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NEST DEFENSE BY MALE AND FEMALE SPANISH IMPERIAL EAGLES

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ABSTRACT.—Sexual differences in nest defense behavior in response to human intruders were studied in the Spanish Imperial Eagle (*Aquila adalberti*). Females defended the nest more than males, and their defense increased as the breeding cycle progressed. The defensive behavior of the female was independent of male presence.

Defensa del nido por progenitores de Aguila Imperial Ibérica

EXTRACTO.—Se estudian las diferencias entre sexos en el comportamiento de defensa del nido, en respuesta a la presencia humana, en el Aguila Imperial Ibérica (*Aquila adalberti*). Las hembras defienden el nido más que los machos, y su comportamiento defensivo aumenta al avanzar el ciclo reproductivo. El comportamiento defensivo de la hembra es independiente de la presencia del macho.

Diurnal raptors exhibit three strategies of nest defense: principally by the female, by both sexes, or principally by the male (Mueller and Meyer 1985, Andersson and Wiklund 1987). There are also differences in the division of other roles associated with reproduction, such as incubation, provisioning of food, feeding the young and surveillance (Cramp and Simmons 1980, Mueller and Meyer 1985). In the Spanish Imperial Eagle (*Aquila adalberti*), incubation and care of chicks in the nest are principally carried out by the female (Cramp and Simmons 1980), but it is unknown whether or not there are sexual differences in offspring protection. Several authors have suggested that the general trend towards reversed sexual dimorphism in the Falconiformes may be at least partly an evolutionary response to sexual differences in nest defense (Snyder and Willey 1976, Andersson and Norberg 1981, Andersson and Wiklund 1987). Information on the division of nest defense between the sexes is scarce in raptors (Mueller and Meyer 1985), however.

Recently Andersson and Wiklund (1987) studied nest defense in the Rough-legged Buzzard (*Buteo lagopus*) and found that the smaller males undertake

most of the defense. Although contrary to the prediction, this result does not refute the hypothesis. The evaluation of such an evolutionary hypothesis necessitates a comparative analysis seeking repeated patterns throughout the order (Pages and Harvey 1988). In this study, I examine the contribution of male and female Spanish Imperial Eagles to nest defense against human intruders.

METHODS

The study was undertaken in Doñana National Park in southwest Spain from 1974–1988. Observations were made during 201 visits to 51 nests of 15 different pairs. A visit involved one person climbing to the nest to record breeding stage and examine eggs or young. During the visit I recorded the sex, and distance from the nest and attack behavior of the adults. Even though the sexual dimorphism is slight (mean weight was 2613 g [N = 16] for males, and 3467 g [N = 21] for females, Ferrer unpubl. data), it was possible to assign sex to adults with confidence approximately 50% of the time, using individual differences in moult and observations of the two members of the pair together. Nest defense was classified into three categories based on the distance the adults kept from the person investigating the nest: 1) >50 m when the adult remained more than this distance from the nest while the chicks were handled or the eggs examined, 2) <50 m when

Table 1. Observations of nest defense by Spanish Imperial Eagles according to distance classes and sex (0 m corresponds to direct attack).

DISTANCE	MALE		FEMALE	
	INCUBA-TION	NESTLING STAGE	INCUBA-TION	NESTLING STAGE
> 50 m	10	8	15	9
< 50 m	2	2	9	17
0 m	0	1	2	10
Total	12	11	26	36

the adult remained closer than this distance and, 3) 0 m when the adult attacked the observer. Statistical analyses for evaluating the significance of nest defense variations were performed using N X M exact test (Wells and King 1980).

RESULTS

In 85 observations the sex of attending adults was recorded. The female was always present, while the male was present on only 23 occasions (27%). The single versus paired ratio during visits in which the sex of the adults could not be identified ($N = 116$) was 41.3%. Females remained closer and made more attacks than males (Table 1; $\chi^2 = 10.65$, $P = 0.005$). During incubation, females were not significantly more aggressive than males ($\chi^2 = 2.66$, $P = 0.269$). However, during the nestling stage the female was more aggressive than the male ($\chi^2 = 8.32$, $P = 0.015$).

Males did not differ significantly in defense activity between incubation and nestling stages ($\chi^2 = 1.18$, $P = 0.784$). In contrast, females increased defense significantly in the later stage of the nesting cycle ($\chi^2 = 7.89$, $P = 0.019$). The responses of females did not differ in the presence of males (Table 2, incubation $\chi^2 = 0.35$, $P = 0.834$, nestling $\chi^2 = 0.04$, $P = 0.978$).

DISCUSSION

In the Spanish Imperial Eagle, incubation and the care of chicks in the nest are principally carried out by the female (Cramp and Simmons 1980). This was evident from our data, as we never observed the male alone at a nest, and we frequently observed females alone. During incubation, males provide food, while females are spending more time at the nest. Females defended more than males. This is in agreement with the hypothesis that the maintenance of reversed sexual dimorphism favors larger females which can better defend the nest against predators

Table 2. Observations of female Spanish Imperial Eagles defending their nests in relation to presence or absence of the male (0 m corresponds to direct attack).

DISTANCE	INCUBATION		NESTLING STAGE	
	MALE PRESENT	MALE ABSENT	MALE PRESENT	MALE ABSENT
> 50 m	8	8	3	6
< 50 m	3	5	5	12
0 m	1	1	3	7
Total	12	14	11	25

(Snyder and Willey 1976, Andersson and Norberg 1981).

Recently, some authors (Wiklund and Stigh 1983, Andersson and Wiklund 1987) have presented an alternative hypothesis for the maintenance of reversed sexual dimorphism in Falconiformes. Although still arguing that nest defense is an important selection pressure, they suggest that the selection would not be to increase female size, but rather to decrease male size. This would enhance flying agility and reduce the risk of defending the nest against predators of larger size, including human intruders (Andersson and Wiklund 1987). This hypothesis is not supported by our data because the smaller males did not defend the nest vigorously. Additionally, Pleasants and Pleasants (1988) have suggested that sexual dimorphism evolved through an increase in female size and not a decrease in male size, at least in diurnal raptors.

My data show a rise in female nest defense behavior as the breeding cycle progresses, a decrease in distances from the observers and an increase in the frequency of attacks. In contrast, males did not increase their defensive efforts along the breeding cycle. Similar results have been found in Merlins (*Falco columbarius*) by Wiklund (1990). He suggested that male investment in nest defense influenced mate selection by females. Consequently, later in the breeding cycle a greater investment is not necessary for males. The increase in female defensive behavior could be more related with the age of the chicks and accumulated investment (Andersson et al. 1980). Nevertheless, Ferrer et al. (in press), reported a rise in nest defense over the years in this eagle population, suggesting that this increase can be attributed to experienced adults whose defense behav-

ior has been positively reinforced upon not losing their offspring after a hypothetical predatory attack (Knight and Temple 1986). The fact that females spend more time at the nest and, consequently, they probably have more previous experiences with human intruders than males, could explain, at least in part, the increase of aggressive behavior detected in this sex.

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THE IDENTITY OF PENNANT'S "WAPACUTHU OWL" AND THE SUBSPECIFIC NAME OF THE POPULATION OF *Bubo virginianus* FROM WEST OF HUDSON BAY

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ABSTRACT.—The name *Strix wapacuthu* Gmelin, often used for the subspecies of *Bubo virginianus* west of Hudson Bay, cannot be associated with certainty with either *B. virginianus* or *Nyctea scandiaca*. The subspecific name for the population of *B. virginianus* from Mackenzie to central-eastern British Columbia and northern Ontario should be *B. v. subarcticus* Hoy.

Identidad del Buho Wapacuthu de Pennant, y el nombre dado a una población de *Bubo virginianus* del oeste de la Bahía de Hudson

EXTRACTO.—El nombre *Strix wapacuthu* Gmelin, usado frecuentemente para una subespecie de *Bubo virginianus* del oeste de la Bahía de Hudson, no puede ser asociado con certeza ni con el *Bubo virginianus* ni con el *Nyctea scandiaca*. El nombre para esa subespecie, desde Mackenzie hasta el oeste central de Colombia Británica, y el norte de Ontario debe de ser *Bubo virginianus subarcticus* Hoy.

[Traducción de Eudoxio Paredes-Ruiz]

Gmelin (1788:291) proposed the name *Strix wapacuthu* for a species separate from what are now *Nyctea scandiaca* (Snowy Owl) and *Bubo virginianus* (Great Horned Owl). Latham (1790) followed Gmelin (op. cit.). Swainson and Richardson (1832) likewise did not associate *Strix wapacuthu* with either *N. scandiaca* or *B. virginianus*. However, Swainson (in Swainson and Richardson 1832) described another taxon as *Strix (Bubo) arctica*, a name later used subspecifically for Great Horned Owls of much of western Canada (see Stone 1896). After Richmond (1902) showed that Swainson's name was preoccupied by *Bubo arcticus*, proposed by Forster (1817) for the Snowy Owl, and therefore unavailable for any Great Horned Owl, the name was replaced by *B. v. subarcticus* proposed by Hoy (1852).

The name *wapacuthu* was associated with *N. scandiaca* by Coues (1874), Brewster (1906), Oberholser (1908, 1917), Manning (1952), Snyder (1961), and Godfrey (1986). On the other hand, Sharpe (1875) synonymized *wapacuthu* with *B. virginianus*, and the name was subsequently used for the subspecies of *B. virginianus* west of Hudson Bay by others (Oberholser 1904, Ridgway 1914, Cory 1918, Peters 1940, American Ornithologists' Union [A.O.U.] 1944, 1957, Snyder 1957). Todd (1963:454) recommended that the name *wapacuthu* be discarded altogether

because it "cannot certainly be identified with any species." Authors (e.g., Manning 1952, Godfrey 1986) who reject *wapacuthu* as applicable to *B. virginianus* follow Richmond (1902), the A.O.U. (1910, 1931), and Taverner (1938) in their use of *B. virginianus subarcticus* as the name for the pale subspecies of the Great Horned Owl from west of the Hudson Bay region.

In recently published books on owls, Karalus and Eckert (1974) used *wapacuthu* as the name of a subspecies of *B. virginianus* distinct from *subarcticus*, whereas Johnsgard (1988) stated that it is "identical" to *subarcticus*, and Voous (1988) referred to the western Hudson Bay population as "(*subarcticus* or *wapacuthu*).” McGillivray (1989) also indicated uncertainty by using "*wapacuthu*/*subarcticus*." Karalus and Eckert's (1974) treatment is taxonomically unverified as well as conceptually faulty (the ranges of the two subspecies are shown to overlap). Johnsgard's synonymy is incorrect even if his concept is correct, because he did not use the earliest available name for the subspecies. Because of the continuing various applications of *wapacuthu* in spite of earlier brief discussions of its description, a review of its use and identification follows.

