. 2000, Zalles and Bildstein 2000) suggests that the northern end of the Gulf of Elat serves as a major bottleneck for north bound steppe buzzards returning to their breeding grounds each spring, unless adult steppe buzzards are less likely to be wind drifted east toward Elat, and thus more likely to follow the western shoreline of the Red Sea all the way to the northern end of the Gulf of Suez each spring. However, there is no evidence that the adults are less vulnerable to wind drift than immatures (Shirihai 1996, Shirihai and Christie 1992, Shirihai et al. 2000). It seems reasonable to attribute the 1.9:1 juvenile-to-adult age ratio of trapped birds to the increased vulnerability of stressed immatures to being caught in food-baited traps (Gorney and Yom-Tov 1994). We believe that large numbers of steppe buzzards, particularly immatures, reach Elat in rather poor condition, and that many of these die there, succumbing either to starvation or predation in the area.

In conclusion, we submit that the fact that, within age classes, heavier individuals are trapped early in the season suggests more efficient migrants pass earlier than less efficient migrants.

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PROVISIONING RATES AND TIME BUDGETS OF ADULT AND NESTLING BALD EAGLES AT INLAND WISCONSIN NESTS

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Abstract.—We used a remote video recording system and direct observation to quantify provisioning rate and adult and nestling behavior at Bald Eagle (*Haliaeetus leucocephalus*) nests in north-central Wisconsin in 1992 ($N = 5$) and 1993 ($N = 8$). Eagles nesting in this region have a high reproductive rate (≥ 1.3 young/occupied territory), and the number of occupied territories has expanded nearly three-fold since 1980. The season-long provisioning rate averaged 5.2 prey deliveries/nest/d and 3.0 prey deliveries/nestling/d, and did not vary by year or with nestling number or age. Fish (Osteichthyes) made up 97% of identified prey deliveries followed by reptiles (Reptilia) (1.5%), birds (Aves) (1.2%), and mammals (Mammalia) (0.6%). Nearly 85% of prey items were >15 cm and <45 cm and 13% were <15 cm in length. Adult attendance (time ≥ 1 adult was at the nest) at nestling age 2–4 wk was >90% of the day and was negatively correlated with nestling age. Time adults spent feeding nestlings was negatively correlated with nestling age. Nestlings stood or sat in the nest >30% of the day, began to feed themselves, and exhibited increased mobility in the nest at 6–8 wk. We identified three stages of the nestling period and several benchmarks that may be useful when scheduling data collection for comparison of Bald Eagle nesting behavior. Our results support the hypothesis that food was not limiting this breeding population of Bald Eagles.

Key Words: *Bald Eagle; Haliaeetus leucocephalus; Wisconsin; time budgets; provisioning; behavior.*

Tasas de aprovisionamiento y presupuestos de tiempo de adultos y polluelos de Aguilas Calvas en nidos del interior de Wisconsin

Resumen.—Usamos un sistema remoto de video grabación y observaciones directas para cuantificar las tasas de aprovisionamiento, y el comportamiento de adultos y polluelos en nidos del Águila calva (*Haliaeetus leucocephalus*) en el norte-centro de Wisconsin en 1992 ($N = 5$) y 1993 ($N = 8$). Las águilas que

anidan en esta región tienen una alta tasa reproductiva (≥1.3 juveniles/territorio ocupado), y el numero de territorios ocupados se ha expandido a cerca de tres veces desde 1980. La tasa de la estación de gran aprovisionamiento promedió 5.2 presas entregadas/nido/d y 3.0 presas entregadas/nido/d, y no vario por año o con el número de polluelos ni la edad. Los peces (Osteoictios) represento el 97% de las presas entregadas identificadas seguido por reptiles (Reptilia) (1.5%), aves (Aves) (1.2%), y mamíferos (Mammalia) (0.6%). Cerca del 85% de los ítems presa tuvieron >15 cm. y <45 cm. y 13% tuvieron <15 cm. de longitud. La asistencia de los adultos (tiempo en que ≥1 adulto esta en el nido) a una edad de los polluelos de 2–4 semanas fue >90% del día y estuvo correlacionado negativamente con la edad del polluelo. El tiempo que los adultos pasaron alimentando a los polluelos estuvo correlacionado negativamente con la edad del polluelo. Los polluelos permanecieron parados o sentados en el nido >30% del día, comenzando a alimentarse por si mismos, y exhibiendo un incremento en la movilidad en el nido a las 6–8 semanas. Identificamos tres estados del periodo de anidación y algunos puntos de referencia que pueden ser útiles durante la programación de colección de datos para la comparación del comportamiento de anidación de las águilas calvas.

[Traducción de César Márquez]

Previous investigations (Weekes 1975, Gerrard et al. 1979, Fraser 1981, Bortolotti 1984a, Cain 1985, Jenkins 1989) have described Bald Eagle (*Haliaeetus leucocephalus*) nesting season behavior using direct observation and time-lapse still photography. These studies reported behavior and time budgets of nestlings and adults, and chronology and development of certain physical and behavioral characteristics of nestling eagles. Previously, small sample size has limited quantitative comparison of Bald Eagle behaviors. We describe Bald Eagle nestling behavioral ontogeny and parental time budgets quantitatively to facilitate comparison among specific subpopulations.

Quantitative information on provisioning rates and adult and nestling time budgets is of particular interest because productivity may be related to prey availability early in the nesting season (Gerrard et al. 1979, Swenson et al. 1985, Hansen 1987, Steidl et al. 1997, Anthony 2001). Provisioning rate is usually indicative of prey availability in the environment (Newton 1979, Collopy 1984) and food supply has been indicated as a key factor in limiting Bald Eagle breeding success (Dykstra et al. 1998, Elliott et al. 1998). Adult and nestling behavior may be influenced by prey availability, in that time spent foraging is a function of prey availability, and nestling growth and development may be related to food provisioning (Dykstra 1995).

The Bald Eagles breeding in north-central Wisconsin have high nesting success and productivity (1.3 young/occupied territory, 1.7 young/successful nest [Kozie and Anderson 1991], and 1.26 young/breeding attempt [Dykstra et al. 1998]), and the number of occupied territories increased by 265% (1980–93) (F. Quamen pers. comm.). Further, this breeding population has exhibited low levels of contaminants in eggs (Dykstra et al. 1998).

Our objectives were to quantify the provisioning rate and time budgets of adult and nestling Bald Eagles in northern Wisconsin from hatching through fledging. This information may be useful for comparison to other populations in the Great Lakes region and throughout the breeding range.

STUDY AREA AND METHODS

Study Area. We monitored Bald Eagle nests in north-central Wisconsin >50 km inland from Great Lakes shorelines (ca. 46°N, 90°W). North-central Wisconsin is predominately forested with coniferous trees, including pine (*Pinus* spp.), spruce (*Picea* spp.), hemlock (*Tsuga* sp.), and fir (*Abies* sp.) (Curtis 1959). White pine (*Pinus strobus*) is the predominant nest tree species of Bald Eagles in the region (pers. observ.). Location and productivity of Wisconsin nests have been documented by Wisconsin Department of Natural Resources personnel during aerial surveys conducted twice annually since 1974 (WDNR unpubl. data). Within this study area, we selected nests where placement of video recording equipment was possible, or a good vantage for nest observation was available. These selection constraints resulted in a non-random sample of nests in the study area. However, we believe that these nests were representative of Bald Eagles breeding in northern Wisconsin, as these constraints are likely not related to behavior or prey availability.

Video Recording. In January and February 1992, six black-and-white video cameras (four Sony® model M-350, and two Sony® model M-332, Fuhrman Diversified, Inc., Seabrook, TX) were positioned to record behavior at nests. M-350 cameras were placed in an adjacent tree <15 m from the nest and M-332 cameras were placed in the nest tree 1–2 m above the nest. Cameras were concealed by affixing natural and/or artificial vegetation around them. Coaxial cable connected cameras to the video recorders which were located 200–400 m from the nest tree.

Recorders (time and date were stamped in the frame) captured ca. four consecutive days of diurnal behaviors

Table 1. Provisioning rates to inland Wisconsin Bald Eagle nests where behavioral data were collected in 1992–93

YEAR	NEST ID	N NESTLINGS	OBSERVATIONS	MEAN PREY DELIVERIES PER DAY (SD)	MEAN PREY DELIVERIES PER NESTLING PER DAY (SD)
1992	IR-33[a]	3	22	6.9 (2.8)	2.3 (0.9)
	IR-9c[a]	2→1	24	2.1 (0.6)	2.0 (0.7)
	ON-49[a]	1	14	5.6 (1.2)	5.6 (1.2)
	VI-61c[a]	3	19	7.3 (0.8)	2.4 (0.3)
	ON-79[a]	2	29	6.4 (3.7)	3.2 (1.9)
1993	VI-100[b]	2	2	3.5 (0.7)	1.8 (0.4)
	ON-16[a]	1	16	4.3 (1.4)	4.3 (1.4)
	VI-84a[b]	2	5	4.0 (1.3)	2.0 (0.6)
	ON-47a[b]	2	2	11.5 (0.7)	5.8 (0.4)
	IR-26d[b]	2	3	3.5 (0.7)	1.8(0.4)
	VI-68a[b]	2	2	2.5 (0.7)	1.3 (0.4)
	ON-25b[b]	2	2	5.5 (0.7)	2.8 (0.4)
	VI-57[c]	1	4	3.8 (1.1)	3.8 (1.1)
Mean		1.8		5.2	3.0

[a] Video cameras.
[b] Direct observations.
[c] Both.

before requiring a tape and battery change. Recorders at nests with M-350 cameras recorded one frame every second; those with M-332 cameras recorded one frame every four seconds. Video recordings were analyzed by viewing on a television monitor.

Nest Observations. Direct observations began 5 May 1993 and continued through 27 July 1993 when all nestlings had fledged. We attempted to conduct one observation session each week at each study nest from blinds 200–400 m from nest trees. Locations of blinds were chosen to minimize potential for observer influence on eagle behavior while still providing researchers with a vantage adequate for collection of behavioral data (i.e., an unobstructed view of the nest area). Dawn to dusk surveillance was maintained on all eagles visible from the blind.

Data Organization and Analysis. Behavioral data collected by nest observers and by reviewing video were summarized to develop time budgets for each observation day. The specific behaviors quantified were: adults—present in the nest, absent, feeding, prey delivery, and brooding; and nestlings—lying, sitting, standing, feeding, being fed, and preening. At nests with more than one young, we attempted to identify individual nestlings throughout each day. Age of nestlings at each nest was determined by video recording or by back-calculating from age at banding (Bortolotti 1984b). At nests with multiple young, we used the date of hatch of the oldest nestling when assigning nestling ages for data analysis. Week one was defined as 1–7 d post-hatch.

Lying, sitting, and standing were defined as in Jenkins (1989). We combined sitting and standing for analysis (calling it upright). Brooding behavior was defined as an adult covering >50% of at least one nestling. Feeding ended when there was a break of >1 min between bites

of food. We assumed that when behaviors of young nestlings (<4 wk) could not be determined, they were lying in the nest. Following Ellis (1979), we assumed that nestlings being brooded were lying. Branching was defined as nestlings exiting the nest and standing on adjacent branches.

Each hour was divided into twelve 5-min time intervals At the conclusion of each 5-min interval, the behavior of each bird visible during the period was summarized, and location and primary behavior of each bird were recorded. The primary behavior was defined as the behavior recorded for the most cumulative time in the preceding 5-min. The daily time budget was the proportion of all 5-min time intervals each behavior was recorded as the primary behavior. Daily time budgets were averaged at individual nests each week of age, then pooled for all nests to produce weekly time budgets across the study area

We summarized the provisioning rate at each nest each week (prey deliveries/nest/d) and pooled rates by nestling age for a study-area-wide weekly-prey-delivery rate. We calculated a season long average provisioning rate at each nest. All provisioning rates were also standardized by the number of nestlings (prey deliveries/nestling/d). All statistical tests were considered significant at the $\alpha = 0.05$ level.

RESULTS

We monitored five nests in 1992 and eight nests in 1993. All nests where eggs were laid fledged at least one young and 1.8 young fledged/successful nesting attempt (Table 1). At one territory, where
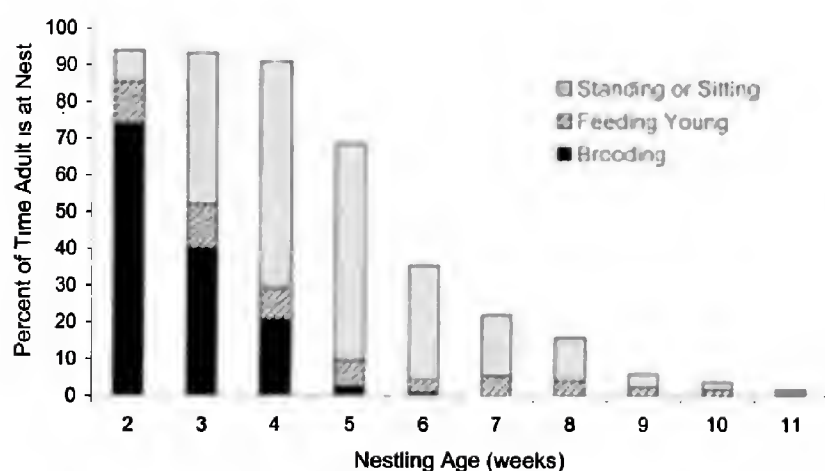
Figure 1. Weekly time budget (nestling age 2–11 wk) of nestlings related to the presence of one adult Bald Eagle at inland Wisconsin nests (1992–93). Total adult attendance is the sum of behaviors shown.
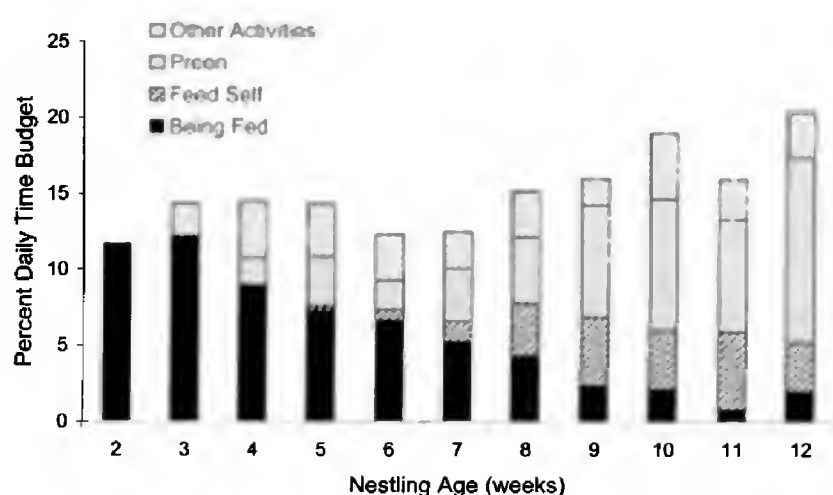

Figure 2. Weekly time budget of nestling Bald Eagle activities (age 2–11 wk) at inland Wisconsin nests (1992–93).

a camera was placed at one nest, the eagles used an alternate nest.

Provisioning. There was no difference between years in the season-long provisioning rate (1992 = 5.6 prey deliveries/d; 1993 = 4.8 prey deliveries/d; $t = 0.57$, df = 11, $P = 0.59$), so data from both years were pooled. Mean provisioning rate did not differ among nests with differing numbers of nestlings ($F_{2,10} = 1.07$, $P = 0.38$). The season-long mean daily provisioning rate adjusted for number of nestlings was 3.0 prey deliveries/nestling/d (Table 1). The adjusted provisioning rate showed no correlation to nestling age ($r^2 = 0.13$, slope = 0.03, SE = 0.014, $P = 0.072$).

Sixty-five percent of prey items delivered were identified to class (549 of 848 deliveries). Fish (Osteichthyes) made up 97% of all prey items identified, followed by reptiles (Reptilia) (1.5%), birds (Aves) (1.2%), and mammals (Mammalia) (0.6%). Eighty (9.4%) prey items were identified to genus. Bullhead (*Ameiurus* spp.) made up 40% of all items identified to genus, followed by northern pike (*Esox lucius*) (33.8%), and suckers (*Catostomus* spp.) (8.8%).

Observers and video reviewers estimated size of prey delivered in 70% (594) of prey deliveries. Nearly 85% of prey items were >15 cm and <45 cm. Prey items <15 cm made up 13% of prey deliveries and made up a greater portion of prey delivered to nests in 1993 than in 1992 ($\chi^2 = 103$, df = 3, $P < 0.001$).

Adult Behavior. Adult attendance was negatively correlated with nestling age ($r = -0.94$, SE = 0.02, $P < 0.001$; Fig. 1). Also, time adults spent feeding nestlings was negatively correlated with nestling age ($r = -0.94$, SE = 0.014, $P < 0.001$).

Nestling Behavior. Time lying made up nearly 100% of the nestling time budget at 2 wk and was negatively correlated with nestling age ($r = -0.84$, SE = 0.01, $P < 0.001$). Time resting in an upright position (standing or sitting) was positively correlated with nestling age ($r = 0.7$, SE = 0.02, $P = 0.05$). Eaglets actively sought sun and shade at 5 wk. Time spent active increased as nestlings aged, but was not related to nestling age ($r = 0.3$, SE = 0.01, $P = 0.07$; Fig. 2). Nestlings were not observed feeding themselves until 4 wk. Time nestlings spent at all feeding behaviors (being fed and feeding themselves) was negatively correlated with age ($r = -0.9$, SE = 0.01, $P = 0.01$).

DISCUSSION

Provisioning Rate and Habitat Quality. Bald Eagles breeding in north-central Wisconsin had high productivity compared to eagles breeding in other areas (1.8 young fledged/successful nesting attempt [this study]; Kozie and Anderson 1991, Steidl et al. 1997, Elliott et al. 1998, Anthony 2001), and the number of occupied territories increased by 265% from 1980–93 (F. Quamen pers. comm.). Three nestlings fledged from two nests in this study, an uncommon occurrence among Bald Eagles (Gerrard and Bortolotti 1988). Only one nestling in our study did not fledge (96% fledged). Gende and Willson (1997) reported that from 18 nests, only one nestling died and suggested that was evidence food was not a limiting factor. Hansen (1987) concluded that reproduction was influenced by available prey and that nest success was higher in areas with better food supplies. Elliott et al. (1998) recommended that the role of food supply be considered when studying the effects of hab-
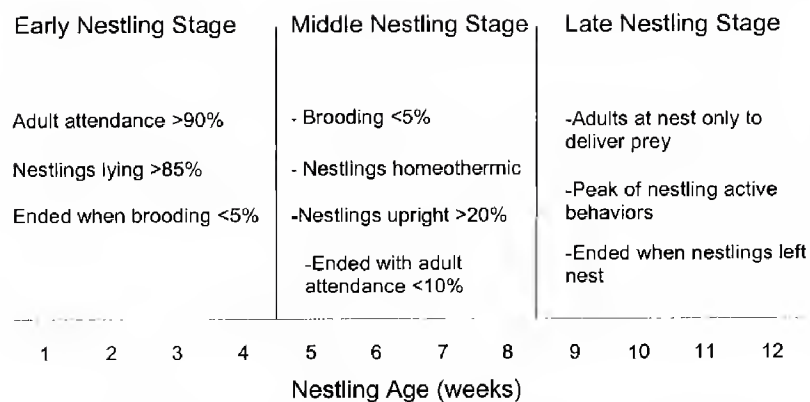
Early Nestling Stage	Middle Nestling Stage	Late Nestling Stage
Adult attendance >90%	- Brooding <5%	-Adults at nest only to deliver prey
Nestlings lying >85%	- Nestlings homeothermic	-Peak of nestling active behaviors
Ended when brooding <5%	-Nestlings upright >20%	
	-Ended with adult attendance <10%	-Ended when nestlings left nest

1	2	3	4	5	6	7	8	9	10	11	12

Nestling Age (weeks)

Figure 3.   Early, middle, and late nestling stages defined by adult and nestling Bald Eagle behavioral changes at inland Wisconsin nests (1992–93). The captions describe characteristic behaviors during each stage.

itat quality and contaminants on Bald Eagles. Lower provisioning rates and food supply were thought to be the factors limiting productivity on the British Columbia coast (Elliott et al. 1998). Furthermore, measured nestling energy intake in north-central Wisconsin Bald Eagles was not different than predicted energy requirements (Dykstra 1995) suggesting that the provisioning rate we recorded was sufficient to support the observed productivity.

Bennetts and McClelland (1997) found support for the hypothesis that ability to obtain food increases with age. The age of the adults breeding in northern Wisconsin was unknown so we could not test that hypothesis. However, productivity was uniformly high in northern Wisconsin (away from the Great Lakes shorelines) at the same time the number of territories increased rapidly.

We conclude that the mean provisioning rate recorded in this study (5.2 prey deliveries/d, 3.0 deliveries/nestling/d) reflects adequate prey availability in the environment to support high Bald Eagle reproductive success rates in the Great Lakes region. Our results support the hypothesis that food was not limiting Bald Eagle productivity in northern Wisconsin. These data may serve as a baseline for comparing provisioning rates and productivity throughout the Great Lakes region. However, the provisioning rates of Bald Eagles in northern Wisconsin may be less useful for comparison to breeding birds in other regions of the range due to potential covariates such as weather, prey type and size, and nesting chronology (Jackman et al. 1999).

Adult Behavior. Three distinct adult behavioral stages evident after nestlings hatched (Fig. 3) may be important to nestling survival and may be relat-

ed to regional and local nesting conditions. When nestlings were 2 wk, adults brooded >70% of the time. Subsequently, brooding declined rapidly and ended by 5 wk. Bortollotti (1984a) predicted that Bald Eagle nestlings were able to thermoregulate at 15 d, but that they may still require adult brooding. Collopy (1984) found that brooding in Golden Eagles (*Aquila chrysaetos*) was related to age as did Fraser (1981) for Bald Eagles. Cain (1985) concluded that brooding lasted 50 d as did Ellis (1979) (Golden Eagles). Weather is likely a significant covariate when comparing brooding behavior. Our data generally agree with other studies and the loss of only one nestling in our study indicates that adults provided adequate protection to nestlings.

Adult nest attendance was high 4–5 wk after brooding decreased to <20% and adults mostly stood or sat in the nest. Jenkins (1989) and Fraser (1981) reported that adult attendance at the nest remained high after brooding ended. Adult presence was likely important to reproductive success because it may have deterred predation and/or shielded nestlings from sudden weather changes, increasing nestling survival and adult fitness (Harmata et al. 1999). Fishers (*Martes pennanti*) have been observed attempting to prey on Bald Eagle nestlings in Wisconsin (Dykstra et al. 1993, Taft et al. 1999), and Perkins et al. (1996) reported Redtailed Hawk (*Buteo jamaicensis*) predation on an eaglet.

Decline in adult attendance at the nest 6–12 wk may be related to reduced risk of nestling predation, nestling thermal independence (Fraser 1981, Jenkins 1989), the need of energetically-stressed adults to forage more frequently, or the primary prey (fish) being less available to eagles after spawning, which resulted in increased time spent foraging to provide adequate provisioning (Bennetts and McClelland 1997).

Nestling Behavior. Nestlings 2–4 wk were inactive and dependent upon the adults for survival. Nestlings began to feed themselves, preen, and explore the nest at 4 wk. Collopy (1984) reported Golden Eagle nestlings feeding themselves at 34–37 d and Jenkins (1989) reported preening was evident in Bald Eagle nestlings at 7 wk. Nestlings appeared to be thermally independent 29 d after hatching, and possibly sooner, as brooding at 5 wk (29–35 d) was <3% of the day. These findings are consistent with previous studies (Fraser 1981, Collopy 1984, Hansen 1987). The proportion of active time spent feeding declined throughout the nest-

ing period indicating that nestlings were able to satisfy increasing energy needs by ingesting larger boluses of food and were more skilled at picking bits of food from carcasses.

As nestlings grew older, the time spent in an upright position in the nest increased. This may have important implications in both behavioral development and survival. Competition among nest mates for food items has been documented (Collopy 1984, Jenkins 1989) and nestlings that are adept at standing and maneuvering in the nest may dominate siblings and secure more energy.

Conclusions. Quantification of Bald Eagle nesting behaviors in high-quality habitat yielded several benchmarks we feel will be useful for comparison in the Great Lakes region. First, provisioning rate averaged 5.2 prey deliveries/d (3.0 prey deliveries/nestling/d) throughout the nestling period. Second, at least one adult was at the nest for >90% of the time 1–4 wk (the early nestling stage). High adult attendance during the early nestling stage is likely critical to nestling survival because adults provide protection from weather stress and predation. Third, based on their behavior, nestlings in this study were homeothermic at 5 wk.

Division of the nestling period into three stages that are discernible based on nestling and adult behavior with each stage clearly defined by changes in adult behavior may be useful for optimally scheduling data collection with limited resources and may facilitate behavioral comparisons among regional breeding populations.

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A LINE TRANSECT SURVEY OF WINTERING RAPTORS IN THE WESTERN PO PLAIN OF NORTHERN ITALY

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Abstract.—The raptor population wintering in lowland farmland of northwestern Italy was monitored during the winters of 1998–99 and 1999–2000 by means of a roadside vehicle survey. To estimate the density of wintering raptors, we recorded perpendicular distances of the birds from transect lines. Seven species of raptors were recorded, but a sufficient number of observations to estimate density was collected only for the Common Buzzard (*Buteo buteo*). The extensive rice fields in the eastern part of the region and some other restricted areas, rich in humid meadows and scattered woodlots, showed high Common Buzzard densities (1.1–1.6 birds/km^2), but the other cultivated areas, mainly cornfields, had a significantly lower density (0.2 birds/km^2). On the basis of these data, we estimated a wintering population of Common Buzzards of the lowland farmland, covering about 6700 km^2 in the Piemonte region of northwestern Italy of 3700 (3200–4400) birds.

Key Words: *Common Buzzard*; Buteo buteo; *raptors*; *winter survey*; *transect*; *Italy*.

Un estudio con transectos lineares de Rapaces invernantes en la planicie occicental del Po en el norte de Italia

Resumen.—La población de rapaces invernando en zonas agrícolas bajas del noroeste de Italia fue monitoreada durante los inviernos de 1998–1999 y 1999–2000 por medio de un estudio hecho desde un vehículo. Para estimar la densidad de rapaces invernantes registramos las distancias perpendiculares de estas aves a transectos en línea. Siete especies de rapaces fueron registradas, sin embargo un numero suficiente de observaciones para estimar densidades solo fue colectado para el gavilán común (*Buteo buteo*). Los extensos campos de arroz en la parte oriental de la región y algunas otras áreas restringidas, ricas en prados húmedos y bosquecillos dispersos, mostraron altas densidades de gavilanes comunes (1.1–1.6 aves/km^2), pero en las otras áreas cultivadas, principalmente campos de maíz, tuvieron una densidad significativamente mas baja (0.2 aves/km^2). En base a estos datos, estimamos una población invernante de gavilanes comunes en las granjas de zonas bajas, que cubrían cerca de 6700 km^2 en la región Piemonte del noroeste de Italia de 3700 (3200–4400) aves.

[Traducción de César Márquez]

Over 40% of Europe's area is occupied by lowland farmlands, which offer important habitats for many birds in the breeding season and, even more, in winter. However, agricultural intensification and modern farming practices, fostered by international policies, is rapidly eliminating meadows, hedges, woodlots, and orchards, dramatically affecting the carrying capacity of most birds associated with these farmlands (Tucker and Heath 1994). Many raptor species traditionally associated with agricultural or pastoral landscapes such as kestrels (*Falco*

spp.), harriers (*Circus* spp.), and buzzards (*Buteo* spp.) are known to be affected in a number of ways by land use intensification (del Hoyo et al. 1994). Some of these species, such as the Common Buzzard (*Buteo buteo*), seem to be recovering in Europe from low populations due to past persecution and pesticide effects, while others, such as the Eurasian Kestrel (*Falco tinnunculus*), do not show similar positive trends (Hagemeijer and Blair 1997). Their populations in intensively-cultivated areas may be regarded as important ecological indicators and the monitoring of their trends as an important conservation task.

The Po Plain in northern Italy is an intensively-

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cultivated, inhabited area and, notwithstanding low winter temperatures (below the 2°S isotherm in January), is regarded as one of the primary wintering areas in Italy for some raptor species, namely Hen Harrier (*Circus cyaneus*), Eurasian Sparrowhawk (*Accipiter nisus*), Common Buzzard, Eurasian Kestrel, and Merlin (*Falco columbarius*) (Chiavetta 1986). However, objective assessments of their winter numbers and trends are generally lacking, due to scarcity of surveys. Information is mainly limited to bird-distribution atlases covering part of the Po Plain (e.g., Fornasari et al. 1992, Cucco et al. 1996).

Changes in land use, potentially influencing raptor distribution and numbers, are expected in the next few years, mainly as a consequence of the European community agricultural politics (e.g., Communication of the European Community Commission, number 278/7.6.2000). Therefore, we started a project to estimate the wintering raptor populations over representative portions of the Po Plain, to provide a basis for future evaluations of trends.

A vehicle road survey, driving at slow speed, is a common method to count diurnal raptors, especially in open habitats and in winter season (Thiollay 1976, Fuller and Mosher 1981). From these counts, an index of the relative abundance can be obtained usually expressed as birds per kilometer.

Comparisons of indices of abundance among areas, times, and different species could be made only by assuming similar detection probabilities, an assumption rarely met for species of different sizes and detectability or in habitats with different vegetative cover (Burnham et al. 1981). Moreover, detection probability might change from one year to the next in the same habitat (Andersen et al. 1985).

Comparisons of density estimates avoid this assumption, but generally require labor-intensive methods, applicable only on limited areas and with territorial birds. A way of obtaining density estimates of wintering raptors over large areas is use of a "distance" sampling method (Buckland et al. 1993). Distance sampling consists essentially of line transects with the registration of the perpendicular distances from the objects of interest to the line (Burnham et al. 1981) or point counts measuring the radial distance from the observer to the objects (Reynolds et al. 1980, Buckland 1987).

In spite of their potential usefulness, distance methods have not been applied commonly to raptor surveys until recently. Specifically, Andersen et

al. (1985) investigated raptor densities in a military reserve of Colorado with line transects and Hall et al. (1997) estimated the population of the endangered Hawaiian Hawk (*Buteo solitarius*) with point counts. Point counts, however, generally are less effective for monitoring rare species. Transects may be more effective because birds can be sampled continuously without breaks. In addition, the variance of the counts are greater with point counts than with distance transects (Buckland et al. 1993: 302). On the basis of these considerations and previous experience with point counts, we decided to use line-transect sampling and to evaluate the practicality and efficiency of this method in our field situation.

STUDY AREA AND METHODS

The study area is the intensively-cultivated western Po River Plain included in the region Piemonte (Italy). The main crops in the western half of the region (provinces of Torino and Cuneo) are corn, wheat, and hay; rice fields dominate in the northeastern portion (provinces of Vercelli, Biella, and Novara) and wheat in the southeastern quarter (province of Alessandria).