Gmelin (1788:291) cited the "Arctic Zoology" of Pennant (1785) as the basis for the description of

Strix wapacuthu. Pennant's (1785) description was based on manuscript notes supplied by Thomas Hutchins. Hutchins, employed at York Factory by the Hudson's Bay Company as surgeon and "Corresponding Secretary," copied a manuscript by (Williams 1969, 1978) or collaborated with (C.S. Houston, *in litt.*) Andrew Graham, an employee of the same company who worked mostly at Fort Severn. Hutchins (*in Allen* 1951:521) stated that "In persuance of Mr. Graham's advice, I have described the plumage of the Birds, but as my knowledge of the variety of colours is very small, consequently the description must be very imperfect." In 1784 Hutchins convinced Pennant that he was the author of Graham's observations (Williams 1978); both Pennant (1785), who knew of Graham's work, and Latham (1785:43) credited Hutchins for information on birds from what is now northwestern Ontario and northeastern Manitoba.

Hutchins and Graham sent birds to the Royal Society in England (Forster 1772, Williams 1969) and to Latham (1821:xii), but those specimens are no longer extant (Williams 1978). The fate of the name *wapacuthu* must rest on its written description.

Pennant's (1785:231–232) description is under the section heading "without ears" in a review of Arctic owls and is "no. 119. Wapacuthu [owl]." The description is as follows: "With glossy black bill, and claws much incurvated: base of the bill beset with strong bristles: irides bright yellow: space between the eyes, cheeks, and throat, white: the ends of the feathers on the head black: scapulars, and all the coverts of the wings, white, elegantly barred with dusky reddish marks, pointing downwards: primaries, secondaries, and tail feathers, irregularly spotted and barred with pale red and black: back and coverts of the tail white, mixed with a few dusky spots: breast and belly dirty white, crossed with innumerable reddish lines: vent white: legs feathered to the toes which are covered with hairs. Weight five pounds: length two feet: extent four." Pennant (*op. cit.*) also gave descriptions of several other species of owls. Among these he included detailed descriptions of what are now *B. virginianus* (pp. 228–229) under the heading "with ears," and *N. scandiaca* (p. 233) under the heading "without ears."

Comments in the literature on Pennant's description of the Wapacuthu Owl are brief. Brewster (1906: 205) stated that *wapacuthu* referred to *N. scandiaca* because it was described as "earless." Ridgway (1914) acknowledged that *N. scandiaca* has rudimentary ear

tufts but associated the name *wapacuthu* with the Great Horned Owl, commenting that molting *B. virginianus* "are often destitute of obvious ear-tufts . . . or the ear-tufts may have been plucked before the specimen came into his [Pennant's] possession." Peters (1940) used the name *B. virginianus wapacuthu*; he believed that Pennant's description was a composite that included characteristics of both *B. virginianus* and *N. scandiaca*. Manning (1952) stated that "there is nothing in this [Pennant's] description which is not reconcilable [sic] with a Snowy Owl; while apart from there being no mention of horns or the fine vermiculation of a Horned Owl (its most obvious characteristics), there are several points which definitely separate it from any Horned Owl . . ." but did not provide additional details. If the ear-tufts had been plucked or were absent through molting (Ridgway 1914) the combination of plumage characters could suggest *B. virginianus*; if the bird was normally "earless" the Wapacuthu Owl can easily be associated with *N. scandiaca*.

Pennant (1785) further stated that the Wapacuthu Owl "makes a nest on the moss on the ground. The young are hatched in May, and fly in June, and are white for a long time after." Nesting on the ground is consistent with *N. scandiaca*; *B. virginianus* usually nests in trees, and only rarely on the ground (Bent 1938), cliffs (Peck and James 1983) and rock outcrops (Johnsgard 1988). The description of the young as white is consistent with both *B. virginianus* and *N. scandiaca* for about the first 10 days of the natal plumage (Godfrey, *pers. comm.*; Johnsgard 1988). Older *B. virginianus* are buffy with the developing flight feathers similar to those of the adults (Johnsgard *op. cit.*). Older *N. scandiaca* are chocolate brown with white specks (N.K. Johnson, *in litt.*), the facial disc is white, and the flight feathers are white with brown crossbars "and brown vermiculations in the form of speck-like marbling" (Mikkola 1983). Hutchins (*in Latham* 1787:49) stated that the eggs of the Wapacuthu are "from five to ten in number." This exceeds the normal clutch size of *B. virginianus* (only one nest containing five eggs is cited in Bent [1938]) but is within the range of *N. scandiaca* clutches (Portenko 1972).

The name "Wapacuthu" of Pennant's (1785) owl was from the Cree language, in which "wap" refers to white (C.S. Houston, *in litt.*). Swainson and Richardson (1832) and Brewster (1906) commented that "wapacuthu" meant "White Owl." Graham (*in Williams* 1969:xxxv, 106, 107) used the names

"Wawpekatheu, the Spotted Owl" and "Wapacathew Omissew, The Snowy-Owl." We agree with Glover (*in Williams* 1969:106) that Graham's "Wawpekatheu" appears to be a heavily spotted example of *N. scandiaca*. Graham's "Wapacathew Omissew," merely described as smaller than the "Wawpekatheu," probably also refers to *N. scandiaca* and was so identified by Glover (*in Williams* 1969:107).

We conclude that the description of the Wapacuthu Owl as lacking ear-tufts, information on the nesting and clutch size, and the meaning of the Cree name indicate that Pennant's description was of *Nyctea scandiaca*. However, we agree with Todd (1963) that *wapacuthu* cannot be identified with certainty. The name *Strix wapacuthu* Gmelin, 1788 should be regarded as a nomen dubium (a name of doubtful application), and the subspecific name for the population of *Bubo virginianus* from Mackenzie to central-eastern British Columbia and northern Ontario (Godfrey 1986) should be *subarcticus* Hoy, 1852.

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HABITAT USE OF THE NORTHERN HARRIER IN A COASTAL MASSACHUSETTS SHRUBLAND WITH NOTES ON POPULATION TRENDS IN SOUTHEASTERN NEW ENGLAND

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ABSTRACT.—Northern Harrier (*Circus cyaneus*) use of a 55.3 ha, shrub-dominated coastal peninsula in Massachusetts was monitored, year-round, from 19 February 1987 to 26 April 1988. In 1987, two harrier pairs established breeding territories there. Two nests with eggshells were found, and represent the only documented harrier nesting attempts on mainland Massachusetts (excluding Cape Cod) in more than a decade. Both nests were situated within patches of low (0.93 ± 0.28 m), dense shrubs dominated by Black Huckleberry (*Gaylussacia baccata*). Each winter, most harriers roosted within the same two patches of dense Black Huckleberry (\bar{X} shrub height = 0.84 ± 0.18 m). The maximum count of harriers at the winter roost site was 23 during February of 1988 (3 adult male, 20 brown). Though the number of breeding harriers in Southeastern New England has declined during this century, analysis of Christmas Bird Count data from 1962 to 1988 demonstrates an increase in the number of wintering harriers in the same region during that period.

Uso del habitat por el *Circus cyaneus* en un terreno de arbustos de una costa de Massachusetts, con notas sobre las tendencias de población en el sudeste de Nueva Inglaterra

EXTRACTO.—Desde el 19 de febrero de 1987 hasta el 26 de abril de 1988, se han hecho observaciones del uso que hacen las aves raptoras *Circus cyaneus*, de 55.3 hectáreas pobladas de arbustos, en la costa de la península de Massachusetts. En 1987, esta área fue el territorio nupcial de dos parejas de estas aves raptoras. Dos nidos con cáscaras de huevos han sido hallados y representan los únicos indicios, en más de una década, de las tentativas de anidar que las raptoras de esta especie han dejado en tierra firme de Massachusetts (excluyendo Cape Cod). Los dos nidos estaban situados dentro de pequeñas áreas pobladas densamente por bajos arbustos (0.93 ± 0.28 m) en los que domina el arándano negro (*Gaylussacia baccata*) [“Arándano = . . . Planta de la familia de las ericáceas . . . con ramas angulosas, hojas alternas . . . frutos bayas negruzcas o azuladas, dulces y comestibles . . .”]. Cada invierno, la mayor parte de estas aves descansaban dentro de esas dos áreas pobladas por densos arándanos (\bar{X} altura por planta = 0.84 ± 0.18). El máximo número de estas aves en estos lugares de descanso invernal fue de 23 (3 adultos machos, 20 marrones), en febrero de 1988. Aunque el número de estas aves de rapiña durante el ciclo reproductivo, en el sudeste de Nueva Inglaterra, ha declinado durante esta centuria, los análisis del cómputo de aves, realizado en las épocas navideñas, desde 1962 a 1988, demuestran un aumento en el número de ellas, en los inviernos, en la misma región durante ese período.

[Traducción de Eudoxio Paredes-Ruiz]

The Northern Harrier (*Circus cyaneus hudsonius*) is found year-round in southeastern New England. Although there is evidence to suggest that numbers of wintering harriers have increased in this region during recent years (Christmas Bird Count data in Audubon Field Notes 1962–1970, and American Birds 1971–1988), numbers of breeding harriers have declined during this century (Forbush 1927, Bent 1937, Griscom and Snyder 1955, Hill 1965, Serrentino and England 1989, Nikula and Holt, in

prep.). Breeding harriers have been nearly extirpated from mainland habitats in Connecticut, Massachusetts and Rhode Island (Serrentino and England 1989). Breeding populations persist in Massachusetts on Cape Cod and offshore islands, and on Block Island, Rhode Island (Serrentino and England 1989, Nikula and Holt, in prep.). The harrier is an endangered species in Rhode Island, and is listed as threatened in Massachusetts (no status available for Connecticut).

Serrentino and England (1989) reported on the diminishing number of nesting harriers in the Northeast, and suggested areas of research for de-

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veloping effective management/recovery strategies for the species. Here, we provide detailed, year-round data on the habitat use of harriers at Barney's Joy Point, a coastal shrubland in southeastern (mainland) Massachusetts. We monitored winter roosting activity beginning February 1987, and in April 1987 documented the establishment of breeding territories by two male harriers. A nest found in one of the territories represents the first documented harrier nesting attempt in mainland Massachusetts (excluding Cape Cod) in more than a decade, and a nest from the previous breeding season (with eggshell fragments) was also discovered.