We conducted the survey in two consecutive winters, in the first winter (19 December 1998–28 January 1999) we worked only in the western part (Cuneo and Torino provinces); in the second winter (17 December 1999–22 January 2000) the sample was extended to the eastern rice fields (Vercelli, Biella, and Novara provinces).

During the 1999–2000 winter, we stratified (Sutherland 1996) the sample according to the topography and to the prevailing conditions of the rural landscape. We identified two strata corresponding to the geographically well-separated western and eastern plains characterized by the prevailing cultivation (maize and rice, respectively); each of these were then divided in two subareas, mainly on the basis of different intensity of agricultural utilization. Corine land cover digital maps (level 3) and Geographical Information System (GIS) analysis allowed us to calculate the area of each strata defined as follows (Fig. 1).

Western cornfields (WC): an area of intensive agriculture with wheat, meadows, soybean, but mainly maize fields, extending over the main part of the plain between the cities of Turin and Cuneo (estimated area 2700 km^2),

Western meadows (WM): included in the preceding area, but characterized by a greater habitat diversity, with presence of humid meadows, small uncultivated fields, poplar (*Populus* spp.) plantations and natural woodlots, due to the poor agricultural quality of soils (IPLA 1982) (estimated area 500 km^2);

Eastern rice fields (ER): an area with mostly intensive rice fields, almost treeless except for a few isolated poplars or oaks (*Quercus* spp.) and a single 4-km^2 forest patch (estimated area 1250 km^2);

Eastern heathlands (EH): an area with recently developed rice fields, a growing proportion of woodland, especially
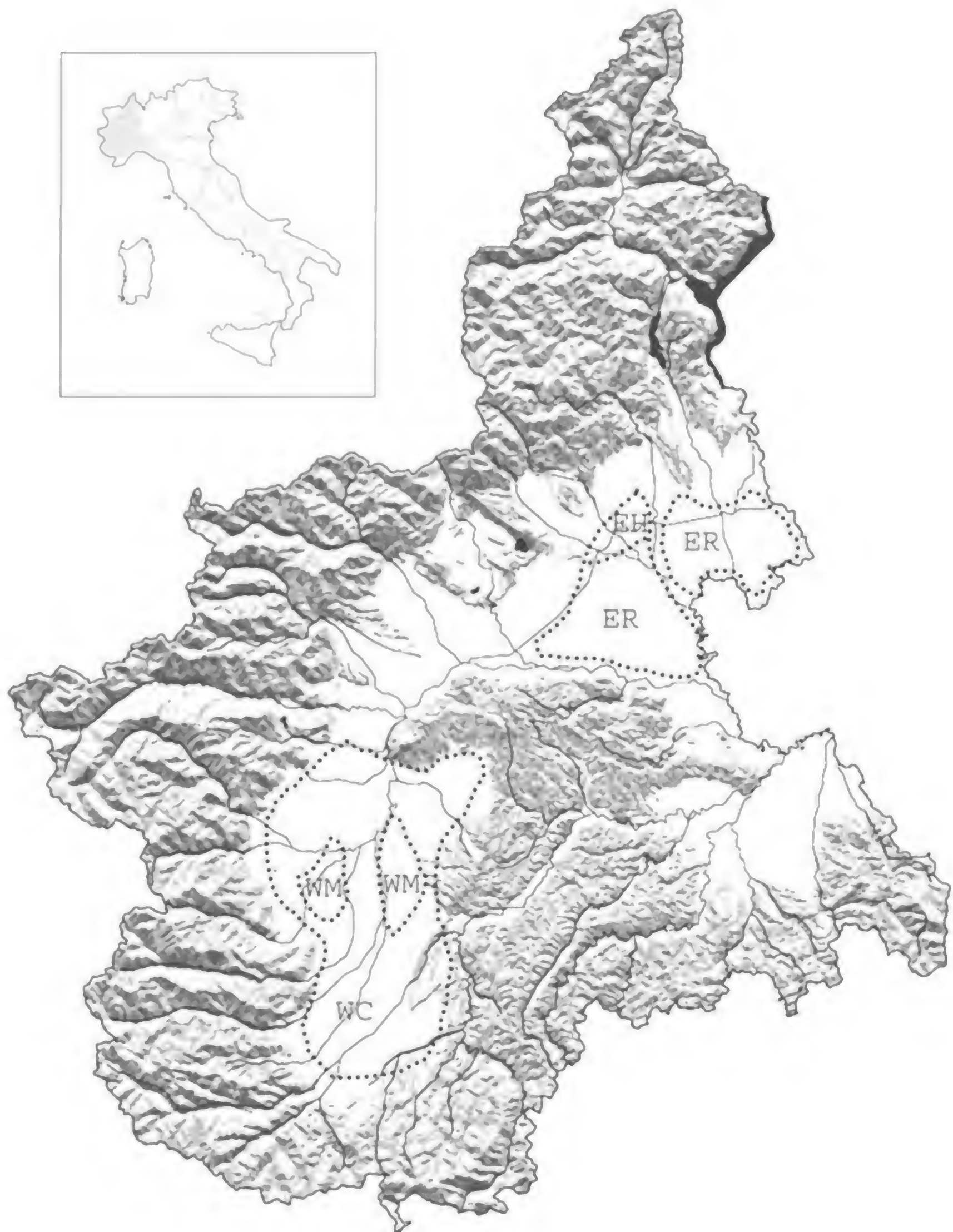
Figure 1.　The study area in the western Po Plain with the four strata (WM = western meadows, WC = western cornfields, ER = eastern rice fields, EH = eastern heathlands). Slope and mountain areas in gray.

along rivers, and with residual heathland of ancient pastoral origin (estimated area 250 km²).

We established linear transects and recorded transect length, species observed, and the perpendicular distances between the transect line and birds on both sides of the transect.

To obtain unbiased and representative estimates of densities for the whole area, according to Burnham et al. (1981) and Buckland et al. (1993), it is necessary to consider the following assumptions:

(1) *The detection probability of the birds on the transect line should be 1.* This is the most important assumption of the method: the lack of detection of some individuals just on (or very nearby) the transect line biases the results; but the method explicitly allows some animals to go undetected away from the transect line. In practice, it is necessary to ascertain that no birds fly from the transect line undetected. This condition was not difficult to meet with medium to large raptors (e.g., Common Buzzard) in open country, but may be problematic with smaller or more elusive species (e.g., Eurasian Sparrowhawk, Merlin).

(2) *The perpendicular distances from the transect and each observed bird should be estimated accurately.* The authors alternatively assumed the roles of observer and driver and the accuracy of the observations and measurements was improved with slow driving (15–40 km/hr) and the use of binoculars (LEICA Geovid 7 × 42 BDA) that estimate the distances with a laser telemeter (precision of ±1 m; range 25–1000 m). The distances of birds under 25 m were paced or estimated visually. Birds flying away from the line due to the approaching vehicle were measured at the perpendicular distance from transect where they were first seen. A few birds flying independently from our approach were recorded when they came abeam of the vehicle. All the birds observed were counted with no truncation distance, and, due to the open habitat, we saw birds up to 550 m, but for the DISTANCE analysis we truncated the data at 450 m to eliminate outliers.

(3) *The transect should be allocated randomly with respect to the distribution of the counted animals.* For the estimated densities to be representative of the true densities, the transects should be allocated independent of the bird distribution. This requisite is the most difficult to accomplish. Because we could obtain a sufficient number of observations only with very long transects, we were required to travel along existing roads.

Generally road transects should be avoided because they are likely to be unrepresentative of the entire area (Buckland et al. 1993) due to the disturbing effects of traffic that drive away the birds, and because roads sometimes run parallel to power and telephone lines, that may favor higher densities of birds. We tried to reduce these problems by using secondary and dirt roads; moreover, we traveled the routes on days with low traffic such as Sundays and holidays.

During the first winter, the transect selection was influenced by our knowledge of the territory. In the second winter, from the Italian Geographical Militar

Institute (IGMI) 1:25 000 maps of the study area, we pre-selected routes crossing the center portions of each map and maintained a prevailing transect direction (east-west or north-south) as much as possible. When we were obliged to change routes for whatever reason, we selected the new route at random. We did not exclude the small country towns (along <2 km of road) from the transects, which occur at a relatively high frequency in the study area.

We counted mainly from 1000–1500 H because in winter the daylight is relatively short: at 1600–1630 H it becomes dark and in the morning fog is often present, so the middle hours of the day are the best conditions for the counts. We did not notice obvious differences of bird behavior during these hours.

During the survey season, the birds were wintering and there was no noticeable movement; the migration in the region lasts from March–May and from August–November for all the species. Mortality due to starvation between the beginning of December and the beginning of February was probably not important because the winters were not particularly hard.

(4) *The observations should be independent of each other.* We did not observe clusters of birds and so the observations were probably independent of each other.

(5) *The length of the survey should be sufficient to detect at least 30–40 and preferably 60–80 animals.* We sampled 455 km of transect in the first winter and 405 km in the second, subdivided into 19 and 18 transects respectively of 10–30 km each. We did not replicate routes, but used different transects for each survey. In a day we sampled 100 km of transect and generally counted one day each week.

During the first winter, we collected sufficient data only to estimate the density of Common Buzzards Therefore, in the second year, we subdivided the effort to sample a sufficient number of Common Buzzards in each strata.

Finally the calculation of the densities and abundances was made with the program DISTANCE 3.5 (Thomas et al. 1998) and the variance was calculated empirically; the program fit a series of functions to the distance data and the model best fitting the data was selected by use of the Akaike Information Criterium (AIC) (Anderson and Burnham 1999).

The comparisons among the estimated densities of the different strata were made with the technique described by Hines and Sauer (1989), implemented in the program CONTRAST.

RESULTS

We counted 251 raptors (Table 1): Common Buzzards, Eurasian Kestrels, Peregrine Falcons (*Falco peregrinus*), and the single Red Kite (*Milvus milvus*) were mostly perched when observed (<5% of buzzards recorded flying); Hen Harriers, Eurasian Sparrowhawks, and Merlins were usually seen flying. Excluding the Common Buzzard, the only species for which we made a sufficient number of observations to estimate density, the indices of

Table 1. Raptors observed in the primary study areas of the western Po Plain, northern Italy, in the winter.

SPECIES		1998–99 WESTERN AREA		1999–2000 WESTERN AREA		1999–2000 EASTERN AREA	
		N	N/km	N	N/km	N	N/km
Common Buzzard	*Buteo buteo*	71	0.16	57	0.19	82	0.80
Kestrel	*Falco tinnunculus*	13	0.03	6	0.02	9	0.09
Sparrowhawk	*Accipiter nisus*	6	0.01	1	0.00	3	0.03
Peregrine	*Falco peregrinus*	2	0.00	0	—	2	0.02
Hen Harrier	*Circus cyaneus*	1	0.00	0	—	1	0.01
Merlin	*Falco columbarius*	0	—	1	0.00	1	0.01
Red Kite	*Milvus milvus*	0	—	0	—	1	0.01
Total		93	0.20	65	0.21	99	0.97
Sampling effort (km)			455		303		102

abundance (hawks/km) of all other birds were generally low: in the western part of the area we drove 20–30 km to see one non-buzzard raptor, but the situation was better in the eastern area, where we observed a mean of 1 raptor/6 km.

Common Buzzard Density. Following the guidelines of Buckland et al. (1993:46–51) we analyzed the data with DISTANCE, testing the uniform and half-normal keys alone and with cosine and Hermite adjustments. We selected the best models based on the lowest AIC values for each strata.

Analysis of the data collected during the first winter in the western zone shows a mean density of 0.69 Common Buzzards/km² (95% C.I. = 0.51–0.93 hawks/km²; length of transect = 455 km). However, during the fieldwork we noticed apparent density variation with a high frequency of encounters (about one buzzard per km) in some patches interspersed with large areas with an encounter rate of <1 hawk every 5 km. This obser-

vation and the inclusion of the eastern area induced us to stratify the sample in 1999–2000. The analysis of these data showed similar detection curves among strata, as partly expected from the relative homogeneity of the agricultural landscape of the Po Plain. Therefore, we decided to fit the detection function to data pooled across the four strata. As suggested by Buckland et al. (1993), if the AIC of the latter analysis is lower than the sum of the AIC values for the four strata, we can assume a common detection function across strata and estimate encounter rate and density separately by stratum. The AIC of the pooled analysis (395.97) was lower then the AIC sum of the models for each strata (396.89). Thus, we present the histogram of sighting data (Fig. 2) and the estimates for each strata (Table 2).

A contrast analysis (Hines and Sauer 1989) among the four estimates indicates a significant density difference among strata ($\chi^2 = 209.25$, df = 3, $P < 0.001$). This difference seemed to be entirely due to the lower density of hawks in the western cornfields stratum, as no statistical significance was achieved by contrasting the other three strata ($\chi^2 = 4.54$, df = 2, $P = 0.10$).

DISCUSSION

Our results show that the line-transect method in the study area can, with moderate effort, generate suitable results for the most common species, the Common Buzzard. The other wintering raptors are much scarcer, and only for the Eurasian Kestrel would we likely obtain a sufficient count to estimate density with an effort of 1000–2000 km of transect. Another strategy would be to pool data
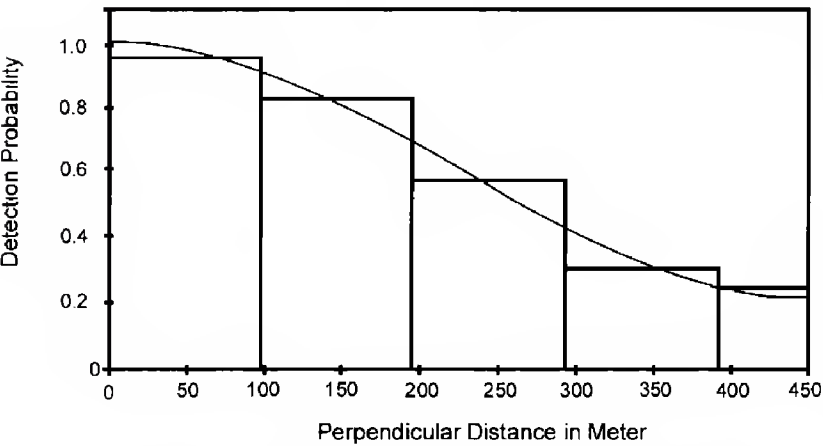

Figure 2. Graphical representation of sighting distances of buzzards from transects (winter 1999–2000) and fitted detection curve ($\chi^2 = 0.158$, df = 3, $P = 0.984$).

Table 2. Density estimates based on a DISTANCE analysis of Common Buzzard data for the winter 1999–2000 (uniform key with cosine adjustment of order 1).

Stratum	Length (L) (km)	N	N/L	SE (N/L)	Density (hawks/km²)	SE (D)	95% C.I. (hawks/km²)
Western cornfields	262	32	0.12	0.02	0.22	0.03	0.16–0.30
Western meadows	41	25	0.61	0.01	1.11	0.07	0.97–1.26
Eastern rice fields	61.7	44	0.71	0.06	1.30	0.13	0.99–1.69
Eastern heathlands	40	35	0.87	0.12	1.59	0.25	1.03–2.45

across years for estimating a detection function, provided no significant difference in detection probabilities among years exists.

We realize that our estimates may only be inferred to the limited areas along the transect roads, but we suggest that the estimates may be a reasonable approximation of the densities typical of the western Po Plain. This suggestion follows from our selection of secondary roads, from the large effective strip width sampled, and from the high density of such secondary roads, irregularly crossing the entire region.

Moreover, the estimates of density obtained for the Common Buzzard were very similar to those obtained near Biella (Table 3) with intensive searches in restricted areas included in our "eastern heathlands" subarea.

Therefore, based on our analysis using DISTANCE, we estimate the wintering Common Buz-

zard population of the region as follows: 1620 (95% C.I. = 1250–2110) individuals in the eastern rice fields, 400 (260–610) in the eastern heathlands, 600 (440–820) in the western cornfields, and 560 (490–630) in the meadow area, with a combined estimate of 3180 individuals (2690–3760).

Clearly the data demonstrate that cornfields are a less suitable wintering habitat for Common Buzzards (Table 2) than other habitats. However, rice fields seem to be equally suitable as meadows and heathlands. The index of abundances (hawks/km) of these areas are, in fact, much higher than known for other Italian regions and many Mediterranean countries (Table 4). The density estimates (Table 3) are, however, lower than those observed in some central European countries such as France and Germany.

Finally, on the basis of the known distribution of Common Buzzards (Cucco et al. 1996), we specu-

Table 3. Density estimates of wintering Common Buzzards in some European and Mediterranean countries.

Area	Years	Effort (km²)	N/km²	Sources
Biella, Piemonte (Italy)	1983–84 1986–87	36.75	0.67–1.24	Bordignon 1998
Novara, Piemonte (Italy)		88	0.18	Mostini 1981
Vercelli, Piemonte (Italy)			1.9	Ruggieri in Cucco et al. 1996
Po River, Piemonte (Italy)			0.5–1.0	Pulcher in Mingozzi et al. 1988
Lombardia (Italy)			0.007	Canova in Brichetti et al. 1992
Ostholstein (Germany)			0.17–0.23	Westernhagen 1966 in Glutz & Bauer 1980
Mittel and Sud-Mecklenburg (Germany)			1.0–3.5	Jung 1970 in Glutz & Bauer 1980
Baden-Württenberg (Germany)		840	0.9	Jacoby & Schuster in Glutz & Bauer 1980
Oberrheinebene Bodenseegebiet (Germany)			2.0–2.1	Jacoby & Schuster in Glutz & Bauer 1980
Schwabische Alb (Germany)			0.41	Jacoby & Schuster in Glutz & Bauer 1980
Westfalen (Germany)			1.3–5.2	Mester & Prunte 1968 in Glutz & Bauer 1980
Plzeň (Germany)	1993–96	4.2	2.4–5.1	Schropfer 1997
France			1.5–4.0	Nore in Yeatman-Berthelot 1991

Table 4.   Indices of abundance of wintering Common Buzzards in some European and Mediterranean countries.

AREA	YEARS	EFFORT (km)	N/km	SOURCES
Cote d'Or (France)	1966–77	10748	0.22	Bloc 1987
Aube (France)	1970–77	24120	0.40	Bloc 1987
Rhone-Alpes (France)	1981–86	?	0.28–0.46	Bloc 1987
Camargue (France)	1972–73	240	0.01–0.03	Walmsley in Blondel
	1974–75			& Isenmann 1981
Sicilia (Italy)	1977–80	1676	0.04–0.07	Massa 1980
Sicilia (Italy)	1987–90	2233	0.06 (0.03–0.14)	Sarà 1996
	1993–94			
Sardegna (Italy)	1989–90	1630.7	0.09 (0.07–0.12)	Sarà 1996
	1991–92			
Basilicata (Italy)	1993–94	818.5	0.06	Sarà 1996
Puglia (Italy)	1993–94	606	0.006	Sarà 1996
Tunisia	1987–88	1638	0.005	Sarà 1996
	1989–90			

latively generate an estimate for the entire western Po Plain (in the Piemonte region) attributing the lower density estimate (0.22 hawks/km^2) to the remaining 2500 km^2. Thus, we estimate a total wintering population of about 3700 (3200–4400) Common Buzzards. We suggest this is an underestimate because the lower densities, which are likely in some intensively-cultivated areas, should be overcompensated by a higher density of hawks along many riparian corridors.

The only other comparable Italian estimate is that of the wintering populations of the nearby region Lombardia provided by Fornasari et al. (1992); these authors, observing 246 Common Buzzards from 5731 points and assuming a detection distance of 200–500 m, estimated 1300–8000 birds over the whole region (23 850 km^2 including hills and mountains). Jointly, these results emphasize that the estimate of under 5000 wintering Common Buzzards (Chiavetta 1986) for the whole of Italy (301 302 km^2) was an underestimate.

Finally, we suggest that the distance transect method should be used for future raptor surveys to provide more rigorous comparisons of density and abundance estimates over large areas.

ACKNOWLEDGMENTS

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Short Communications

Bald Eagle Reproductive Performance Following Video Camera Placement

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Key Words: *Bald Eagle,* Haliaeetus leucocephalus; *behavior, Great Lakes, reproductive performance, video camera.*

Bald Eagle (*Haliaeetus leucocephalus*) nesting behavior is difficult to quantify because of the sensitivity of adult eagles to human activity and their habit of nesting in supercanopy trees often not visible from the forest floor. Time-lapse movie cameras have been utilized in at least two studies of nesting Bald Eagles. Cameras were placed at three nests in northern California when nestlings were 4–6 wk old (Jenkins 1989) with no adverse effects on adult behavior or reproduction. However, cameras placed at nests during incubation and the first two weeks post-hatch caused a high rate of nest abandonment at nests in southeast Alaska (Cain 1985). Both studies also employed repeated visits to the nest site to change film and batteries. To minimize this type of disturbance, we located video recorders 200–400 m from Bald Eagle nest trees and mounted cameras remotely at nests to quantify adult and nestling behavior (Dykstra et al. 1998, 2001, Warnke et al. 2002). As a test of our hypothesis that this technique would not decrease Bald Eagle reproductive success, we documented eagle reproductive performance following camera placement and compared it with the average reproductive performance of a healthy, rapidly expanding population in northern Wisconsin.

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Methods

Study Areas. Bald Eagle nests studied were clustered primarily in three regions in northern Wisconsin: inland Wisconsin, along the Lake Superior shore, and along the Lake Michigan shore. Northern Wisconsin inland nests were located along the shores of natural lakes, reservoirs, or large rivers in Iron, Oneida, and Vilas counties, Wisconsin. Lake Superior nests studied were <8 km from the Lake Superior shore in Iron, Ashland, Bayfield, and Douglas counties, Wisconsin. Lake Michigan nests studied were <8 km from the Lake Michigan shore in Oconto and Marinette counties, Wisconsin. A single nest was studied in central Wisconsin (Adams county) along the Wisconsin River Study areas were described by Warnke et al. (2002). Cameras were placed at selected nests located in all study areas ("camera nests" hereafter). For comparison, we measured reproduction at all 1992–94 nests not disturbed by camera placement in Vilas and Oneida counties ("undisturbed nests" hereafter). Human activity (primarily hikers, boats, airplanes, and automobiles) differed from nest to nest, but was generally low at Lake Superior nests (camera nests) and moderate at northern Wisconsin inland nests (camera and undisturbed nests) and Lake Michigan nests (camera nests).

Video Cameras. Video cameras (four Sony model M-350 and two Sony model M-332) were mounted adjacent to or in the nest tree above nests between November and early February at 17 nests from 1992–96. The timing of camera placement was selected to coincide with the period that eagles were least likely to be on their territories, because most northern Wisconsin pairs migrate south in winter. Video cameras were also mounted at three nests during the summer prior to our experiment and left in place over winter for the spring breeding season (1994–98).

Cameras were placed in trees ≤15 m from the nest and

Table 1. Reproductive performance of Bald Eagles at nests where video cameras were placed and at undisturbed nests in northern Wisconsin, 1992–98.

Nest Treatment	Young per Breeding Attempt (N)		Young per Successful Nest (N)		Nest Success[1] (Percent)
Camera nests	1.28	(18)	1.77	(13)	72
Undisturbed nests	1.26	(362)	1.68	(271)	75

[1] Percent of breeding attempts that were successful.

ca. 1–3 m above the level of the nest bowl or 1.1–2.0 m above the nest in the nest tree. Cameras were camouflaged by fixing natural or artificial vegetation such as spruce (*Picea* spp.), northern white cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and pine (*Pinus* spp.) boughs to 2.5-cm mesh chicken fencing and fastening this around the camera and its mounting plate. Coaxial cable (RG-8UM type) connected cameras to the video recorders, which were located 200–400 m from the nest tree, out of the line-of-sight from the nest tree. Time-lapse video recorders (two Sony® EVT-820 Fieldcams and one Fuhrman WCMS-4/V11) were used to record nest behaviors. Video tapes were replaced about once per week at nests containing eggs or nestlings. Researcher activity in the vicinity of the nest during the breeding season consisted primarily of weekly visits to the recorder to change batteries and tapes. For details, see Warnke et al. (2002).

Reproductive Success. Reproductive outcomes at camera nests were determined by observing video recordings from each nest throughout the breeding season. Nests were considered to be breeding attempts if eggs were laid (Steenhof 1987) and were considered successful if at least one nestling was raised to fledging age. Nests were considered unoccupied if no eggs were laid, and failures if eggs were laid but no nestlings were fledged.

Reproduction at undisturbed nests was assessed during 1992–95 by the Wisconsin Department of Natural Resources (WDNR) by inspecting nests from the air twice during the breeding season, once during incubation, and again when nestlings were 4–7 wk old. In the first aerial survey, nests where the eagle pairs were incubating eggs were counted (defined as a "breeding attempt" by Steenhof [1987]), and in the second survey, the nestlings were counted.

We compared reproductive outcomes at camera nests to that at undisturbed nests. Eagle productivity for all nests was calculated in two ways: (1) by dividing the total number of young produced by the total number of territories where birds attempted breeding and (2) by dividing the total number of young produced by the total number of successful territories. Nest success was determined as the proportion of breeding attempts producing ≥1 young.

RESULTS

Video cameras were placed in or adjacent to nest trees within 20 Bald Eagle territories in northern Wisconsin

from 1992–98. Eagles at 13 of these territories (65%) nested in the tree where the cameras were placed, eagles at five of these territories (25%) nested at alternate nests within the territory, and two territories were not occupied (10%). Nesting was successful at 13 of 18 territories where breeding attempts occurred (72%; Table 1); nine of 13 nest attempts were successful when eagles nested in trees where cameras were placed (69%), while four of five attempts were successful at alternate nests (80%). Twenty-six young hatched at the 18 territories where breeding attempts occurred (1.44 nestlings hatched/breeding attempt) and 23 young fledged (1.28 fledglings/breeding attempt; Table 1); one nestling was killed by its older sibling at about 1 wk of age at an inland nest and two nestlings were killed by a mammalian predator at 6 wk of age near Lake Superior.

Camera nests and undisturbed nests did not differ in any measure of productivity (Table 1). The reproductive success of eagles at undisturbed nests averaged 1.26 ± 0.05 young/breeding attempt (N = 362, t = 0.08, P = 0.93) and 1.68 ± 0.04 young/successful nest (N = 271, t = 0.53, P = 0.60; Table 1).

DISCUSSION

Our results indicated that video cameras can be used to document adult and nestling Bald Eagles' behaviors without causing a decrease in productivity. In other studies, a productivity rate >0.8–1.0 young/occupied territory has been associated with healthy, expanding Bald Eagle populations (Buehler et al. 1991, Best et al. 1994, Bowman et al. 1995). Productivity at undisturbed nests in northern Wisconsin averaged 1.26 young/breeding attempt in 1992–94, or 1.1 young/occupied territory (measured 1994–95), similar to the reproductive success observed at camera nests. Comparison of reproductive performance at camera nests (1.28 young/breeding attempt) to that indicative of healthy populations (>0.8–1.0 young/occupied territory) is complicated by the use of slightly different reproductive measurements, but other investigations have shown that the number of young/occupied territory is about 10% lower than the number of young/breeding attempt in this region (Dykstra 1995) Thus, the reproductive rate at both camera nests and un-

disturbed nests was likely greater than that associated with healthy, expanding populations.

Two factors may have contributed to the low impact of video cameras used in this study. First, at territories where cameras were mounted in winter, great care was taken to mount cameras when eagles were not present on the territory; this was only possible because all pairs we studied were migratory. Second, the location of the recorder, 200–400 m from the nest tree, ensured that eagles were not disturbed when tapes were changed and batteries were replaced. If coaxial cable was damaged (by fallen trees or by animals' chewing) within sight of the nest tree, repair was not undertaken until chicks were banded at 4–6 wk of age (two territories). Although this decision resulted in some lost data, it reflected our primary goal of minimizing impact on nesting eagles during incubation and the early nestling period.

Because some pairs nested at alternate nests within their territories, not all cameras placed in winter can be expected to provide useful information. Breeding attempts at the camera nests can be expected at ca. two-thirds of territories. The use of alternate nests in this study was probably not due to the presence of the cameras, as the frequency of switching to another nest (5 of 18 breeding attempts, 27.8%) was the same as that of an undisturbed, neighboring population of eagles in the western Upper Peninsula of Michigan ($\bar{x}$ = 30 9% annual frequency of switching to an alternate nest, 1991–93; S. Postupalsky unpubl. data) and was only slightly higher than that of inland Wisconsin eagles in the north-central region of the state (18.5% annual switch frequency, 1992–95). In addition, the nest-switching had no impact on overall productivity. Northern Wisconsin provides excellent Bald Eagle habitat, and many eagle pairs in this region have five or more alternate nests. Where alternate nests are not available in areas of marginal habitat, camera placement could be more disruptive to reproduction.

RESUMEN.—El comportamiento de anidación del águila calva (*Haliaeetus leucocephalus*) es difícil de monitorear debido a que las águilas adultas son muy sensibles a la actividad humana. Registramos el comportamiento de anidación usando video cámaras montadas cerca de los nidos y grabadores temporizados localizados 200–400 m de los nidos. Las cámaras de video fueron colocadas cerca de 20 nidos del norte de Wisconsin durante el invierno cuando las águilas estaban ausentes de sus territorios o durante el verano anterior. Para evaluar el impacto de las cámaras y de la actividad humana asociada, documentamos el desempeño reproductivo mediante cámaras emplazadas y comparamos estas con el desempeño reproductivo promedio de águilas no perturbadas del norte de Wisconsin. El éxito reproductivo en los nidos con cámaras no difirió de los nidos imperturbados (1.28 vs. 1.26 juveniles/intento reproductivo y 1.77 vs. 1.68 juvenil/nido exitoso, respectivamente). Similarmente, la anidación exitosa no difirió

(72% vs. 75% de los intentos reproductivos fueron exitosos en los nidos con cámaras y en los nidos sin perturbación respectivamente). Concluimos que las cámaras de video pueden ser usadas exitosamente para documentar el comportamiento de anidación del águila calva sin causar detrimento en la productividad.

[Traducción de César Márquez]

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Absence of Blood Parasites in Nestlings of the Eleonora's Falcon (*Falco eleonorae*)

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Parasites are an important factor influencing the dynamics of populations and the structure of animal communities (Sheldon and Verhulst 1996). In birds, haematozoan parasites have been found in more than 2500 of 4000 species examined (Bennett et al. 1992, Bishop and Bennett 1992). The order Falconiformes includes ca. 285 species (Peirce et al. 1990). No haemoproteids have been described for the families Cathartidae (75 species), Pandionidae (15 species), and Sagittaridae (15 species), but four species of haemoproteids have been described from the family Falconidae (59 species). The Eleonora's Falcon (*Falco eleonorae*) is a migratory falcon that nests on islands of the Mediterranean region and winters in southeast Africa, mainly in Madagascar and the Mascarene islands (Walter 1979).