STUDY AREA

The study area, Barney's Joy Point, is a shrub dominated coastal peninsula in South Dartmouth, Massachusetts (Fig. 1). The 55.3 ha study area is bordered to the northwest by a coastal dune system and tidal pond/marsh complex. Cultivated fields lie to the north of the study area, and the remainder of the point is surrounded by the waters of the Slocum's River to the east, and Buzzard's Bay to the south and southwest. Harriers hunted in habitats adjacent to the study site, however all breeding and most roosting occurred within the boundaries of the study area. Although cattle grazing in past years has left an extensive network of cowpaths throughout the area, it is presently used as pasture for less than twenty cattle in the summer.

We classified the habitats of the study area into five types. Shrub/herb (14.8 ha, 26.8% total area) occupies two tracts of pasture land in the northern and northeastern zones of the study area (Fig. 1). Several small, seasonal freshwater pools are found within the northeastern tract. Shrub/herb is characterized by a complete ground cover of grasses and forbs occurring beneath a sparse 1- to 2-m tall shrub overstory. Shrubs are denser and taller (2–4 m) along remnant hedgerows and within a few small patches within this community. Dominant shrubs are Black Huckleberry (*Gaultheria shallon*), Highbush Blueberry (*Vaccinium corymbosum*), Dwarf Sumac (*Rhus copallina*), and Northern Arrowwood (*Viburnum recognitum*).

Grassland (6.5 ha, 11.8% total area) covers two tracts that are interspersed with the shrub/herb tracts in the northern section of the study area (Fig. 1). This habitat is maintained by annual mowing and is dominated by Red Fescue (*Festuca rubra*) and Wavy Hair Grass (*Deschampsia flexuosa*). Various forbs are also present.

Dense shrub/grassland (16.9 ha, 30.6% total area) occupies a wide band in the center of the study area (Fig. 1). It is characterized by dense, 0.5- to 2-m tall patches of Black Huckleberry (62% of total area) with pockets of short (<30 cm) grasses (38% total area) interspersed among the shrub patches. Subdominant shrubs include Bayberry (*Myrica pensylvanica*), Virginia Rose (*Rosa virginiana*) and Pasture Rose (*Rosa carolina*). Grassy areas are dominated by Red Fescue and Wavy Hair Grass. Several junipers (*Juniperus virginiana*), most less than 3 m tall, are scattered throughout the community.

Dense shrub/dune (7.7 ha, 13.9% total area) is found in a band along the southwestern edge of the dense shrub/grassland habitat (Fig. 1). This habitat consists of low, rolling sand dunes with numerous, small (<50 m²) patches of low (≤0.5 m) shrubs interspersed among herbaceous dune vegetation and areas of unvegetated sand. Black Huckleberry and Seaside Rose (*Rosa rugosa*) are the dominant shrubs; American Beachgrass (*Ammophila breviligulata*) and Beach Heather (*Hudsonia tomentosa*) dominate the herbaceous community.

Beachgrass dune (2.6 ha, 4.7% total area) occupies the southwestern corner of the study area (Fig. 1). This habitat consists of primary and secondary sand dunes, and is covered almost entirely by American Beachgrass. Other species include Dusty Miller (*Artemisia stelleriana*), Seaside Goldenrod (*Solidago sempervirens*), and Seaside Rose. Areas of unvegetated sand are also present.

A brackish pond (0.8 ha, 1.4% total area) is located adjacent to the shoreline on the eastern side of the study area. Unpaved roads and rocky shoreline comprise the remaining 0.3 ha (0.5%) and 5.7 ha (10.3%) of the study area, respectively.

METHODS

Observations of harriers at Barney's Joy were made from 19 February 1987 to 26 April 1988. That period encompassed one full breeding season, which we defined as 9 April (initiation of courtship behavior) to 31 July 1987. We made 93 hours of observations during that breeding season. We observed harriers for 57 hours during the 86–87 roost period and for 112 hours during the 87–88 roost period. Most roost observations in 87–88 were made during evenings. However, between 12 January and 10 March 1988, weekly counts were made during the morning by two observers, each counting the number of harriers leaving roosts. Observers arrived approximately 30 minutes before sunrise and remained until dispersal activity ceased, up to 1 hour after sunrise.

A cover map of the study area (Fig. 1) was made from 1:9600 scale black and white vertical aerial photographs. Habitat patches >50 m² were delineated with the aid of a 4× lens stereoscope and an 8× monocular lens. We also delineated two areas where most wintering harriers roosted. We did not attempt to delineate breeding territory boundaries. The areas of each habitat type and of the two winter roosts were measured on an enlarged (1:4048 scale) cover map using a dot-grid and compensating polar planimeter.

After the 1987 breeding season, shrub heights were estimated within each of the two principal roost sites, and within the shrub/herb and dense shrub/grassland habitats. Within each area sampled, two transects perpendicular to one another, and crossing at an approximated center of the area, were established; the bearing of the first transect was determined randomly. Shrub height and species were noted at 10-m intervals (5 m within roost sites) across the full length of each transect. No data were taken if the sample point fell in an herbaceous patch.

The percent cover of habitat types surrounding the two nest sites was estimated along four, 5-m transects extending out from each nest (Holt and Melvin 1986, Brower

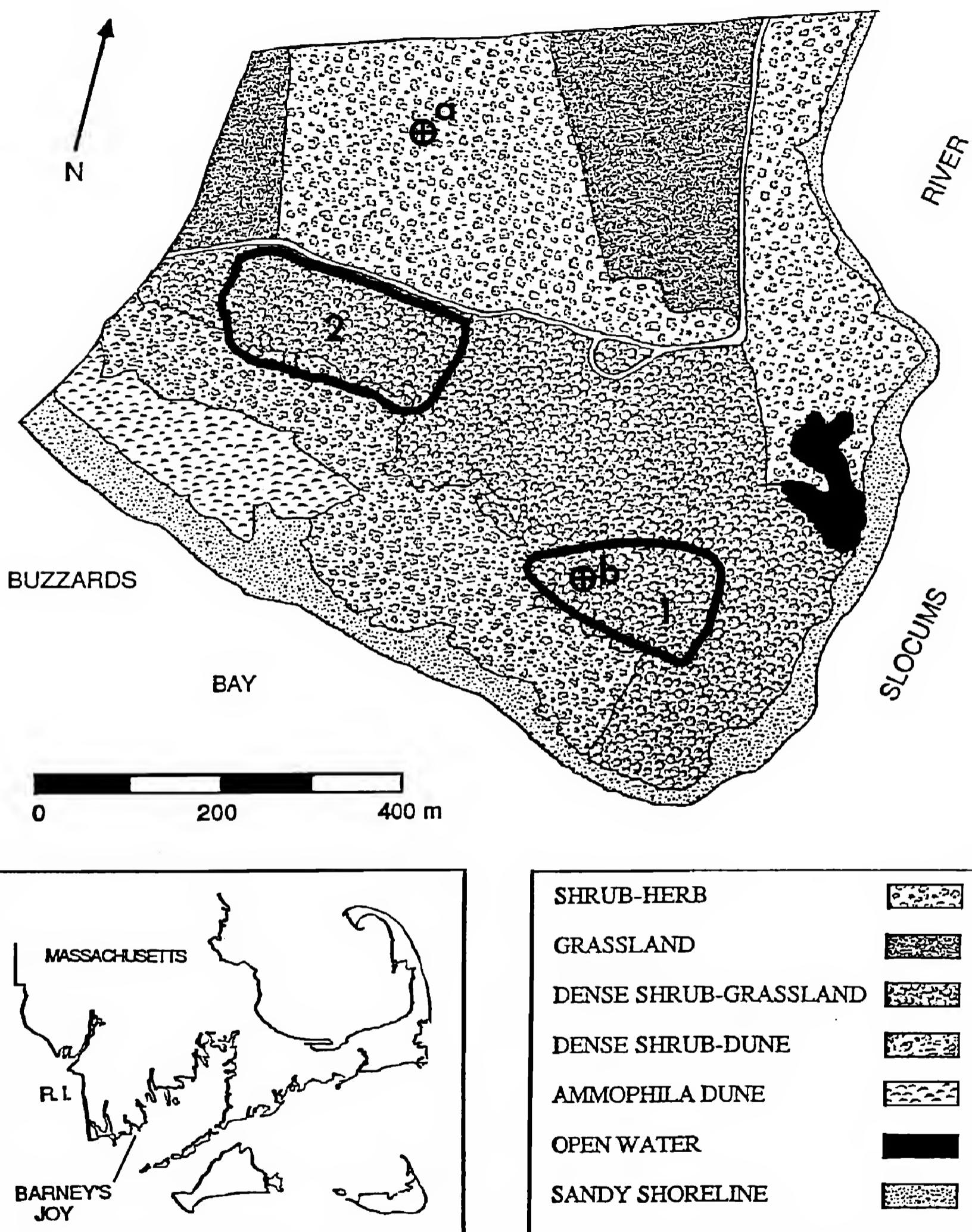


Figure 1. Distribution of habitats at Barney's Joy Point, South Dartmouth, Massachusetts. Delineated areas represent winter roosts 1 and 2. Circled "+" signs indicate the sites of nests a and b.

and Zar 1977). The transects were then extended from the nest to the edge of the patch of shrubs within which it occurred to determine the mean distance from each nest to the edge of its patch (Holt and Melvin 1986).

To assess population trends of wintering harriers in southeastern New England, we determined the mean number of harriers counted per party hour (Raynor 1975) across 17 Christmas Bird Count (CBC) census-circles in Massachusetts (9 circles), Connecticut (6 circles) and Rhode Island (2 circles) for each year from 1962 to 1988. CBC census-circles with no reported harrier observations during that period were excluded from our analysis. Also excluded were census-circles that were not censused during each year of that period. We chose 1962 as a starting point since several CBC census-circles with substantial harrier counts were added in that year.

RESULTS AND DISCUSSION

Year-round Activity. Six to ten harriers (including 2 adult males) roosted at Barney's Joy from February through March 1987. Behavior suggesting defense of a breeding territory was seen for the first time on 1 April 1987, when one male was seen escorting (Bildstein and Collopy 1985) another for approximately 8 minutes in the evening. Immature harriers were seen for the last time on 9 April, coinciding with the first day an adult male was seen performing aerial courtship displays. By 15 April, two male harriers had established breeding territories, the first of which (Territory 1) was centered in the larger shrub/herb field, and the second (Territory 2) in the dense shrub/grassland habitat tract of the study area (Fig. 1). The two males repeatedly engaged in escorting flights along a line where the two territories met. Female harriers were frequently seen within the study area at that time.

Courtship behaviors, including skydancing and aerial food transfers (Hamerstrom 1986) peaked during the 3rd week in April, and by late April two breeding pairs were established. Copulation (Territory 1 pair) was first seen on 30 April, and on 27 May a female was nest-building. Occasional food transfers were observed until the end of June; however, neither of the pair from Territory 1 was seen during July. A nest containing eggshell fragments was found in Territory 1 on 31 July; the eggs had apparently been destroyed by a mammalian predator.

The male from Territory 2 was seen carrying nesting material on 7 May. The female of this pair was never associated with a nest, and was last seen on 28 May. An incomplete nest was found in Territory 2 on 24 June; we believe that that nest was built by the male as observed by Hamerstrom (1986).

A lone male roosted in this territory throughout the remainder of the breeding season.

After the 1987 breeding season, harriers began roosting at Barney's Joy in mid-September, and by mid-October, 4 to 6 birds were roosting regularly within the same shrub patches as those used the previous winter. Throughout the 87–88 winter roost period there were substantial fluctuations in the numbers of roosting harriers. A maximum count of 23 (including only 3 adult males) was made on 12 January 1988; numbers then decreased over the next two weeks and levelled at approximately 15 until 25 February, after which numbers steadily decreased until the last count of two brown birds on 14 April.

A brush fire on 19 March 1988 consumed 25.7 ha (46.5%) of the study area, including most shrub/herb, dense shrub/grassland, and grassland habitats. For the remainder of the study period, only a few female or immature harriers roosted in the area, and no breeding territories were established at Barney's Joy during 1988.

Roosting Behavior and Habitat. Harriers generally left roosts between 20 min before and 40 min after sunrise, with most leaving approximately 10 min before sunrise. In the evening, single harriers began arriving at the roost approximately 40 min before sunset. Most had entered the roost area by 10 min past sunset, and the greatest number of harriers could be seen at this time. These behaviors are consistent with the findings of Weller et al. (1955) in Missouri, and Bosakowski (1983) in New Jersey.

Harrier roosting sites were concentrated within two large patches of dense Black Huckleberry (within dense shrub/grassland) in both years (Fig. 1). Roost 1 (1.9 ha) had 74.9% dense shrub cover; Roost 2 (2.6 ha) had 73.3% dense shrub cover. The mean height of shrubs in Roost 1 was 68.7 cm ($SD \pm 21.8$ cm) and in Roost 2, 83.7 cm ($SD \pm 17.6$ cm). Roosting harriers avoided patches of shorter shrubs (<0.3 m), which were interspersed with the taller shrub patches in Roost 1.

Harriers roosted in dune swales to the west of the study area for more than a month after fire removed shrub cover from most of Roost 1. Although shrub height in shrub/herb was not significantly different than that in dense shrub/grassland ($\bar{X} = 84.8$ cm and 82.2 cm, respectively), harriers did not roost in the former, suggesting that dense shrub patches are preferred over sparse stands as roosting sites.

Within roost areas, harriers used three site-types for roosting: (1) small patches of flattened forbs with-

in the shrubs; (2) completely or partially flattened shrubs; and (3) narrow, grass covered cowpaths within the shrub patches. Most individual roost sites were smaller than 0.25 m^2 , and biweekly pellet collection demonstrated that harriers were generally faithful to these sites for several days or weeks at a time. Occasionally, feces and pellets would be piled on opposite sides within a site, indicating that the harrier had spent several nights in the same position on the ground. Harriers infrequently roosted together in the same opening within a shrub patch. Though the harriers used the same shrub patches for roosting during each winter period, the actual roost sites used within the patches were not the same in each year.

Breeding Season Habitat. Both breeding territories were centered in shrub-dominated habitats. The mean height of shrubs sampled in Territory 1 (shrub/herb) was 84.8 cm ($SD \pm 32.6$), and in Territory 2 (dense shrub/grassland), 82.2 cm ($SD \pm 29.3$).

The two nests found with eggshell fragments were both within patches of dense shrubs of the same height ($0.93 \pm 0.28 \text{ m}$). The 1987 nest (Territory 1) was placed in a patch of dense huckleberry within the generally sparser, shrub/herb habitat, near the highest elevation of the study area (Fig. 1, nest a). Sumac, Northern Arrowwood and blueberry were subdominant shrubs at that site. The nest from the 1986 breeding season (found while sampling vegetation characteristics within the boundaries of Territory 2) was situated on a low hummock, uniformly covered with very dense huckleberry, Virginia Rose and Pasture Rose (Fig. 1, nest b).

The habitat used by breeding harriers at Barney's Joy was similar to that of harriers nesting on Nantucket Island, Massachusetts in 1985 (Holt and Melvin 1986). There, as at our study site, nests were placed in dense shrub patches within shrub-dominated territories. The mean distance from the Nantucket nests to the edge of the shrub patch within which they occurred (i.e., nearest herbaceous vegetation) was 14.3 m (range = 3.1–27.0 m) (Holt and Melvin 1986); the mean for the two nests at Barney's Joy was 17.3 m (10.8 and 27.7 m).

Thus, although historical accounts of harriers in southeastern New England do not list upland habitats as nesting sites (Forbush 1927, Bent 1937, Griscom and Snyder 1955, Hill 1965), such sites are now relatively common. This suggests that harriers have

moved into upland sites in recent decades, or alternatively, that upland sites went unnoticed by previous investigators. F. Hamerstrom (pers. comm.) theorizes that harriers have been forced to breed in shrub communities as more preferred nesting habitats have become scarcer. Regardless of the reason, coastal upland-shrub habitats should be considered as potential harrier nesting areas when conducting surveys of breeding harriers, or of potential breeding habitat.

Harrier Population Trends in Southeastern New England. As early as 1927 Forbush (1927: 100) noted that harriers were "formerly much more common" in New England, and subsequent accounts provide evidence that a decline in the number of breeding harriers has continued throughout this century (Bent 1937, Griscom and Snyder 1955, Hill 1965, Serrentino and England 1989, Nikula and Holt, in prep.).

Presently, only 8–10 pairs are believed to nest on Cape Cod, and the islands of Martha's Vineyard and Nantucket each support about 25 pairs (Nikula and Holt, in prep.). The harrier has been extirpated from mainland Connecticut and Rhode Island, and Barney's Joy represents the only known mainland (excluding Cape Cod) breeding site in Massachusetts (T. French, pers. comm.). Nikula and Holt (in prep.) cite loss of habitat as the principal reason for the marked reduction in the number of breeding harriers in Massachusetts. Serrentino and England (1989) broaden that explanation to include all of the Northeast. Both cite loss of coastal wetlands and the reforestation of farmlands as the principal factors relating to habitat loss.

Serrentino and England (1989:42) noted that "Harrier populations do not appear to have decreased as drastically on their wintering grounds in the Northeast compared to the decline in the number of breeding birds. . ." That premise is supported for southeastern New England by our relatively high counts of wintering harriers at Barney's Joy, and by Reinert (1984), who observed as many as five harriers hunting simultaneously during the winter at Sachuest Point, Rhode Island, where harriers do not breed. Results of the Christmas Bird Count analysis indicate a trend of increasing numbers of wintering harriers in southeastern New England beginning in 1975, with a leveling off occurring from 1983–1988 (Fig. 2). The mean number of harriers per 100 party hours was 3.66 from 1962–1966, and 5.35 from

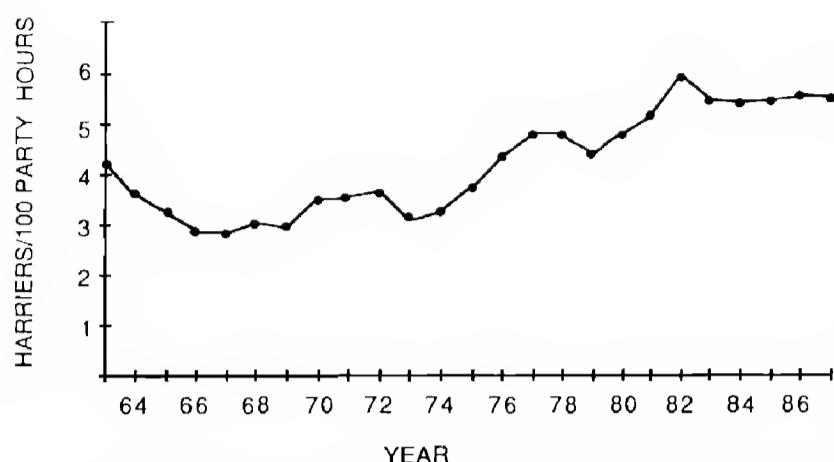


Figure 2. Three-year moving average of number of harriers seen per 100 party hours during Christmas Bird Counts, cumulatively for 17 census-circles in Massachusetts, Connecticut and Rhode Island, for years 1962–1988.

1984–1988, which represents an increase of 46% during the 27-year period. We found no significant relationships between harrier numbers and mean temperature or snow cover during the same 27-year period.

Thus, while the number of breeding harriers in southeastern New England has decreased during recent decades, there is substantial evidence to suggest that wintering numbers have increased. This indicates that (1) a pool of harriers, which represents potential nesting birds, departs from the region at the end of the winter roost period, and (2) factors which do not operate in the winter are acting to limit the number of harriers that remain in southeastern New England to breed. Serrentino and England (1989) suggest that harriers leave wintering areas with potentially suitable nesting habitat due to the increased use of coastal areas by humans during the breeding season months. This explanation seems plausible at areas such as Barney's Joy and Sachuest Point, where nearby beaches attract many visitors and seasonal residents in the spring and summer seasons. However, it is premature to attribute the opposing seasonal trends in harrier populations solely to this explanation. Other factors, such as migration patterns, seasonal changes in prey availability, and attraction to natal breeding areas, may also play roles. An understanding of these factors is essential in developing effective management strategies for breeding harriers, and we urge wildlife researchers elsewhere in the Northeast to initiate investigations in this area. Of particular interest would be studies of (1) harrier movements as they disperse from their

winter roosts (via marking or radiotelemetry), and (2) the relationships between the prey base and harrier nesting and roosting habitats.

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MOLT PATTERN AND DURATION IN A FEMALE NORTHERN GOSHAWK (*Accipiter gentilis*)

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ABSTRACT.—The successive molt patterns (1983–1989) of the major flight feathers (alulas, primaries, secondaries and tail) were studied in a wild bred, captive female German goshawk (*Accipiter gentilis*). Where possible, the date that each feather was shed was recorded, and the rachis length and thickness measured.