In this study, we examined blood smears of 42 nestlings of the Eleonora's Falcon (18 in 1999 and 24 in 2000) to detect the presence of blood parasites. The only published works on the prevalence of blood parasites in Eleonora's Falcon are those by Wink et al. (1979) and Ristow and Wink (1985), who reported a low prevalence (13%) of *Leucocytozoon toddi* in adult birds (2 of 16 birds infected), but no information for nestlings was provided. To our knowledge, our work is the first to report on blood parasites in nestlings of the Eleonora's Falcon.

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Nestlings sampled came from the Columbretes archipelago, a small (19 ha) volcanic outcrop located 63 km off the coast of Castellón (39°54'N, 0°41'E) where about 30 pairs of Eleonora's Falcon breed (A. Martínez-Abraín unpubl. data). Vegetation is typical of a Mediterranean island with small shrubs and annual plants. The only sources of fresh water are two cisterns which collect water from the scarce rainfall (annual mean ca. 250 mm). All 1999 samples came from the main group of islands (Columbrete Gran and Mancolibre), but in 2000 we included samples from Foradada and Ferrera islands. Nestlings sampled came from eight different nests in 1999 and from 16 in 2000. Blood samples were collected by venipuncture of the ulnar vein of 20–25-d-old chicks from 17–22 September 1999 and from 21–23 September 2000. Smears were air-dried and fixed in methanol on the day of sampling. In the laboratory, slides were stained with Giemsa and examined under a microscope with oil at 1000×, using the techniques of Korpimäki et al. (1995). Prevalence was established through the inspection of 100 fields, containing about 100 erythrocytes each. All smears were inspected twice by the same person (A. Martínez-Abraín) and once by a second observer (B. Esparza) at lower power (400×). We sampled haematophagous night-dwelling insects in September 2000, with a Center for Disease Control (Kimsey and Chaniotis 1984) mosquito trap placed for three consecutive nights on the main island but no haematophagous insect was trapped.

No blood parasites were found in the 42 blood samples taken from Eleonora's Falcon nestlings. Because the Eleonora's Falcon is an island species and marine habitats seem to represent an unsuitable environment for po-

tential vectors of haematozoan parasites (Little and Earlé 1994, Piersma 1997) it is very likely that the absence of blood parasites in the nestlings sampled is due to the absence of appropriate vectors in the Columbretes Islands, located far from the mainland. The lack of appropriate vectors is one of the reasons commonly used to explain the absence of blood parasites in birds linked to saline or marine habitats (Greiner et al. 1975, Figuerola et al. 1996) and in Spain birds associated with cliffs, like the Griffon Vulture (*Gyps fulvus*) (Blanco et al. 1998). Tella et al. (1996) attributes the low prevalence of *H. tinnunculi* in adults of the Lesser Kestrel (*Falco naumanni*), breeding in open, arid areas of the northern Iberian plateau, to the scarcity of suitable vectors. In contrast, adult falconids breeding in forested areas may have higher prevalences of infection, as is the case of the American Kestrel (*Falco sparverius*), with a prevalence of 85% (Apanius 1991), 74% for females and 53% for males (Wiehn et al. 1997), and 75% (Castellucci et al. 1998). However, neither Korpimäki et al. (1995) studying Eurasian Kestrels (*Falco tinnunculus*) or Apanius and Kirkpatrick (1988) studying American Kestrels, were able to detect blood parasites in most nestlings, although 69% of juvenile American Kestrels were infected with *H. tinnunculi* during the autumn migration. Thus, parasite transmission by *Culicoides* vectors, for forest-dwelling falconids, may happen mainly after fledging and before the first autumn migration. This seems not to be the case for chicks of the Eurasian Sparrowhawk (*Accipiter nisus*) which showed very high *Leucocytozoon toddi* parasitemias as early as 12–14 d of age (Peirce and Marquiss 1983, Ashford et al. 1991) as well as for chicks of the Northern Goshawk (*Accipiter gentilis*) (Toyne and Ashford 1997). Tella et al. (1999) found that macrohabitat constraints are important in the dynamics of hematozoan transmission. They suggested that the overall low prevalence of blood parasites in Spanish diurnal birds of prey may be due to an overall scarcity of hemoparasite vectors, because Iberian habitats are commonly drier and less-forested than temperate or boreal areas. Sol et al. (2000) have shown that the prevalence of *Haemoproteus columbae*, among near-by populations of the Rock Dove (*Columba livia*), unequivocally paralleled variation in abundance of its main vector, which represents strong support for the hypothesis linking prevalence and vector abundance.

A more comprehensive insect survey and the sampling of adult birds in their breeding colonies would be required to strengthen our conclusions.

RESUMEN.—Se examinaron 42 frotis sanguíneos de pollos volantones de halcón de Eleonora (Falco eleonorae) de la colonia de las islas Columbretes (NE, España). No se hallaron hemoparásitos en ninguna de las muestras. Se sugiere que la ausencia de vectores apropiados en las islas podría explicar la ausencia de parásitos sanguíneos, aunque se deberá realizar un mayor esfuerzo de muestreo de vectores así como obtener frotis de aves adultas para confirmar nuestras conclusiones.

[Traducción de los autores]

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POSSIBLE CHOKING MORTALITIES OF ADULT NORTHERN GOSHAWKS

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Choking deaths in wild birds are rarely reported in the ornithological literature. Such incidences have been reported in some easily-observed birds such as Pelecaniformes (Skead 1980, Wilson and Wilson 1985, Septon 1989, Bunkley et al. 1994) and Anseriformes (Septon 1989,

Holzinger 1989), as well as in White-backed Vultures (*Gyps africanus*) (Carlyon and Meakin 1986). However, we only found one reported observation involving raptors, a Tawny Owl (*Strix aluco*) (Spirett 1984). Here we report on two cases of apparent choking mortality in female Northern Goshawks (*Accipiter gentilis atricapillus*) nesting in the western United States.

We fitted an adult female Northern Goshawk with a backpack-harness radio transmitter in early June 1998 at her nesting territory in western Washington. Weekly radiotelemetry monitoring over the next 30 d showed that she remained primarily in the nest stand and <200 m from the nest until early July. After that she began leaving the area to hunt and deliver prey to the one fledgling from this nest. Use of the surrounding landscape by this bird appeared normal over the next couple of weeks as she, and her mate, continued to supply food to the developing fledgling. On 12 July, we observed this goshawk about 4 km from her nest within minutes after capturing a Douglas' squirrel (*Tamiasciurus douglasii*). We approached the bird by homing in on the telemetry signal and identified the prey by fur remains below her perch site after she flushed. She landed 100 m away and continued feeding.

Seven days later we returned to the area and found her dead about 300 m from the location where the squirrel was killed. The goshawk had not been preyed upon or scavenged. There was no sign of any broken bone or recent wound. She was lying on the forest floor, ventral side down with wings spread out. About 10 m away we found a large Douglas-fir (*Pseudotsuga menziesii*) in which she apparently spent a considerable amount of time before dying. There were multiple patches of feces, five goshawk retrices, and one goshawk remige below this tree (other than these six flight feathers and a few chest feathers the carcass was completely intact). We inspected the oral cavity and extracted a considerable amount of Douglas' squirrel fur, of which about 1 cm in length was protruding from the mouth. In addition to the fur in the mouth, there were also bones from the squirrel in the crop, including a fully-articulated leg bone with the foot.

The fit of the harness holding the transmitter appeared normal and clearly did not directly affect the bird's flying ability. Additionally, the fit of the harness in the crop area at the post-mortem inspection did not appear to be unusually tight or high. Therefore, we do not believe that it was a factor in the death. We suspect, based on the presence of a large amount of fur in the oral cavity and a lack of evidence indicating another cause of mortality (e.g., predation, collision with tree, disease), that this bird suffocated to death while consuming the Douglas' squirrel. We are not certain if it was the same squirrel that was captured the previous week. It is possible that researcher disturbance played a role in this occurrence. Perhaps the goshawk was forced to fly at a time when it normally would not and a portion of the squirrel became lodged in the trachea, making breathing difficult.

The second case occurred in east-central Arizona. On 3 June 1999, we set up a remote camera at a Northern Goshawk nest in order to assess nestling food habits. Also, as part of a long-term demography study of this population, all adult females were marked with alpha-numeric coded, colored leg bands (not radio tagged). On 12 June, just prior to dawn, we set up a dho-gaza net array, with a Great Horned Owl (*Bubo virginianus*) as lure, to trap and mark the adult female. We had received no response from the adult female by 30 min after sunrise, so we examined the nest area. We climbed the nest tree and found the adult female dead, lying on her back on the outer rim of the nest. We also found two 10–14-d-old live nestlings, one whole Steller's Jay (*Cyanocitta stelleri*), a partially consumed chipmunk (*Tamias* spp.), Northern Flicker (*Colaptes auratus*) feathers, and the head of a short-horned lizard (*Phrynosoma douglassi*). Upon inspecting the adult female we found a 20-cm-long piece of cottontail rabbit (*Sylvilagus* spp.) hide stuck down her throat, of which about 5 cm protruded from the mouth.

We subsequently inspected the videotapes from 9–12 June and found that at 1515 H on 9 June the adult female brought a decapitated cottontail rabbit to the nest After feeding the young for ca. 30 min she left the remains of the rabbit in the nest and flew off. The tape stopped recording at 1615 H. When the camera resumed recording on 10 June, 0.5 hr before sunrise, she was already dead. For the following 2 d (10 and 11 June) the nestling goshawks consumed the rabbit.

While death by asphyxiation (caused by fur blockage of the tracheal passageway) appears to be the most parsimonious explanation for these events, we must consider possible alternative scenarios. Predation by avian or mammalian predators while the goshawks were consuming their prey is unlikely. Neither bird showed evidence of being punctured by teeth or talons. If an avian predator, such as a Great Horned Owl, killed either of the birds, it would seem likely that the owl would have then fed on the dead goshawk. If the goshawk was able to escape after being hit initially, it seems unlikely that it would still have a large amount of fur in its mouth when it died. Diseases, such as trichomoniasis, are a possibility; however, both of these birds were at least midway through a successful breeding season suggesting that they were healthy. In adult birds substantial mass loss occurs with this disease (Arnall and Keymer 1975) and birds will be emaciated upon collection. While the Washington bird was recovered too late to assess body condition, the Arizona bird was in good flesh with no signs of chronic mass loss. It is possible that the birds had a mild case of this disease and it, in conjunction with eating prey, caused difficulty in swallowing (P. Redig pers. comm.). Both of these birds were in relatively remote locations, which make diseases associated with eating pigeons or doves (Columbidae), such as trichomoniasis or liver hepatitis, unlikely causes. Neither of these birds received an immediate necropsy by a trained veterinarian. If conducted, these birds may

have showed important signs of cause of mortality, such as disease. In the absence of such an evaluation, however, death by asphyxiation associated with consuming mammalian prey is a reasonable deduction.

Resumen.—Reportamos dos casos separados de muertes por shock en dos hembras adultas de azor norteño (*Accipiter gentilis atricapillus*) en el oeste de los Estados Unidos. Los azores monitoreados durante la epoca reproductiva (uno con telemetria y el otro en el nido con una camara de video), fueron encontrados muertos con cantidades protuberantes de piel de mamifero en sus bocas. Ninguno de los dos mostro signos de mortalidad causada por depredacion o enfermedad. Aunque una necropsia hecha inmediatamente por un veterinario hubiera mostrado signos de de otra causa de mortalidad, como una enfermedad, esto fue descartado. In ausencia de dicha evaluacion, concluimos que estos azores murieron por asfixia asociada al consumir un mamifero.

[Traducción de César Márquez]

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EXHUMATION OF FOOD BY TURKEY VULTURE

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The success of Turkey Vultures (*Cathartes aura*) as forest scavengers is largely due to their highly developed sense of smell (Owre and Nothington 1961). Stager (1964) conducted a set of experiments with ethyl mercaptan which confirmed the ability of Turkey Vultures to locate odors when no visible object was associated with them. Turkey Vultures fly low over the forest canopy and can detect carrion on the forest floor entirely by smell. Carcasses that are completely hidden by foliage have been located as readily as visible ones (Houston 1987). Turkey Vultures evidently cannot detect animals that have recently died if hidden from view (probably because such carcasses do not yet emit a detectible smell) but are highly efficient at locating carcasses >1-d old and tend to reject those that are badly decayed (Houston 1986). The ability of Turkey Vultures to locate carrion hidden from view is well documented, though excavation of buried food is not reported in the review by Kirk and Mossman (1998).

On 21 July 1989 near Guilford, Connecticut, a woodchuck (*Marmota monax*) was trapped and then buried at dusk in a 2-ha tilled field that was planted with pumpkins and gourds. On that day at this site, no Turkey Vulture was observed, though people were in the field several hours, including most of the hours between trapping and burial. The carcass of the woodchuck was buried below the reach of cultivator tines and covered with ca. 10–15 cm of soil, tamped down by foot. The burial site was then tilled with a cultivator, so no visual sign of burial was present.

On 23 July 1989 the weather was clear, and the temperature at nearby Stratford, Connecticut ranged from 18–30°C (NOAA 1989). At about 1400 H the senior author noticed a Turkey Vulture circling the field. When the senior author and two farm workers left the field for a noon break, the vulture descended almost immediately and landed directly on the burial site within 20 m of the three observers. It scratched away the soil until the carcass was exposed, and then proceeded to tear off pieces of flesh. This activity was observed for several minutes; when the observers approached, the vulture left the carcass and soared over the field for several minutes before it left the area. Examination of the exposed carcass showed that the vulture had torn off and eaten the flesh from the chest and rib cage area of the woodchuck.

During the 2 mo prior to this observation, 18 woodchucks, which had been destroying pumpkins, were trapped and buried at various locations in the field. In this period, several other carcasses had been unearthed and fed upon in a similar manner. Neither mammalian scavengers nor their tracks had been observed in the field. It is possible that previous instances of exhumed and partially eaten carcasses were due to foraging Turkey Vultures, which had been observed circling this field at a height of ca. 50–60 m on previous days. The observation of a Turkey Vulture descending and immediately proceeding to unearth a buried woodchuck suggests that this bird had knowledge of the location of the carcass and that it had previous experience in this behavior.

As early as the 1930s, field petroleum engineers made practical use of Turkey Vultures' sense of smell by introducing heavy concentrations of ethyl mercaptan into natural gas pipelines to attract Turkey Vultures to the sites of leaks in the line (Stager 1964). Some obscure literature previously suggested the ability of Turkey Vultures to detect and exhume buried

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carcasses (Coles 1938, Stager 1964). We believe that our observation represents detection by smell, but we cannot totally discount that the Turkey Vulture had watched from a distance as the senior author buried the woodchuck carcass. However, this seems unlikely because Turkey Vultures normally return to their roost 1–3 hr before sunset (Davis 1983), the woodchuck was buried at dusk, and no Turkey Vulture roost existed within several km of the tilled field.

Competition has a profound influence on natural selection. For example, the development of a keen sense of smell in Turkey Vultures likely provides advantage over sympatric avian scavengers for which the sense of smell is relatively unimportant in securing food, such as Black Vultures (*Coragyps atratus*), Common Ravens (*Corvus corax*), and American Crows (*Corvus brachyrhynchos*) (Terres 1982:831). The ability to exhume carcasses enables Turkey Vultures to exploit food resources such as the prey items frequently buried and cached by red foxes (*Vulpes vulpes*) and mountain lions (*Felis concolor*) (Whitaker and Hamilton 1998), or by other large predators.