The observed variation in the total number of feathers molted each year was due to annual differences in the number of tail and secondary feathers shed. With the exception of 1985, all alulas and primary feathers were replaced annually. The pattern of secondary and tail feather loss in any one year was largely dependent on the molt pattern of the previous year. Although the duration of the overall molt decreased from a maximum of 141 days in 1984 to a minimum of 98 days in 1988, the onset of each molt remained relatively constant between days 134 and 145. The length of 2nd and subsequent primaries was greater than that of the first primaries grown in the nest. A significant thickening of the rachis in some primaries was also found, indicating an increase in feather strength between juvenile and subsequent feathers.

Patrones y duración del cambio de las plumas en un Gavilán Azor hembra (*Accipiter gentilis*)

EXTRACTO.—Los patrones del cambio sucesivo (1983–1989) de las plumas necesarias para vuelos mayores (bastardas, primarias, secundarias, y de cola) han sido estudiadas en un Gavilán Azor (*Accipiter gentilis*) hembra, cautiva pero silvestremente incubada y criada. En lo posible, se ha registrado la fecha de la caída de cada pluma, así como se han medido el largo y grosor del cañón. La variación observada en el número total de plumas cambiadas cada año se debió a las diferencias en el número de plumas de cola y secundarias caídas anualmente. Con la excepción de 1985, todas las plumas bastardas y las primarias fueron reemplazadas anualmente. El patrón de caída de las plumas secundarias y de cola en un año, dependió mayormente del patrón de cambio del año anterior. Aunque la duración de la muda total de plumas decreció desde un máximo de 141 días en 1984 a un mínimo de 98 días en 1988, el comienzo de cada muda permaneció relativamente constante entre los 134 y los 145 días del año, contando desde enero. El largo de las segundas y subsecuentes plumas primarias fue mayor que el de las primeras primarias crecidas en el nido. Se encontró un aumento significativo del grosor del cañón en algunas plumas primarias, lo que indica un aumento en el vigor de las plumas correspondiente con la edad del ave.

[Traducción de Eudoxio Paredes-Ruiz]

The goshawk has recently been identified as one of a relatively small number of species in which the lead (Pb) and cadmium (Cd) contamination of certain well defined feathers can be measured and used as an indicator of environmental contamination by heavy metals (Dietrich and Ellenberg 1986). It is therefore important to know when or how frequently certain feathers are molted so that the period of contamination can be determined.

Similarly, radiotelemetry is being used, increasingly, in the study of wild raptors, including goshawks, and in these studies the radios are often attached to one or two tail feathers (Kenward 1978). In order to maximize the amount of data obtained from each radio-tagged bird it is important to attach

the transmitters to those feathers which are likely to remain unmolted the longest. The need to understand molt patterns is therefore clear.

The first seven annual molt patterns of a wild bred, captive female German goshawk are described in this paper. The bird was taken as a juvenile in the autumn of the year it hatched (1982) and therefore the successive molts cover the change from juvenile to full adult plumage. The first feathers, grown in the nest, did not start to be replaced until the spring of the following year (1983). I investigated the loss and replacement of the main flight feathers (alulas, primaries, secondaries and tail). This long-term study of an individual captive bird kept under conditions of natural light, temperature and excess

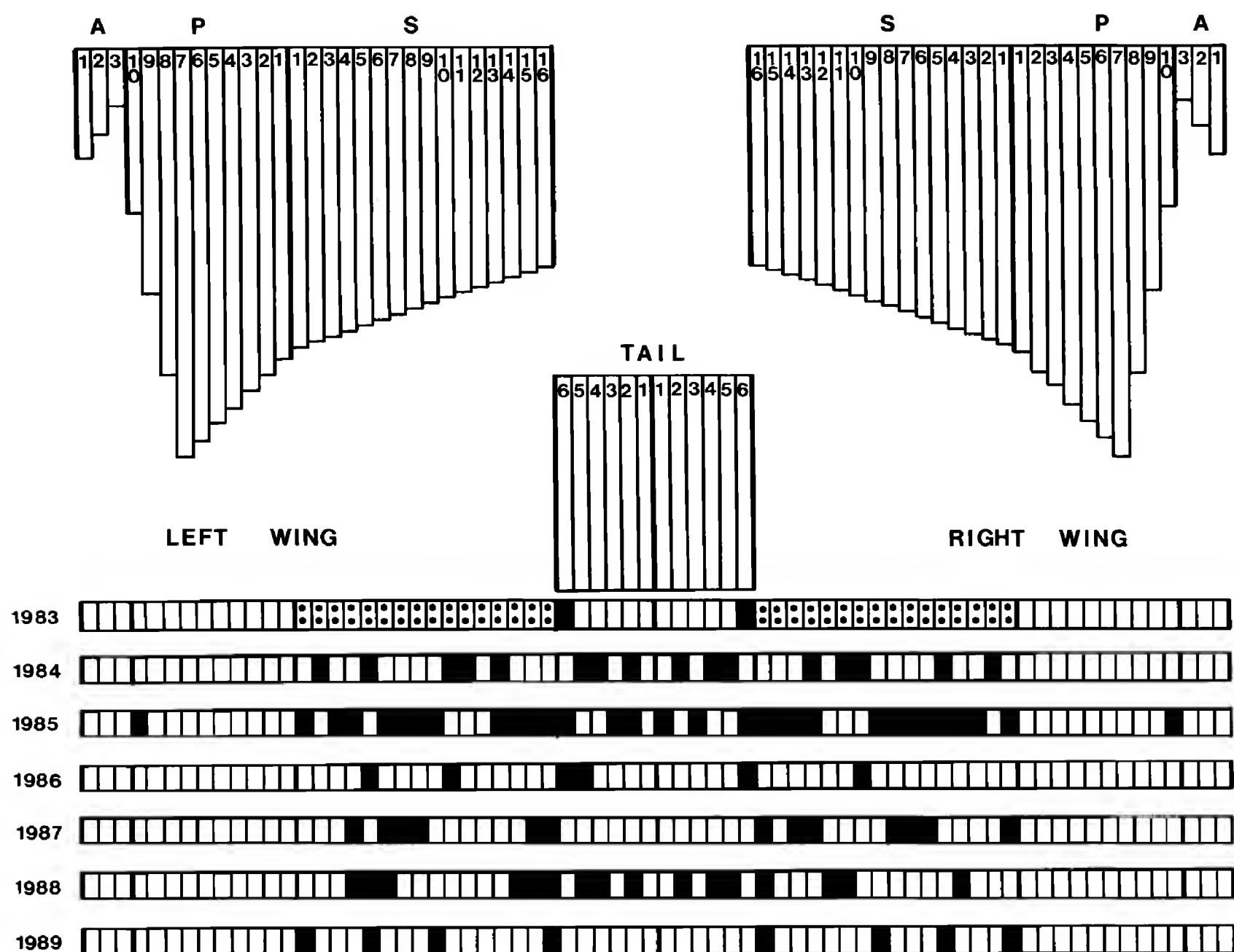


Figure 1. Diagrammatic representation of the main flight feathers in the Goshawk. A = alulas, P = primaries, S = secondaries. The bar codes show which feathers were molted (open cells) or retained (solid cells) each year between 1983 and 1989. The stippled cells represent those feathers for which no molt data were obtained.

food also enabled the changes in molt pattern between years, and the interdependent effects of one molt on the next, to be investigated. Between each molt (October–March) the bird was regularly flown at quarry. It may therefore be considered as a baseline study of a bird, under minimal stress during molt, to which studies of wild birds under many different stresses (food shortage, breeding, weather etc.) can be compared. Although molt data of this type are much more difficult to obtain from studies of wild birds, some limited success was achieved by Brüll (1984) studying wild German goshawks between 1950 and 1959. Unfortunately his data are incomplete. In contrast the molt data obtained in this study are complete for each of the four main flight feather types for either 6 or 7 years and should be

viewed as being complementary to those of Brüll (1984).

METHODS

With the exception of the first year of the study (1983) the date on which each alula, primary, secondary and tail feather was molted was recorded. In 1983 only the primary and tail feathers were recovered and the date on which each was molted was not recorded.

The thickness of the rachis of each feather was measured to an accuracy of 0.01 mm using vernier calipers. With the blade of the feather in the horizontal plane, the thickness of the rachis was taken in the vertical plane at a point 5 mm proximal to the point where the feather barbs attach to the rachis. Flattened rachis length was taken as a measure of feather length and was recorded to an accuracy of 1.0 mm. It was only possible to measure those feathers that were found intact.