RESUMEN.—Su bien desarrollado sentido del olfato ha permitido a *Cathartes aura* localizar ítems alimenticios ocultos a la vista, pero la excavación de ítems enterrados no ha sido reportada. El 23 de julio de 1989, una guala descendió hacia un campo de Connecticut donde una marmota (*Marmota monax*) había sido enterrada en la oscuridad dos días antes. El cuerpo fue enterrado bajo 10–15 cm de suelo en un terreno labrado. La guala localizó el sitio precisamente, excavó el suelo, y comió del cuerpo a 20 m de los observadores. *Cathartes aura* tienen presumiblemente la habilidad de explotar presas escondidas por predadores tales como zorros rojos (*Vulpes vulpes*), Pumas (*Felis concolor*), y otros.

[Traducción de César Márquez]

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BATS AS PREY OF BARN OWLS (*TYTO ALBA*) IN A TROPICAL SAVANNA IN BOLIVIA

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A wealth of information is available on the diet of the Barn Owl (*Tyto alba*) in many regions of the world (Taylor 1994). Mammals, particularly rodents, are the most frequent food item (e.g., Jaksic et al. 1982). Data are overwhelmingly from temperate regions; however, information from tropical localities is scanty (Marti et al. 1993). Here, we report on the diet of the Barn Owl from Beni, Bolivia, a tropical locality where bats are taken commonly as prey.

Pellets were collected in May 1998 and 1999 at El Porvenir, the Operations Center of Reserva de la Biosfera Estación Biológica Beni (14°52'S, 66°20'W; 200 masl). The landscape is a mosaic of small forest fragments distributed over a seasonally-inundated savanna (Herrera-MacBryde et al. 2000). Pellets were collected around an occupied nest in the attic of a small building. In May 1998, there were three chicks and in 1999 there were five eggs in the nest, attended by a single adult on both occasions.

Only whole pellets with identifiable prey remains were included in the analysis. Prey were identified to the species level whenever possible, using available keys and reference collections (Aguirre and Anderson 1997, Anderson 1997, Musser et al. 1998).

We estimated the biomass contribution of each species to the diet as the percent biomass, multiplying the number of individuals in the pellets by the estimated body mass of each prey species divided by the grand sum of biomass. Also for comparative purposes, we estimated the mean mass of small mammal prey (MMSM), as the grand mean obtained from summing the products of the number of individual prey items times their mass, divided by the total number of mammalian prey in the diet (Jaksic et al. 1982). Biomass estimates of mammal species were obtained from Anderson (1997), Eisenberg and Redford (1999), and reference collections.

A total of 440 pellets yielded 567 prey items, all vertebrates except a single Coleoptera. The number of prey

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per pellet varied from one, an individual large prey, such as *Cavia tschudii*, to 13 individuals when they were small as in the case of bats. Mammals were the primary prey, accounting for 95% of items in the diet; birds were of minor importance. At least one bird was a Black-capped Donacobius (*Donacobius atricapillus*) (Troglodytidae), identified from a tag recovered from a 1998 pellet Among mammals, bats were the most frequent prey, accounting for 51% of the diet. *Myotis* spp. comprised more than one third of all items (Table 1). Nevertheless, bats accounted for only 3.4% of biomass. *Cavia* was the second most frequent prey (26%), but 63% (95) were juvenile or subadults. Overall, *Cavia* accounted for 83% of the total biomass (Table 1). Two rodents, *C. tschudii* and *Holochilus sciureus*, contributed 41% of prey items and 95% of biomass in the 2-yr sample (Table 1).

Barn Owls rarely prey on bats (e.g., Ruprecht 1979) The high consumption of *Myotis* in El Porvenir could be associated with its ease of capture. All bats captured by the Barn Owl were colonial species, some of which occurred in the same roost area. *Eptesicus furinalis*, *Sturnira*, and *Myotis nigricans* tend to roost in buildings (Wilson and La Val 1974, Mies et al. 1996) and we observed bats (species not identified) roosting in large numbers in the building where the Barn Owl nested at El Porvenir.

Mean mass of small mammal prey (136.6 ± 16.2 g; $\bar{x}$ ± 2 SE) was almost two times larger in El Porvenir than reported from the Mediterranean regions of Chile (71 g) and California (68 g) and six times larger than that from Spain (21 g; Jaksic et al. 1982). Trophic ecology of Barn Owls is determined by the frequency distribution of mammalian prey sizes available and the owl assemblage in each region (Jaksic et al. 1982). The consumption of larger prey at El Porvenir may be attributed to the availability of a large prey species, *C. tschudii*, whose body mass exceeds those in Mediterranean regions where the largest prey weights available are ca. 350 g compared to 600 g of *C. tschudii* (Jaksic et al. 1982). Alternatively, Barn Owls at El Porvenir may be hunting for relatively large prey because of a lower level of diffuse competition

Table 1. Food habits of the Barn Owl (*Tyto alba*) in Estación Biológica Beni, Bolivia.

PREY	MASS (g)	PERCENT	1998 (N)	1998 PERCENT	1999 (N)	1999 PERCENT	TOTAL (N)	TOTAL PERCENT BIOMASS
Marsupialia								
Gracilinanus sp.	19.5	0	0	0.5	1	0.2	1	0.03
Chiroptera								
Sturnira spp.	19	0	0	1.5	3	0.5	3	0.08
Eptesicus sp.	9.5	0	0	3.4	7	1.2	7	0.09
Lasiurus spp.	12	1.1	4	1.5	3	1.2	7	0.11
Myotis spp.	7.5	24.7	90	54.2	110	35.3	200	2.0
Molossops spp.	7.5	0	0	2.9	6	1.1	6	0.06
Molossus molossus	10.5	15.4	56	6.4	13	12.2	69	0.98
Molossus rufus	25	0.3	1	0	0	0.2	1	0.03
Rodentia								
Oligoryzomys spp.	28.2	0	0	1.5	3	0.5	3	0.11
Oryzomys nitidus	57	0.8	3	0.5	1	0.7	4	0.31
Oryzomys capito	64	0.3	1	0	0	0.2	1	0.09
Oxymycterus sp.	104.5	0.3	1	0	0	0.2	1	0.14
Holochilus sciureus	112.5	21.7	79	3.4	7	15.2	86	13.14
Bolomys spp.	46	0.3	1	0	0	0.2	1	0.06
Cavia tschudii juveniles	300	18.9	71	11.5	24	16.8	95	38.71
Cavia tschudii adults	600.0	8.01	30	11.5	24	9.5	54	44.01
Birds								
Passeriformes		7.4	27	0.5	1	4.9	28	—
No. Prey		100	203	100	364	100	567	
No. Pellets				235		205		440

afforded by a reduced set of syntopic owls (Jaksic et al. 1982). Depending on the specific habitat, at El Porvenir the owl assemblage may include up to seven other owl species (Brace et al. 1997), a figure slightly higher than owl assemblages in Mediterranean habitats (5–6 species; Jaksic et al. 1982). Therefore, we suggest that the large MMSM at El Porvenir is due to the availability of a large prey. Further, the two most commonly preyed rodents, *C. tschudii* and *H. sciureus*, inhabit grasslands and marshes, an open habitat that may render them more vulnerable than species inhabiting the forest fragments located closer to the Barn Owl's nest.

The Barn Owl is considered to prey primarily on rodents throughout its distributional range (Marti et al. 1983). Our study suggests that bats may represent an important diet component in some populations of tropical Barn Owls, as has been reported in some other species, neotropical owls, Stygian Owls (*Asio stygius*) in Brazil (Motta-Júnior and Taddei 1992) and Black and White Owls (*Ciccaba nigrolineata*) in Guatemala (Gerhardt et al. 1994). The possibility this

high consumption of bats is widespread among tropical owls should be examined further.

RESUMEN.—Describimos la dieta de la lechuza blanca *Tyto alba* en una sabana tropical en Bolivia. Las presas más comúnes fueron murciélagos pero en términos de biomasa, *Cavia tschudii* es la presa más importante. El tamaño de presa consumido es mayor que el hasta ahora conocido en otras poblaciones.

[Traducción de los autores]

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FOOD OF THE LESSER KESTREL (*FALCO NAUMANNI*) IN ITS WINTER QUARTERS IN SOUTH AFRICA

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The Lesser Kestrel (*Falco naumanni*) has undergone a drastic decline in this century in its breeding range in the southern Palearctic and is classified as RARE in the *Red Data Book* (del Hoyo et al. 1992, Tucker and Heath 1994). At present, 6000–10 000 breeding pairs occur in Europe (Gonzalez and Merino 1990). Recently, the greatest density of breeding Lesser Kestrels was reported in Spain, where an estimated 20 000–50 000 breeding pairs in 1980 had fallen to 4200–5100 by 1990 (Tucker and Heath 1994).

The Lesser Kestrel is migratory and most individuals winter in the grasslands of the Free State in South Africa

(Siegfried and Skead 1971, del Hoyo et al. 1992). A drastic decline in wintering Lesser Kestrels was also noted in this province, where ca. 74 000 birds were recorded during the austral summer of 1966–67 (Siegfried and Skead 1971) and only 33 900 during the austral summer of 1992–93 (Roos and Roos 1986, Colahan 1993). Prey contaminated by pesticides and the destruction of natural habitats in the Lesser Kestrel's breeding range have been suggested as the main factors responsible for the decline (del Hoyo et al. 1992, Tucker and Heath 1994).

Food availability is one of the most important ultimate factors controlling any avian population and information on the diet of a declining species, such as the Lesser Kestrel, is therefore vital for conservation. Summer diet of the Lesser Kestrel has been investigated quantitatively in Spain, France, and Austria (Cramp and Simmons 1980, Bijlsma et al. 1988). The diet in winter has been examined through the analysis of stomach contents (An-

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derson et al. 1999, Kok et al. 2000). In this paper, I present data on the Lesser Kestrel diet as determined by analysis of pellets collected in South African grasslands.

METHODS

The food of the Lesser Kestrel was determined by analysis of pellets. Most pellets were collected between November 1997 and February 1998 from a traditional roosting site in a stand of large eucalyptus (*Eucalyptus* sp.) in Oosteinde, Bloemfontein, South Africa (29°10'S, 26°15'E). About 2000 Lesser Kestrels roosted there from late October 1997 to early March 1998. A few pellets were also collected in four other traditional roosting sites (in large eucalyptus) in the Free State: at Winburg (27°01'S, 28°30'E), 70 km NE of Bloemfontein (25 pellets collected on 22 November 1997), at Reddersburg (29°39'S, 26°10'E), 40 km S of Bloemfontein (100 pellets collected on 26 January 1998), at Edenburg (29°43'S, 25°55'E), 15 km SW of Edenburg (74 pellets collected on 5 January 1998), and at Trompsburg (30°02'S, 25°43'E), 23 km SW of Edenburg (85 pellets collected on 5 January 1998). The natural vegetation around Winburg is represented by the *Cymbopogon-Themeda* Veld, while the False Upper Karoo is the natural vegetation at the other sites. Most of the natural vegetation around all four sites has been, however, converted into cultivated fields.

The rainfall during November–December 1997 was much lower (50 mm), while during January–February 1998 much higher (420 mm) than long-term (40 yr) average for these periods (ca. 140 mm for November–December and ca. 170 mm for January–February).

Only fresh and compact pellets were collected in the middle and at the end of each month of the study. Each pellet was broken apart by hand and remains of prey items were identified mainly to the level of order. The following prey remains were isolated for identification: chelicerae of sun spiders (Solifugae), exoskeletons, jaws and elytrae of orthopterans (Orthoptera) and beetles (Coleoptera), cerci of earwigs (Dermaptera), heads and wings of termites (Isoptera), and hair of small mammals (Micromammalia).

Frequency of occurrence was calculated as the proportion of the total number of pellets examined containing a given taxon. Estimation of prey number and their wet biomass in the pellets was based on the following assumptions and calculations (wet biomass of prey × mean number of prey per pellet): sun spiders, 1.4 g × 8.5 in November–December, 1.4 g × 2.5 in January–February; orthopterans 1.4 g × 2; crickets (Orthoptera: Gryllidae), 1.4 g × 1; beetles, 0.7 g × 2; scarabaeids (Coleoptera: Scarabaeidae), 0.7 g × 2; ground beetles (Coleoptera: Carabidae), 0.3 g × 2; tenebrionids (Coleoptera: Tenebrionidae), 0.3 g × 2; termites, 0.1 g × 10; earwigs, 0.1 g × 2; dragonflies (Odonata), 1.0 g × 1; scolopendras (Chilopoda: Scolopendromorpha), 2.0 g × 1; small insectivorous mammals (Mammalia: Insectivora), 10 g × 1; small mammals, 20 g × 1.

RESULTS

A total of 2050 pellets was collected from November 1997–February 1998. The Lesser Kestrel's diet during the non-breeding season was dominated by sun spiders. Or-

thopterans and beetles were also an important component, together forming 27.5% of the total number of prey items identified and 44.4% of the total wet biomass (Table 1, Fig 1). Orthoptera were mainly represented by grasshoppers (Orthoptera: Acrididae), while beetles mainly by scarabaeids. Other arthropod groups, such as earwigs, termites, cockroaches (Blattodea), dragonflies, and scolopendras constituted supplementary food (Table 1). Only a few vertebrate items represented by small mammals were found (Table 1) Three pellets contained small stones.

Sun spiders were especially numerous in the Lesser Kestrel's diet in November–December, being recorded in each pellet examined (Fig. 1a), and formed over 80% of the total wet biomass consumed (Fig. 1c) and over 70% of total prey items consumed (Fig. 1b). Out of 105 and 275 pellets selected randomly from November–December (100% of which contained sun spiders) and January–February (49% contained sun spiders), respectively, the mean number of sun spiders per pellet decreased significantly ($t = 4.10$, df $= 26$, $P = 0.005$) from November–December ($\bar{x} = 8.87$, SD $= 25.34$, range $= 1$–17, $N = 105$) to January–February ($\bar{x} = 1.40$, SD $= 8.68$, range $= 0$–10, $N = 275$).

The quantity of sun spiders consumed by the Lesser Kestrel in Bloemfontein, as reflected in the randomly-selected pellets containing sun spiders (Fig. 3), decreased as the wintering season progressed ($\chi^2 = 98.79$, $P < 0.01$, df $= 3$). In contrast, the proportion of pellets containing beetles significantly increased ($\chi^2 = 47.49$, $P < 0.01$, df $= 3$), and Orthopterans were more frequently found in pellets in January–February than in November–December ($\chi^2 = 43.22$, $P < 0.01$, df $= 3$; Fig. 1a). Similarly, the frequency with which other prey, such as earwigs, termites, small mammals etc., were taken increased toward the end of the wintering season ($\chi^2 = 11.86$, $P < 0.01$, df $= 3$; Fig. 1a)

Sun spiders were equally common at other localities in the Free State (Fig. 2), being found in almost every pellet collected ($\chi^2 = 3.49$, $P > 0.05$, df $= 7$). The contribution of orthopteran prey decreased southward, i.e., from wetter to drier areas ($\chi^2 = 23.28$, $P < 0.005$, df $= 7$), while the contribution of beetles and other prey groups to the falcon's diet (Fig. 3) was markedly different from site to site ($\chi^2 = 112.6$, $P < 0.001$, df $= 7$ and $\chi^2 = 21.86$, $P < 0.005$, df $= 7$ for beetles and other prey groups, respectively).