All the feathers were numbered in the following way

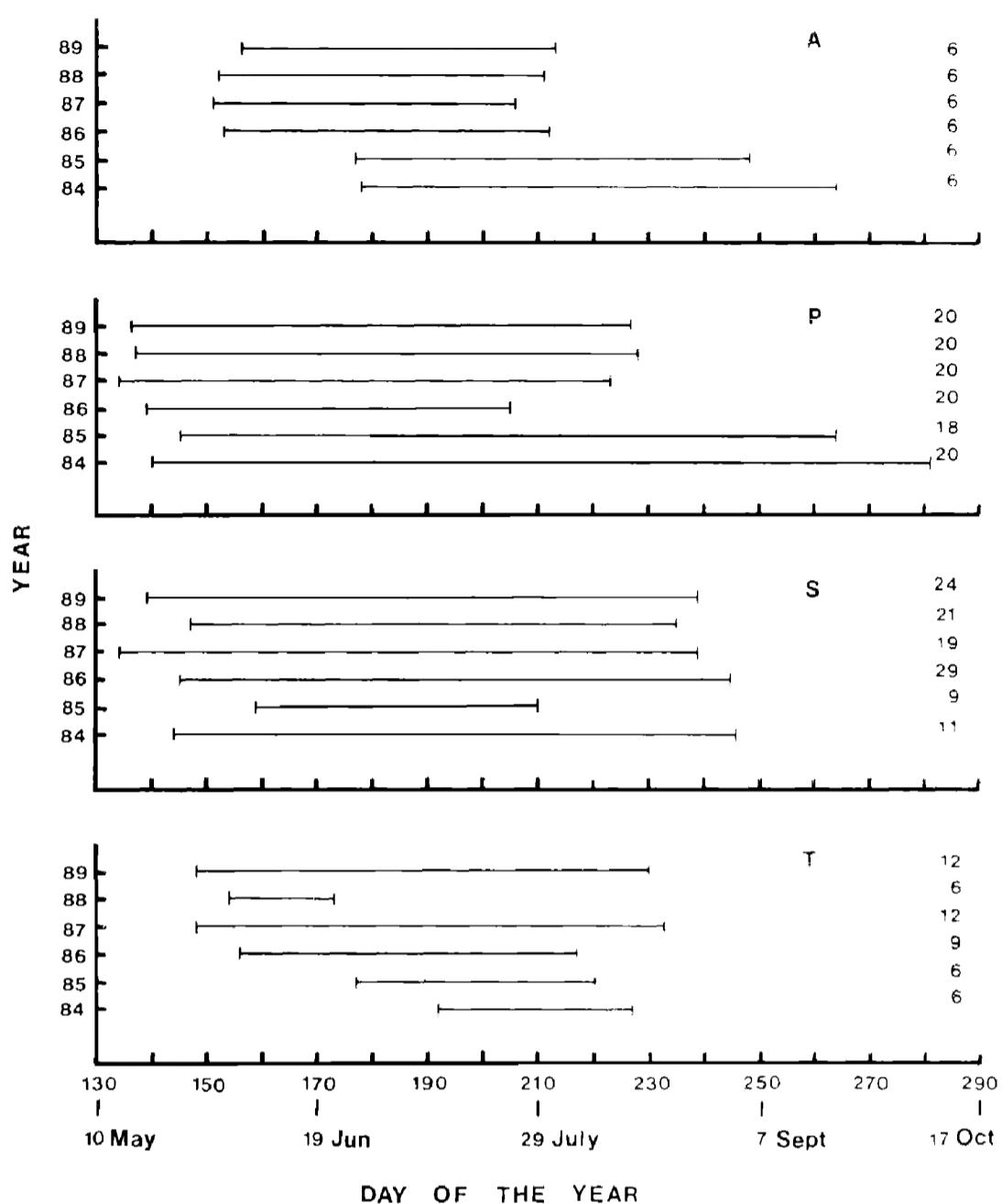


Figure 2. Start and duration of the molt in each of the main flight feather types in the Goshawk for each year from 1983 to 1989. A = alulas, P = primaries, S = secondaries, T = tail. The figures show the number of each feather type molted each year.

The alulas were numbered from the outermost inwards (1–3); the primaries from the innermost outwards (1–10); the secondaries from the outermost inwards (1–16) and the tail from the innermost outwards (1–6). The date on which a particular feather was molted was recorded as the nth day of the year with January 1st being day 1. This convention overcame the potential problem of the extra day during leap years (1984, 1988).

The data were analysed using either Student's *t*-test or linear regression analysis.

RESULTS

A summary showing which feathers were molted during each of the years for the period from 1983–1989 is given in Fig. 1. Similarly the overall duration of each molt for each feather type, and the number of feathers shed, are shown in Fig. 2. Each of the four feather types collected will be dealt with separately.

Alulas. All three alulas on both wings were molted every year, and in sequence, beginning with feather 3 and ending with feather 1. Although the interval between equivalent feathers on each wing being molted ranged from 0–20 days there was an overall reduction in the length of the interval between successive feathers being shed between 1984 and 1986 (Table 1). Between 1986 and 1989 this interval remained relatively constant.

The starting date of the alula molt changed noticeably between 1985 and 1986. In 1984 and 1985 the molt began on days 178 and 177, respectively, whilst between 1986 and 1989 the molt started between days 151 and 156, approximately 24 days earlier. Concurrent with this earlier start there was a reduction in the overall time taken for all six feathers to be shed from 86 and 71 days in 1984

Table 1. Mean number of days taken to molt each feather each year (1984–89) in a female goshawk.

YEAR	ALULA	PRIMARY	SEC-		OVER-
			OND-	ARY	
1984	14.3	14.1	9.3	5.8	2.6
1985	11.8	13.2	11.3	7.2	3.1
1986	9.8	7.3 (6.6) ^a	6.9	6.8	1.7
1987	9.2	8.9	11.0	7.1	1.8
1988	9.8	9.1	8.4	3.2	1.9
1989	9.5	9.1	8.3	6.8	1.7
(1984–85)					
Mean	13.1	13.7	10.3	6.5	2.9
SD	1.8	0.6	1.4	1.0	0.4
N	2	2	2	2	2
(1986–89)					
Mean	9.6	8.6	8.7	6.0	1.8
SD	0.3	0.9	1.7	1.9	0.1
N	4	4	4	4	4

^a In 1986 primary 10, which was not shed in 1985, was shed out of sequence thus resulting in an artificially low mean (6.6). The corrected mean was calculated excluding the feather 10 pair.

and 1985 to between 55 and 59 days for the period 1986 to 1989 (Fig. 2).

Primaries. All ten primaries on each wing were molted every year except 1985 when primary 10 on each wing was retained (Fig. 3). With the exception of 1986 they were also molted in sequence, starting

with feather 1 and ending with feather 10. Although feather 10 was molted out of sequence, between feathers 7 and 8, in 1986 the intervals between the loss of feathers 1 to 9 were not affected. Equivalent primaries on each wing were usually molted on the same day or within 5 days of each other.

Unlike the pattern shown by the alula molt there was no clear change, between 1984 and 1989, in the starting date of the primary molt (days 134–145). There was, however, a significant reduction ($t = 7.05$, $df = 4$, $P < 0.01$), from 1985 to 1986, in the interval between the shedding of successive feathers from a mean of 13.7 days in 1984/1985 to 8.6 days between 1986 and 1989 (Table 1) resulting in a large reduction in the overall time taken to complete the primary molt (Fig. 2).

Secondaries. The total number of secondary feathers molted each year was unpredictable and varied considerably from a minimum of 9 in 1985 to a maximum of 29 in 1986 (Fig. 1). The start of the secondary molt was also more variable than that of the alulas or primaries ranging between day 134 in 1987 and day 159 in 1985 (Fig. 2). No significant change was found in the interval between the molting of successive feathers during the course of the study ($t = 1.13$, $df = 4$, $P > 0.10$; Table 1). There is some evidence, however, to suggest that feathers retained in a particular year were more likely to be molted the following year than those that were previously molted. In only one year, 1986, was an almost full

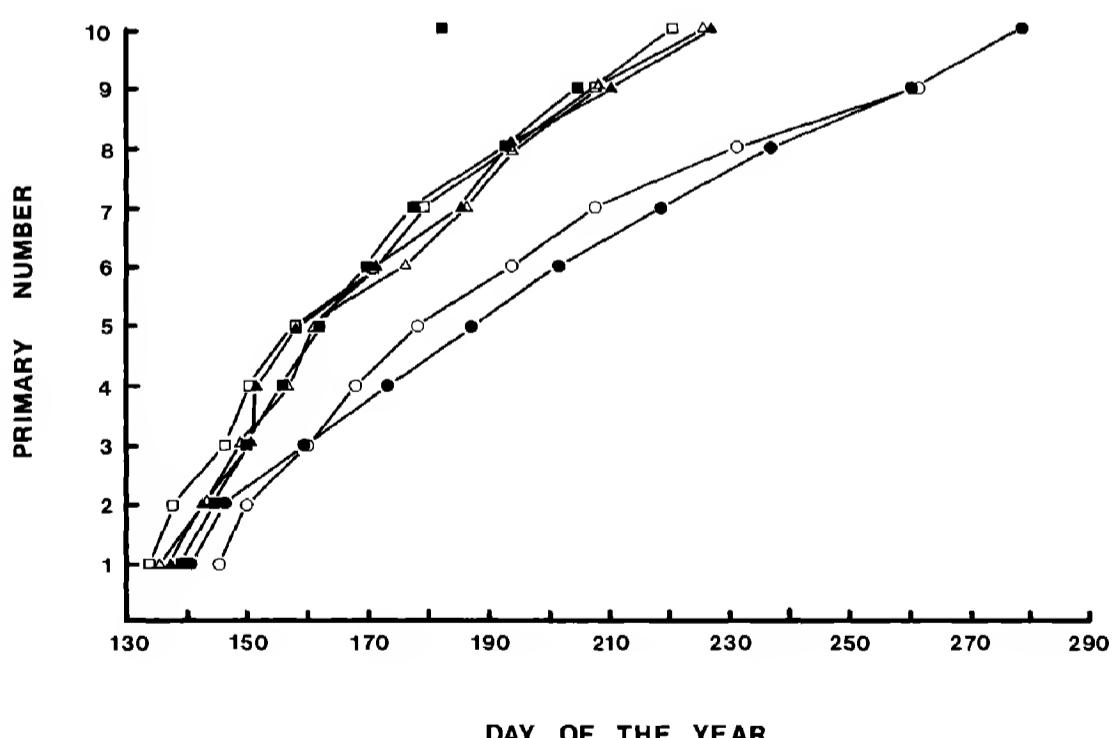


Figure 3. The mean molt date for each pair of primary feathers between 1984 and 1989. ● = 1984, ○ = 1985, ■ = 1986, □ = 1987, ▲ = 1988, △ = 1989. The No. 10 primary, molted out of sequence in 1986, is the primary that was not shed in 1985.

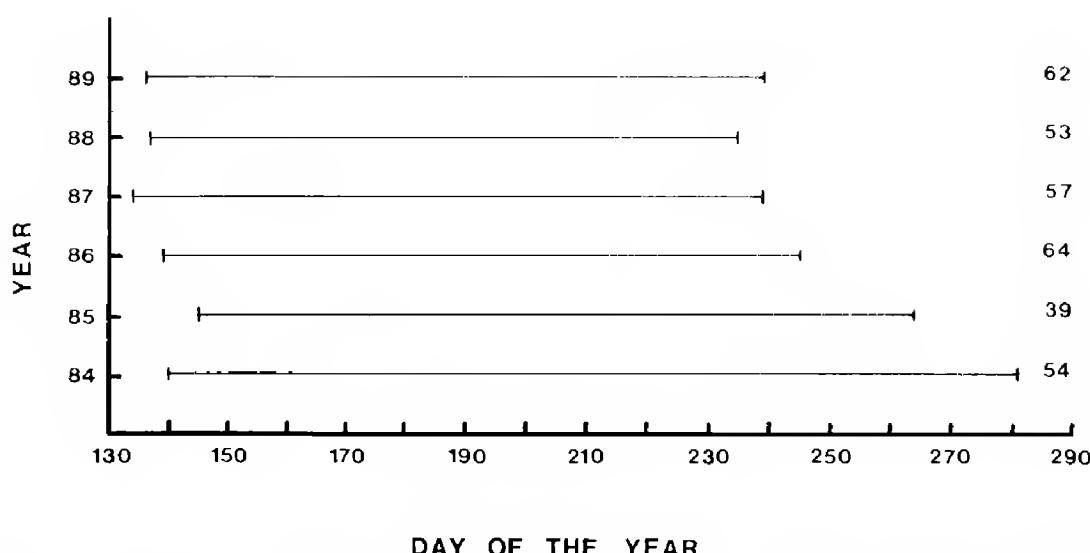


Figure 4. Start and duration of the complete molt for each year between 1984 and 1989. The figures show the total number of feathers molted each year.

complement of secondaries molted and replaced (29/32 feathers).

The sequence in which the feathers were molted varied between years and was, to some extent, also dependent on whether or not a particular feather had been molted the previous year. However, by scoring each molted feather, each year, according to when it was molted and by combining the scores for equivalent feathers on each wing a pattern was found. Overall, the secondary molt followed the sequence: feather 6, 15, 5, 3, 11, 10, 2, 7/14, 12, 13, 9, 8, 4, 1, 16. This pattern suggested the presence of four molt centers on each wing at feathers 3, 6, 11 and 15.

Tail. As with the secondaries, the total number of feathers molted each year was largely unpredictable ranging between 6 and the full complement of 12. There was, however, a tendency for feathers that had not been shed in one year to be shed the following year (e.g., 1984/85; Fig. 1).

The starting date of the tail molt got progressively earlier between 1984 (day 192) and 1987 (day 148), and then stabilized at between days 148 and 154 over the last three years with the biggest difference occurring between 1985 and 1986 (Fig. 2).

The sequence in which the feathers were molted varied between years and was dependent on whether or not a particular feather had been shed the previous year. However, by using the method already explained for secondaries the overall molt pattern for either side of the tail followed the sequence: feather 5, 1, 2, 6, 3, 4. Exceptions to this usually started with the sequence: feather 1, 6, 3.

Overall Timing and Duration of Molt. The total number of major flight feathers molted each

year varied between 39 in 1985 and 64 in 1986, the full complement being 70. Of these the number of alulas and primaries molted annually remained almost constant whilst the variation in the number of secondaries and tail feathers that were molted accounted for the annual differences in the total number of feathers molted.

The start of the annual molt occurred between days 134 and 145. The apparent trend towards an earlier start date with increasing age was not significant ($r^2 = 0.47$, $N = 6$, $P > 0.05$). The time taken to complete the annual molt (Fig. 4) decreased progressively from 141 days in 1984 (54 feathers) to a minimum of 98 days in 1988 (53 feathers). The largest difference between the mean time to molt each feather occurred between 1985 (3.1 days) and 1986 (1.7 days).

Rachis Length and Thickness. Because the 1983 alulas and secondaries, though molted, were not collected it was impossible to compare their rachis lengths with those of feathers from subsequent molts. Similarly, though collected, the 1983 tail feathers all had damage to their tips and therefore it was impossible to compare rachis length in these feathers during the change from juvenile to first adult plumage. It was possible, however, to compare rachis lengths and thicknesses for primary feathers from all seven years. Both an increase in rachis length between first and subsequent years (Table 2) and an increase in rachis thickness were found (Table 3). The thickening of the rachis between 1983 and 1984 did not occur in all the primaries equally, being most noticeable in feathers 1–5.

An analysis of tail feather rachis thickness showed that a significant thickening was only detected in

Table 2. Comparison of mean feather/rachis length (mm) between 1st and subsequent molts for equivalent primaries on the left and right wing of a female goshawk.

FEATHER TYPE	FEATHER NUMBER										
	1	2	3	4	5	6	7	8	9	10	
Primary (1st)	Mean	211	214	222	233	239	265	—	240	226	—
	SD	0	1.4	6.4	11.3	—	0	—	0	2.8	—
	N	2	2	2	2	1	2	—	2	2	—
Primary (2nd+)	Mean	214	222	230	245	275	289	—	—	229	159
	SD	1.4	1.2	1.9	2.2	4.7	8.0	—	—	2.9	2.3
	N	11	12	12	12	7 ^a	4	—	—	5	9

^a Primaries 5–10 being both the outermost and including the largest feathers (5–8) were most prone to damage often making it impossible to measure their length.

feathers 3 ($t = 2.27$, $df = 10$, $P = 0.05$) and 6 ($t = 5.31$, $df = 6$, $P = 0.002$) between first and subsequent molts.

DISCUSSION

A number of conclusions can be drawn from this study of molting in a captive female goshawk. Although all the alula and primary feathers were replaced during the first molt, some tail and possibly some secondary feathers remained and were not shed until the second molt. With the exception of one year, all the alulas and primaries were replaced ev-

ery year. Previous studies of wild sparrowhawks in Scotland (Newton and Marquiss 1982) and both wild sparrowhawks and wild goshawks in the Federal Republic of Germany and the Netherlands (Brüll 1984, Opdam and Müskens 1976) have demonstrated similar molt patterns for the primaries but none looked at the smaller alulas. Complete replacement of the secondary and tail feathers did not occur annually. Instead, it was found that in these two feather types the molt pattern in any particular year was determined to some extent by the molt pattern of the previous year.

Table 3. Mean rachis thickness (mm) of 2nd and subsequent feathers compared with that of 1st feathers. Means calculated using the combined data for equivalent feathers from both wings.

FEATHER TYPE	FEATHER NUMBER										
	1	2	3	4	5	6	7	8	9	10	
Alula (1st)	Mean	—	—	—	—	—	—	—	—	—	
Alula (2nd+)	Mean	3.27	2.89	2.37	—	—	—	—	—	—	
	SD	0.07	0.09	0.06	—	—	—	—	—	—	
	N	12	12	12	—	—	—	—	—	—	
Primary (1st)	Mean	3.71	4.04	4.32	4.53	4.81	5.04	4.69	4.47	3.88	3.28
	SD	0.04	0.06	0.08	0.13	0.13	0.06	0.01	0.04	0.06	0.03
	N	2	2	2	2	2	2	2	2	2	2
Primary (2nd+)	Mean	4.40	4.58	4.80	5.03	5.28	5.26	5.00	4.60	4.01	3.40
	SD	0.10	0.09	0.05	0.07	0.11	0.15	0.15	0.13	0.13	0.10
	N	12	12	12	12	12	12	12	12	12	10
Tail (1st)	Mean	4.89	5.06	5.01	5.15	5.16	5.03	—	—	—	—
	SD	0.27	0.06	0.01	0.01	0.08	0.04	—	—	—	—
	N	2	2	2	2	2	2	—	—	—	—
Tail (2nd+)	Mean	4.80	5.02	5.16	5.19	5.18	5.24	—	—	—	—
	SD	0.17	0.16	0.09	0.08	0.09	0.05	—	—	—	—
	N	10	7	10	8	7	6	—	—	—	—

The increases in feather length between juveniles and adults, seen by Opdam and Müskens (1976) in wild goshawks, were also found in this study. Increases in the thickness of the rachis of some primary (feathers 1–5) and tail (feathers 3 & 6) feathers were also detected. This occurred between the juvenile and first adult feathers and suggests an actual strengthening of the feathers rather than proportional growth. The reasons for this are unclear but may be a response to differences in food availability. Food shortage as a chick may well result in reduced feather growth, whereas in captivity feather growth would not have been constrained in this way, resulting in stronger feathers. In addition, and consistent with this hypothesis, is the fact that the feathers of the first plumage are all grown simultaneously whereas feather replacement following a molt is staggered.

The other main changes occurred between the third and fourth molts. The fourth molt of both the alula and tail feathers started earlier and the duration of the alula and primary molts shortened significantly. In contrast to the findings of Newton and Marquiss (1982) for the sparrowhawk, the onset of the molt remained relatively constant during the seven years of the study and may even have occurred a little earlier as the bird aged.

In a comparison between the molt patterns observed in wild German goshawks (1950–1959) by Brüll (1984) and the captive German goshawk in this study two clear differences emerge. First, the start of the primary molt in the wild birds occurred, on average, about 50 days earlier than in the captive bird but proceeded at approximately the same rate (Brüll's data for the end of the primary molt are poor). Second, the interval between successive primaries being shed in the wild birds was initially very short: 2–7 days for primaries 1–4; but then increased to 16 days between primaries 4 and 5. Brüll gives no reliable data for primaries 6–10. No such sudden increase in the molt interval was found in the captive bird. These differences may illustrate both the hormonal control of molting and its known correlation

with egg laying (Brüll 1984) which in Germany usually occurs in late March or early April (approx day 90), and the effect of food stress on molting and feather growth. Once the female has eggs, she is dependent on the male for food.

With respect to radio-tagging wild goshawks, the tail feather molt pattern determined in this study suggests 1) that feathers 2/3 or 3/4 should be used for the attachment of transmitters, thus largely supporting Kenward's finding (1978) and 2) that new feathers should be used in preference to old ones since these have the highest chance of remaining unmolted the following year.

This was a study of a single captive goshawk and therefore the data should be interpreted with care, particularly when extrapolating to the wild situation. Nevertheless, the data are relevant for those studying wild goshawks/raptors in that they show both the changes that occur in molt pattern with age and the relationship between successive molt patterns.

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RAPTOR ROAD SURVEYS IN SOUTH AMERICA

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ABSTRACT.—Twenty-six (23 traveling and three point) raptor roadside surveys were conducted during a 29,000 km expedition through nine nations of South America. During roadside surveys, we tallied 41 of the 87 (47%) diurnal raptor species (including vultures) that occur in South America. The number of species observed per route varied from 17 in the wet savanna of Venezuela to only two species recorded in the harsh Atacama Desert and the dry montane grasslands of Chile and Peru. Raptor density (non-vultures) varied from 1 per 67 km in the Atacama Desert to more than 1 per km in agricultural areas where caracaras and other species that utilize disturbed habitats were common. Responses of raptor communities to deforestation and other habitat disturbances are discussed. While certain habitat modifications potentially increase raptor abundance and diversity, the alteration of primary forest has the opposite effect, at least on diversity.

Indagaciones sobre aves raptoras, hechas en carreteras de América del Sur

EXTRACTO.—26 (23 viajando y 3 estacionarias) inspecciones de aves raptoras, a lo largo de una carretera, fueron realizadas durante una expedición de 29,000 km a través de 9 naciones de América del Sur. Durante las inspecciones de carretera hemos contado 41 de las 87 (47%) especies raptoras diurnas (incluyendo buitres) que se encuentran en América del Sur. El número de las especies observadas en cada ruta varió de 17 en las praderas lluviosas de Venezuela, hasta solo 2 especies registradas en el desierto de Atacama y las secas lomas de Chile y Perú. La densidad de aves raptoras (no buitres) varió desde 1 por 67 km en el desierto de Atacama, hasta más de 1 por km en áreas agrícolas, donde eran comunes las caracaras y otras especies que utilizan habitats alterados. Se discuten los resultados de la deforestación y otras alteraciones del habitat en las comunidades de aves raptoras. Mientras que ciertas modificaciones del habitat potencialmente aumentan la abundancia y diversidad de aves raptoras, la alteración de florestas naturales tiene el efecto opuesto, a lo menos en la diversidad.