DISCUSSION

During the breeding season, beetles and grasshoppers constitute the bulk of the Lesser Kestrel diet, supplemented by a low frequency of large prey, such as small mammals, lizards (Sauria), bush crickets (Orthoptera. Tettigonidae), and mole crickets (Orthoptera: Gryllotalpidae) (Cramp and Simmons 1980, Bijlsma et al. 1988). In South Africa, these larger prey groups are replaced mainly by smaller sun spiders and termites, while vertebrate prey are taken only occasionally (Anderson et al. 1999, Kok et al. 2000).

Pellet analysis can underestimate the contribution of

Table 1.   Food of Lesser Kestrels wintering near Bloemfontein, Free State, South Africa. Data are from pellets collected from November 1997 through February 1998.

TAXA	FREQUENCY OF OCCURRENCE		APPROXIMATE NUMBER OF PREY		APPROXIMATE WET BIOMASS OF PREY	
	N	%	N	%	GRAMS	%
Arachnida						
Sollifugae	1695	82.6	11 558	68.3	16 180	75.0
Insecta						
Orthoptera	1478	69.9	2815	16.6	3950	18.3
Combined						
Gryllidae	141	6.9	141	0.8	200	0.9
Other						
Orthopterans	1337	63.0	2674	15.8	3750	17.4
Coleoptera	1033	50.4	2003	11.9	1175.5	5.5
Combined						
Scarabaeidae	550	26.8	1100	6.5	770	3.6
Cetoniinae	41	2.0	50	0.3	35	0.2
Carabidae	117	5.7	234	1.4	70	0.3
Tenebrionidae	45	2.2	60	0.4	20	0.1
Curculionidae	1	0.1	1	<0.1	0.3	<0.1
Unidentified						
Coleopterans	279	13.6	558	3.3	280	1.3
Dermaptera	35	1.7	70	0.4	7	<0.1
Isoptera	33	1.6	330	2.0	35	0.2
Blattodea	4	0.2	4	<0.1	1	<0.1
Odonata	2	0.1	2	<0.1	2	<0.1
Chilopoda						
Scolopendromorpha	21	1.0	30	0.2	60	0.3
Mammalia	7	0.3	7	<0.1	140	0.6
Micromammalia						
Insectivora	1	0.1	1	<0.1	10	<0.1
Small stones	3	0.2	20	0.1	10	<0.1
Total	2050		16 915	100	21 570	100

termite alates and scolopendras to the Lesser Kestrel's diet, if the hard body parts (heads, wings) are not well preserved in pellets. Anderson et al. (1999) and Kok et al (2000) showed a much higher proportion of these prey groups than I found in the diet of the Lesser Kestrels wintering in the Bloemfontein area. The prevalence of sun spiders in Lesser Kestrel diet in November–December found in this study may partly be the result of below average rainfall during the study period, but my findings need further confirmation, as pellets were collected during one non-breeding season and none were examined from an 'average' year. Under dry conditions, as those recorded in November–December 1997, mass alate termite flights that normally take place in mid-summer are delayed (pers. observ.). Hence these insects, that are typically an important component of Lesser Kestrel diet (Anderson et al. 1999, Kok et al. 2000) constituted

a small proportion of the Lesser Kestrel diet in this study On the basis of pellet analysis, Van Zyl (1993) showed a summer peak of sun spiders and winter peak of orthopterans in the diet of Eurasian Kestrels (Falco tinnunculus) in South Africa.

The importance of orthopterans in the diet of the Lesser Kestrel increases southward in the Free State. This probably reflects relative abundance of orthopterans in this province, with a much higher density in semiarid Karoo than in wetter Cymbopogon-Themeda grasslands near Winburg. Due to low rainfall, population growth of orthopterans in November–December 1997 was probably slower than normal. Such dry weather could be, however, beneficial to sun spiders, as their greatest population density is in arid areas of Namaqualand (Northern Cape, South Africa) and southern Namibia (Lawrence 1955, Warton 1981). High proportion of sun spiders in the Lesser Kes-
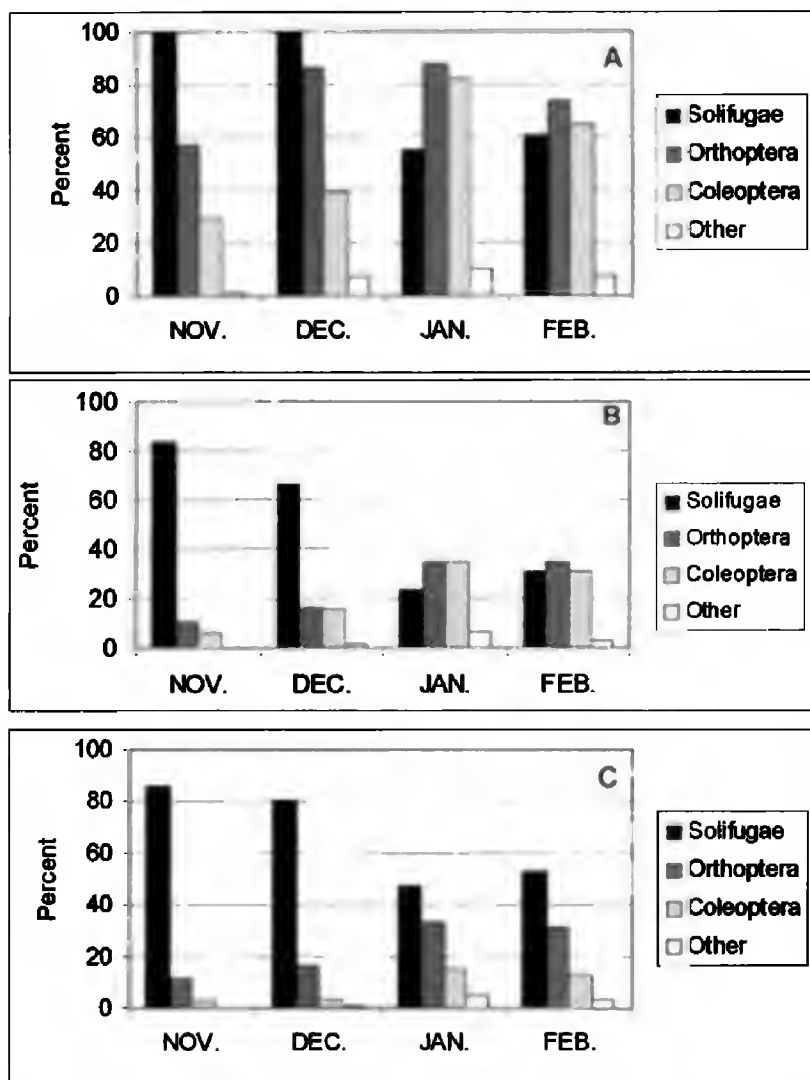
Figure 1.   Monthly changes in percent of main prey groups in Lesser Kestrel diet wintering in Bloemfontein area, South Africa. A—frequency of occurrence in 2050 pellets, B—number of prey (total number of prey items = 16915), and C—wet biomass of prey (total wet biomass = 21570 g).
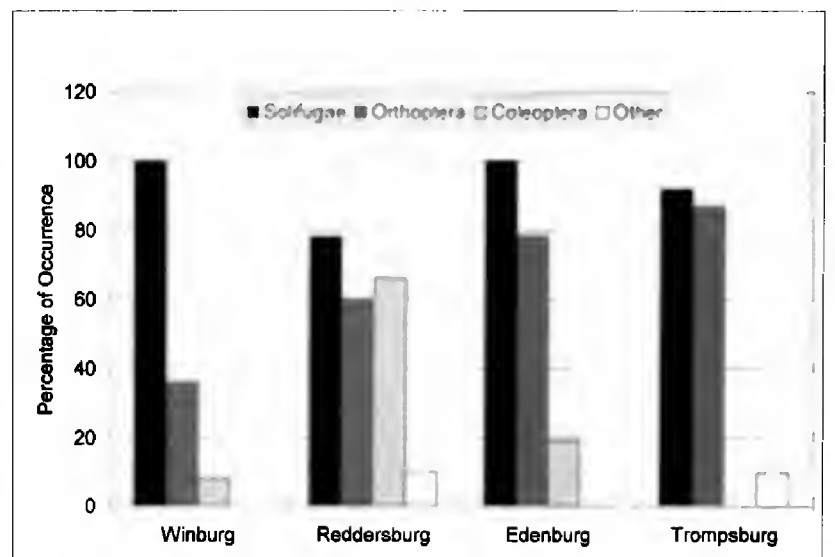

Figure 2.   Food of wintering Lesser Kestrels in different localities in the Free State. Bars indicate percentage of occurrence of given prey groups at Winburg (N = 25 pellets), Reddersburg (N = 100 pellets), Edenburg (N = 74 pellets), and Trompsburg (N = 85 pellets).

trel's diet may also be partly attributed to their rapid, mouse-like movements, which may attract the attention of Lesser Kestrels hunting from a high vantage point.

According to McCann (1994), Lesser Kestrels generally move up to 33 km from their roosting sites while foraging. About 2000 birds were present each evening at the Bloemfontein roost during the austral summer 1997–98. Assuming that each bird produces two pellets per day (Bijlsma et al. 1988, McCann 1994), I estimated that during the study period, the flock consumed ca. 2 400 000 sun spiders in an area of ca. 1500 km². This demonstrates how common sun spiders are in dry grasslands, and how important they can be in feeding Lesser Kestrels during prolonged droughts.

Both in the breeding season (Cramp and Simmons 1980, Bijlsma et al. 1988) and in the non-breeding season (Anderson et al. 1999, Kok et al. 2000) Lesser Kestrels prey extensively on arthropods, which are largely crepuscular or nocturnal (e.g., sun spiders, crickets, earwigs, scolopendras, scarabaeids, termite alate, and mole crickets *Gryllotalpa* spp.; Scholtz and Holm 1985, Bijlsma et al. 1988). Hence, it seems likely that Lesser Kestrels are to some extent crepuscular, or even nocturnal, in their for-

aging. Many birds at Bloemfontein were observed arriving at the roosting site up to a few hours after sunset. This foraging habit of wintering Lesser Kestrels has not been previously reported (Brown et al. 1982).

RESUMEN.—Presentamos los datos sobre la dieta del cernícalo menor (*Falco naumanni*), basados en el análisis de egagrópilas. Las egagrópilas (N = 2050) fueron colectadas en sitios de percha en el Free State, Sudáfrica, donde los cernícalos forrajean en pastizales y campos cultivados. La mayoría de egagrópilas fueron colectadas de una sola percha en Bloemfontein. Solifugae (Arañas sol) constituyeron el grueso de la dieta, pero Orthoptera (principalmente Acrididae) y Coleoptera (principalmente Scarabaeidae) fueron también componentes importantes. Otros grupos de artrópodos tales como Isoptera, Der-
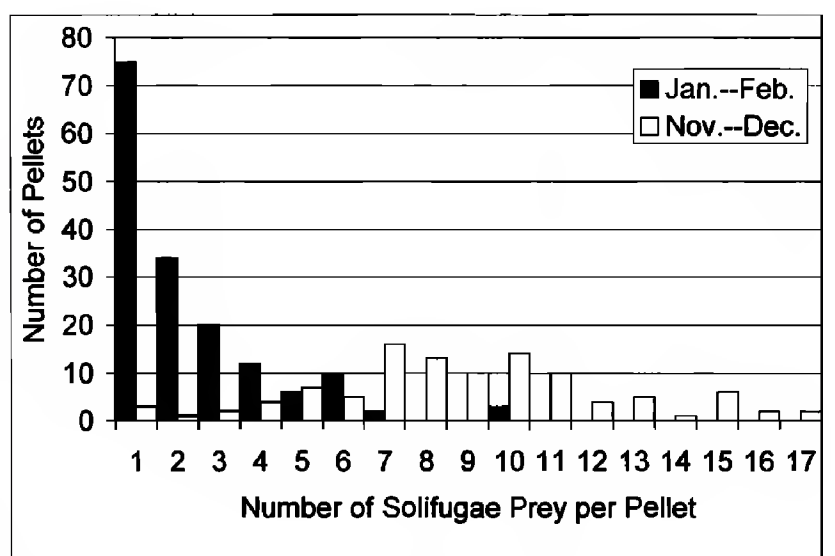
Figure 3.   Number of sun spiders per Lesser Kestrel pellet in dry months (November–December 1997; 50 mm of rainfall) compared to wet months (January–February 1998; 420 mm of rainfall) near Bloemfontein, South Africa.

maptera, Blattodea, Odonata y Scolopendromorpha complementaron la dieta. Solamente unos pocos roedores pequeños fueron registrados. La proporción de los principales grupos de presa fue similar a lo largo de Free State, pero cambio marcadamente en la estación invernal. Con la progresión del verano austral, la proporción de Solifugae decreció, mientras que los otros grupos de presa aumentaron. La gran proporción de presas crepusculares y nocturnas en la dieta del cernícalo sugiere que este es al menos parcialmente crepuscular en sus hábitos de forrajeo.

[Traducción de César Márquez]

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RED-SHOULDERED HAWK FEEDS ON CARRION

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At 0804 H on 1 June 1999 at Avon Park Air Force

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Range, Highlands County, Florida, I observed an adult Red-shouldered Hawk (*Buteo lineatus*) drop off a fence post about 65 m away and land on the grassy shoulder of a paved road. The hawk picked up an object in its talons, flew back to a fence post, and began manipulating the item. Through Zeiss 10 × 25 binoculars, I identified the prey as a Common Nighthawk (*Chordeiles minor*), with conspicuous white bars on the long, blackish wings. The nighthawk remains appeared to consist solely of feathers

and skin attached to bones of the wings and breast. No meat was visible on the nighthawk's body, and the remains appeared very much like that of a flat study skin.

For 4–5 min, the hawk plucked feathers from what remained of the breast and belly of the nighthawk, then began tearing off and consuming pieces of skin and bone. After the hawk had consumed the edible parts of the breast, it plucked all flight feathers from each of the wings and consumed what remained. Once it had finished eating, the hawk wiped its bill on the post, defecated, and flew off.

The ground around the fence post was littered with numerous flight and body feathers of the nighthawk. There was no blood on the top of the fence post where the hawk plucked and consumed the remains. On the road shoulder where the hawk had picked up the carcass, I found a large "puddle" of nighthawk body feathers, including the rectrices. The area within 0.3 m of the feather "puddle" contained many dozens of small ants, probably red imported fire ants (*Solenopsis invicta*). It appeared that the nighthawk had been killed earlier in the day and its flesh had been consumed by the ants, leaving mostly skin, bones, and feathers. Common Nighthawks roosting on roadsides pre-dawn at the Air Force Range are frequent traffic casualties (D. Leonard pers. observ., and D. Swan pers. comm.).

This observation is one of few published reports of a Red-shouldered Hawk feeding on carrion, and possibly the first observation of the species consuming avian carrion. The only mention in Crocoll (1994) of Red-shouldered Hawks eating carrion refers to Palmer (1988), who mentions a hawk in Florida that was observed to rob crows (*Corvus* spp.) of catfish heads that had been discarded by a river otter (*Lutra canadensis*). On 9 February 2000 at Northampton, Pennsylvania, an adult Red-shouldered Hawk was photographed as it perched on the carcass of a white-tailed deer (*Odocoileus virginianus*). In this case, extremely cold temperature was suggested as the cause for this unusual feeding event (R. Wiltraut *in* Bur-

geil et al. 2000). The reason for the Florida hawk feeding on a bird carcass was unclear, but a shortage of food probably was not an impetus; herpetofauna was abundant in central Florida during the summer rainy season when I made the observation. Perhaps this simply was a case of opportunistic feeding.

RESUMEN.—Observe un halcón de hombros rojizos (*Buteo lineatus*) alimentándose del cadáver de un chotacabras común (*Chordeiles minor*) en Avon Park Air Force Range, Florida. Esta es una de las pocas observaciones de esta especie comiendo carroña, y posiblemente el primer reporte de alimentación sobre los restos de un ave. La razón para este tipo de comportamiento es desconocida, pero un déficit de comida probablemente no fue el factor.

[Traducción de César Márquez]

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LETTERS

FIRST REPLACEMENT CLUTCH BY A POLYANDROUS TRIO OF BEARDED VULTURES (*GYPAETUS BARBATUS*) IN THE SPANISH PYRENEES

The Bearded Vulture (*Gypaetus barbatus*) is a territorial, cliff-nesting accipitrid vulture whose diet basically consists of bones. Monogamy is the most common mating system (del Hoyo et al. 1994, Handbook of the birds of the world. Vol. 2. New world vultures to guineafowl. Lynx Edicions, Barcelona, Spain) although some cases of polyandry (15% of 92 territories in 2000) have been documented in the Pyrenees (Heredia and Donázar 1990, *Biol. Conserv.* 53:163–171). Information available about some aspects of its breeding biology (e.g., clutch size, egg-laying, and hatching asynchrony) is scarce because nest sites are generally inaccessible and the adverse weather conditions in winter make study difficult. Replacement clutches rarely have been documented because observations during the breeding season are mostly conducted sporadically to obtain breeding parameters such as productivity and breeding success. To our knowledge one observation of a replacement clutch has been documented recently in a monogamous pair on the French side of the Pyrenees (Margalida et al. 2001, *Vulture News* 44:27–30). In this pair, egg-laying took place on 3 January 1999 and a breeding failure was observed after 13–14 d of incubation. The clutch replacement took place 28–34 d after the initial breeding failure and the chick fledged between 22–25 August when it was 124–127-d old.

In this letter, we describe the first clutch replacement observed in a polyandrous trio of an intensively-monitored Bearded Vulture breeding population in the Spanish Pyrenees. Between 1992 and 2000 we monitored (see Bertran and Margalida 1999, *Condor* 101:164–168, Margalida and Bertran 2000a, *Ardea* 88:259–264, Margalida and Bertran 2000b, *Ibis* 142:225–234) 14–19 nests per year, with a total of 138 breeding attempts observed in Catalonia (NE Spain). In this population the mean laying date was 6 January (range = 11 December–12 February, Margalida et al unpubl. data). During the breeding season of 2000 the first replacement clutch was observed. Egg laying took place on 13–16 January. On 21 January, incubation was still going on normally. On 22 January, breeding failure was confirmed although the cause was unknown. The breeding trio remained in the nesting area, but was not closely watched during the subsequent period. On 3 February, during a routine check of the nesting area, the three adult birds were seen near the nest. The next visit was on 25 February, when an adult was observed incubating inside the nest cave. Incubation proceeded normally and the egg hatched before 18 April (on 8 April an adult was still incubating and on 18 April an adult was observed feeding). Taking into account that the mean incubation period in the Pyrenees is ca. 54 d (pers. observ.), the replacement clutch would have been laid between 14–25 February, 24–35 d after the initial breeding failure. The chick fledged between 28–31 July when it was >102-d old.

This is the first replacement clutch confirmed for the southern side of the Pyrenees. The second clutch could not have been laid by birds other than the polyandrous trio after breeding failure, given the territorial behavior of the species (Margalida and Bertran 2000b). The interval between breeding failure and replacement laying was in agreement with the one case observed in the French Pyrenees (Margalida et al. 2001) and the mean 25-d interval that has been described for the Eurasian Griffon (*Gyps fulvus*) (Martínez et al. 1998, *Ornis Fenn.* 75: 145–148).

Although replacement clutches have been described in other vulture species (Mundy et al. 1992, The vultures of Africa, Academic Press, London, U.K.), there are very few records, and successful replacement clutches are rare. The fact that so few cases are known for large vultures suggests that the costs imposed of producing replacement clutches are probably higher than the potential benefits. In the studied case, increased collective parental contribution of the three adults may have favored the successful replacement clutch. However, in the French Pyrenees case, successful rearing from a replacement clutch was achieved by a monogamous pair. We believe that a successful second breeding attempt may be related to an initial early clutch followed by premature breeding failure. Late laying dates would delay fledging to the period when nest building begins (Margalida and Bertran 2000b), and could influence the body condition and the reproductive success of the following breeding attempt (see Chastel et al. 1995, *Auk* 112 964–972). The low frequency of replacement clutches in this species may be due to the fact that natural selection may favor a low reproductive effort in any one season in the interest of improving the probability of breeding in future seasons (Newton 1979, Population ecology of raptors, T. & A.D. Poyser, Berkhamsted, U.K.). The long life expectancy in this species, the long breeding season (2 mo of incubation and 4 mo of chick-rearing), and the cost

of parental investment by the adults of successfully rearing a chick (Margalida and Bertran 2000b) might explain the low frequency of replacement clutches.

Mississippi Kites Use Swallow-tailed Kite Nests

Mississippi Kites (*Ictinia mississippiensis*) occasionally use old nests of other bird species like the American Crow (*Corvus brachyrhynchos*) and Chihuahuan Raven (*Corvus cryptoleucus*) for nesting (Parker 1999, *In* A. Poole and F. Gill [Eds.], The birds of North America, No. 402. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC U.S.A.). Here, I report the first accounts of Mississippi Kites using failed, abandoned Swallow-tailed Kite (*Elanoides forficatus*) nests.

Along the Gulf Coast, Mississippi Kites and Swallow-tailed Kites often nest near each other where the habitat is suitable (J. Coulson unpubl. data), as they also do in coastal South Carolina (Cely 1987, *J. Raptor Res.* 21:124). In illustration of this close nesting association, a pair of Swallow-tailed Kites used an old Mississippi Kite nest of the previous year (Cely 1987). Arrival and nesting times appear to be staggered, with the majority of the Mississippi Kites nesting about three to four weeks later than Swallow-tailed Kites. In the Pearl River Basin located on the Mississippi-Louisiana border, most Swallow-tailed Kites arrive on the nesting grounds by early to mid-March. In this area, most Mississippi Kites do not arrive on the nesting grounds until early to late April (Lowery 1974, Louisiana birds, 3rd Ed., Louisiana State Univ. Press, Baton Rouge, LA, U.S.A.; J. Coulson unpubl. data). Nesting times between species differ similarly in South Carolina, although both species arrive later (Cely 1987).

In the spring and summer of 1997, a pair of Mississippi Kites nested 50 m from an occupied Swallow-tailed Kite nest in a subdivision, Pearl River, St. Tammany Parish, Louisiana. Both species nested in loblolly pines (*Pinus taeda*). The Mississippi Kite nest tree was 6 m from an occupied house. One young fledged from each nest. I did not mark any adults of either species and do not know if birds returning to the area in following years were the same individuals. In 1998, both species of kites refurbished and used nests from the previous year, and again one young fledged from each. In 1999, a pair of Swallow-tailed Kites reused the old nest, but on 4 May a severe storm with high winds passed through the study area. I visited the nest the following day and found a broken egg under the nest along with nest material (moss, lichens, and lichen-covered twigs). A substantial limb (3 cm in diameter) that supported part of the nest had snapped off and was near the broken egg. The disheveled nest's base was dislodged and no longer tucked into the fork of the nest tree. The pair of Swallow-tailed Kites did not return to this nest after the storm.

On 18 May 1999, an adult Mississippi Kite was incubating on the failed Swallow-tailed Kite nest, which appeared to have received few repairs. The nest was a typical Swallow-tailed Kite nest, sticks adorned with trailing curtains of Spanish moss (*Tillandsia usneoides*) and topped with a layer of fruticose lichens (*Usnea* sp.). Mississippi Kites rarely to occasionally use a small amount of Spanish moss or lichens for nest building, depending on the region (Cely 1987, Parker 1999). One fledgling was produced in this nesting effort.

In the spring of 1999, a pair of Swallow-tailed Kites nested in a sweetgum (*Liquidambar styraciflua*) on the Atchafalaya National Wildlife Refuge, St. Martin Parish, Louisiana, but their nest failed during incubation because of high winds On the subsequent visit I found a large supporting limb (3.5 cm in diameter) on the ground directly below the nest. On 4 June 1999, there was an adult Mississippi Kite on this nest with at least one nestling. The outcome of this nesting is not known because it was not revisited.

Swallow-tailed Kites reused their old nests at 1 out of 28 nests in South Carolina and at 4 out of 17 nests in Florida (Meyer 1995, *In* A. Poole and F. Gill [Eds.], The Birds of North America, No. 138. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC U.S.A.). Mississippi Kites reused their old nests between 16% and 50% of the time, depending on the study area and sample size (Parker 1999). Reusing

nests, whether built by the same or another species, may be particularly important to raptors that are long-distance Nearctic-Neotropical migrants (e.g., Mississippi Kites and Swallow-tailed Kites). If a pair starts with a solid foundation in place, nest building will take less time and energy. Presumably, Nearctic-Neotropical migratory raptors are under time, energy, and resource constraints such that the advantages of old nest use sometimes outweigh the potential costs (e.g., endoparasite and ectoparasite build-up, or predator attraction). However, two studies on the breeding biology of Mississippi Kites found that reused nests had higher failure rates than new ones (Parker 1999).

Factors that delay the start of nest building might increase the benefits of reusing a nest. Experienced breeders might be under more demanding time constraints, if they arrive late on the breeding grounds, are re-nesting because of an early failure, or if one of the pair leaves or dies. Inexperienced breeders tend to nest later and might build a sturdier nest if they refurbish an old one. In spite of risks, both species of kites sometimes reuse nests. Apparently, net benefits maintain this behavior.

ERRATUM

FACTORS INFLUENCING LENGTH OF THE POST-FLEDGING PERIOD AND TIMING OF DISPERSAL IN BONELLI'S EAGLE (*HIERAAETUS FASCIATUS*) IN SOUTHWESTERN SPAIN

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Figures 1 and 3 printed in the article "Factors influencing length of the post-fledging period and timing of dispersal in Bonelli's Eagle (*Hieraaetus fasciatus*) in southwestern Spain," (*Journal of Raptor Research* 35[3]:228–234) were incorrect, draft versions. The correct, revised figures that correspond to this article and that should be substituted for Figure 1 (page 229) and Figure 3 (page 231) are printed below.

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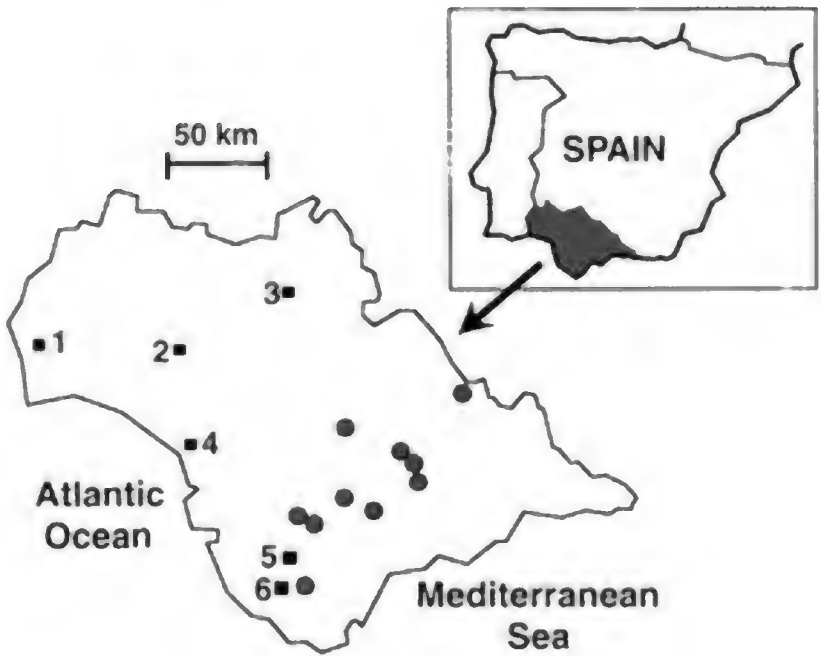
Figure 1. Study area in southwestern Spain, 1998. Grey circles represent the ten territories of Bonelli's Eagles, and numbered black squares are the six sites of prey availability counts.
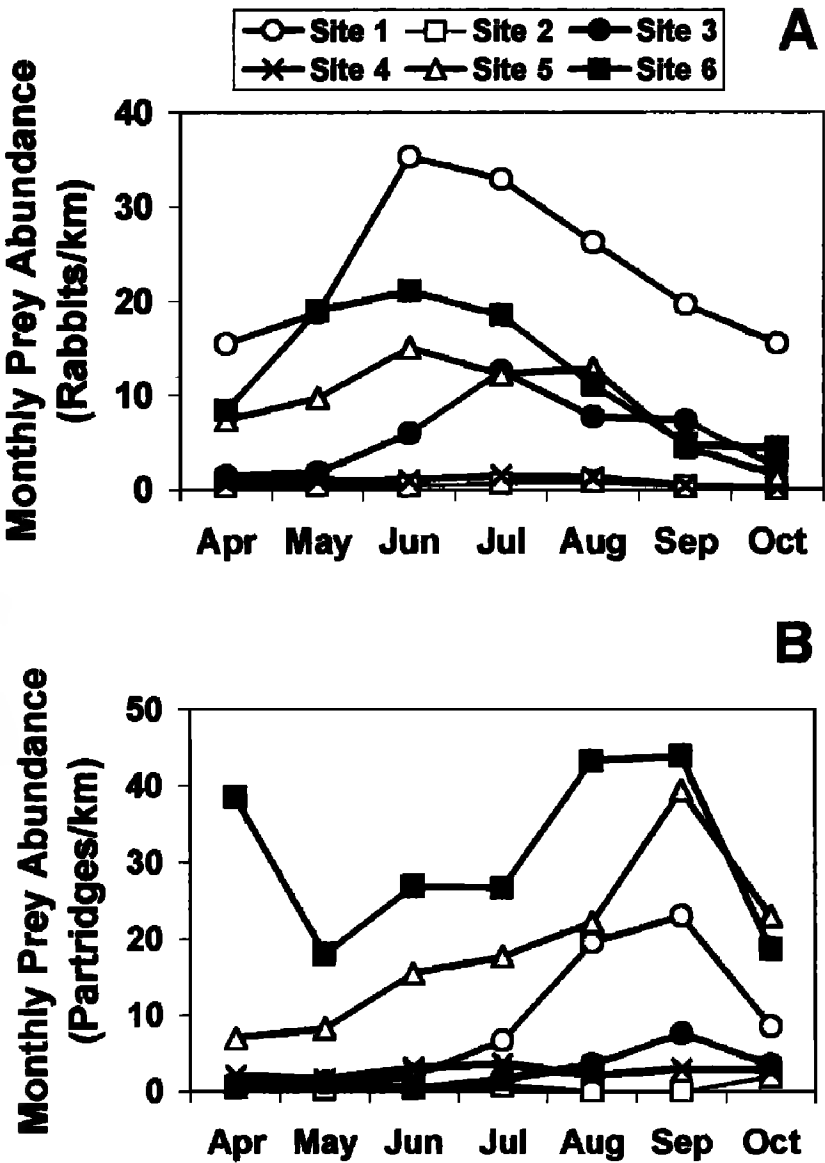
Figure 3. Monthly prey abundance for the six surveyed sites (see Fig. 1 for the geographic locations) during the post-fledging period. (a) European rabbit (*Oryctolagus cuniculus*) abundance. (b) Red-legged Partridge (*Alectoris rufa*) abundance.

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