[Traducción de Eudoxio Paredes-Ruiz]

Raptor survey methods have been reviewed by Fuller and Mosher (1981, 1987). Although the limitations and biases inherent in the road counts are well known (Verner 1985, Millsap and LeFranc 1988), road surveys unfortunately are the only practical means now available for rapidly assessing raptor distribution and, to a degree, abundance over large areas. Roadside surveys have been used to determine species composition and to estimate relative abundance for diurnal raptor communities in Africa (Rowan 1964, Cade 1969), Europe (Meyburg 1973, Saurola 1976), North America (Nice 1934, Craighead and Craighead 1954, Enderson 1965, Johnson and Enderson 1972, Woffinden and Murphy 1977, and many others), and, to a very limited degree, in

Latin America (Reichholz 1974, Ellis et al. 1983, Albuquerque et al. 1986, Wotzkow and Wiley 1988).

Using road counts and point counts, we surveyed diurnal raptors in nine South American nations and related both species composition and relative abundance to gross features of the habitats.

METHODS

The expedition was conducted from 12 January through 23 April 1979. During this time, we established 23 roadside survey routes and two point count locations (Fig. 1). Abbreviated descriptions of survey locations, habitat types, and other salient features are presented in Table 1. Descriptions of the physical and biotic characteristics of the survey routes and photographs of survey route boundaries are available from the senior author.

To facilitate relocating each route in future surveys,

Table 1. Descriptions of South American raptor counts in 1979.

No. ^a	NATION: ZONE	LENGTH (km)	DATE DAY/MO.	TIME START	HABITAT TYPE ^b	DISTURBANCE ^c
1	Venezuela: NC	90	26.01	0645	VDFor (montane), OFor (coastal swamp), AgC	Low-Medium
2	Venezuela: NC	81	29.01	1615	DSav, OSav	Low
3	Venezuela: NC	113	30.01	0910	DSav, OSav, AgP	Medium
4	Venezuela: NE	80	31.01	1355	OFor, VDFor (montane), VDFor (lowland)	Medium
5	Venezuela: E	96	01.02	1130	DFor (montane)	Low-Medium
6	Brazil: N	119	03.02	0835	VDFor & SecG (road swath)	Low-Medium
7	Brazil: N	119	05.02	0722	VDFor & SecG (road swath)	Medium
8	Brazil: WC	144	13.02	0840	D-VDFor & AgC (road swath)	Medium
9	Brazil: SC	124	24.02	1240	OSav & Wd, AgC & AgP	Medium
10	Brazil: S	131	28.02	0825	Wd, AgC	Medium-High
11	Paraguay: S	111	01.03	1050	Wd, AgC	High
12	Argentina: NE	76	03.03	0805	OSav & RGFor	Low
13	Argentina: SE	150	07.03	0945	AgC & AgP, DScrub	High
14	Argentina: S	178	08.03	0920	DScrub	Low
15	Argentina: S	162	12.03	0745	DFor, DScrub	Low
16	Argentina: S	77	12.03	1445	DScrub	Low
17	Argentina: SE	169	16.03	1000	DScrub	Low
18	Chile: C	84	21.03	1100	AgC & AgP	High
19	Chile: NC	134	23.03	1000	SDes	Low
20	Peru: S	202	31.03	0715	MScrub, SDes	Low
21	Ecuador: N	70	07.04	0655	MScrub, OFor, RGFor, AgC	Medium
22	Venezuela: W	79	13.04	1035	DSav, RGFor, AgP, OSav	Medium
23	Venezuela: N	116	15.04	0655	OSav, AgP	Medium
A	Venezuela: NC	N.A.	28.01	1050-1150	VDFor (montane), same location as C	Low
B	Venezuela: NC	N.A.	31.01	1535-1805	OSav (formerly DSav)	Medium-High
C	Venezuela: NC	N.A.	19.04	0835-0935	VDFor (montane), same location as A	Low

^a Count type: Road Count (1-23), Point Count (A-C).^b Habitat type abbreviations and overstory canopy cover (oscc) classes: Desert (Des), Semi-Desert (SDes), Desert Scrub (DScrub), and Montane Scrub (MScrub) 0-5% osc; Open Savanna (OSav) 5-20% osc; Dense Savanna (DSav) 20-50% osc; Open Forest (OFor) 50-70% osc; Dense Forest (DFor) 70-90% osc; Very Dense Forest (VDFor) 90-100% osc; Second Growth (SecG), Woodlots (Wd), Agricultural Pastures (AgP), Agricultural Croplands (AgC), Riparian Gallery Forest (RGFor).^c A gross evaluation of the degree of alteration of habitat from pristine form.

where practical, we chose distinctive topographic features and road junctions to define beginning and ending points of survey routes. We located routes in one habitat type, or in a uniform interspersion of two habitat types. The imposition of these parameters resulted in transects of varying lengths. We also attempted to limit surveys to morning hours (five exceptions) during fair, calm weather. Driving speeds were 70-80 km/hr on paved roads and 50 km/hr or less on dirt roads, although road conditions were occasionally too variable to permit a uniform driving speed.

Roadside counts (a form of Verner's 1985 line transects without distance estimates) were conducted by two experienced observers; a driver and a record keeper, both in the front seat of a Toyota Land Cruiser. A third person acted as a recorder for some of the routes. We identified

and tallied most raptors while we were in transit. Occasionally, we stopped to confirm identification of an individual bird; raptors detected during these stops were not tallied unless, in our judgment, they would have been noted during uninterrupted travel. Although the new world vultures (family Cathartidae) are not now considered members of Order Falconiformes (Rea 1983), we included them in our counts. Along many survey routes, however, vultures were so abundant that to count them all would have diverted our attention inordinately from our search for true raptors. Therefore, only the first 20 individuals of the common vulture species were counted. Only rarely did we identify and tally raptors further than 1 km from the road.

Three point counts (a form of Verner's 1985 point counts

Table 2. Raptor count summary, South America, 1979.

Table 2. Continued.

SPECIES	ROAD COUNT												
	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10	RC11	RC12	RC13
<i>Parabuteo unicinctus</i>	3												
<i>Buteo nitidus (Asturina nitida)</i>	2	3	2		1	1				7			
<i>Buteo magnirostris</i>	1					15			3	2	1		20
<i>Buteo platypterus</i>													
<i>Buteo brachyurus</i>													
<i>Buteo albicaudatus</i>				1	3								
<i>Buteo polyosoma</i>													
<i>Buteo</i> sp.					1			1					14
<i>Spizaetus tyrannus</i>													
<i>Daptrius ater</i>													
<i>Daptrius americanus</i>	9	26	3		6			2	4				
<i>Polyborus phainopeplus</i>													
<i>Milvago chimachima</i>	7	11	7				1						
<i>Polyborinae</i> sp.	1			1									
<i>Herpetotheres cachinnans</i>					1								
<i>Falco sparverius</i>					1								
<i>Falco rufigularis</i>													
<i>Falco femoralis</i>													
<i>Falco peregrinus</i>													
<i>Falconiformes</i> sp.	1	4							2				
Total Species (non-vult. only)	9 (6)	10 (8)	9 (7)	6 (4)	6 (5)	15 (12)	8 (7)	11 (8)	10 (7)	8 (7)	4 (2)	16 (13)	5 (5)
Total Indiv.: non-vultures	18	37	43	10	15	45	12	43	30	38	30	86	59
Diversity: non-vultures	0.699	0.789	0.570	0.654	0.554	0.874	0.778	0.766	0.596	0.400	0.141	0.910	0.566
Abundance: km/bird, non-vult.	5.0	2.19	2.63	8.0	6.4	2.64	9.92	3.35	4.13	3.45	3.70	0.88	2.54

Table 2. Continued.

Table 2. Continued.

SPECIES	ROAD COUNT						POINT COUNT						
	RC14	RC15	RC16	RC17	RC18	RC19	RC20	RC21	RC22	RC23	PCA	PCB	PCC
<i>Parabuteo unicinctus</i>													
<i>Buteo nitidus (Asturina nitida)</i>													
<i>Buteo magnirostris</i>													
<i>Buteo platypterus</i>													
<i>Buteo brachyurus</i>													
<i>Buteo albicaudatus</i>													
<i>Buteo polyosoma</i>													
<i>Buteo</i> sp.	15	1	2	7									
<i>Spizaetus tyrannus</i>													
<i>Daptrius ater</i>													
<i>Daptrius americanus</i>													
<i>Polyborus plancus</i>	19	36	131	6	129	113							
<i>Milvago chimango</i>													
<i>Milvago chimachima</i>													
<i>Polyborinae</i> sp.													
<i>Herpetotheres cachinnans</i>	9	13	1	27	16	8	3	5	1	2			
<i>Falco sparverius</i>													
<i>Falco rufifacies</i>													
<i>Falco femoralis</i>													
<i>Falco peregrinus</i>													
<i>Falconiformes</i> sp.													
Total Species (non-vult. only)	3 (3)	7 (7)	4 (4)	7 (7)	2 (2)	2 (1)	2 (1)	17 (13)	14 (11)	4 (1)	8 (8)	8 (6)	
Total Indiv.: non-vultures	43	194	5	195	129	8	3	5	62	49	2	43	10
Diversity: non-vultures	0.458	0.454	0.579	0.471	0.163	0	0	0	1.020	0.982	0	0.731	0.797
Abundance: km/bird, non-vult.	4.14	0.84	15.40	0.87	0.65	16.75	67.33	14.00	1.27	2.37	—	—	—



Figure 1. South America, showing count locations and route of travel.

without distance estimation) were conducted to evaluate use of a stationary watch in finding and counting raptors and also for comparison with traveling counts. For two of these point counts, an elevated ridge was chosen to afford maximum visual advantage. The point counts were conducted in fair, calm weather. Two observers equipped with 7×50 binoculars and a $20\times$ spotting scope counted all raptors seen during at least a 60-min observation period.

Raptor abundance for each survey route was calculated as the number of km per observed individual (excluding vultures). A gross measure of raptor diversity was obtained using the Shannon diversity index (Zar 1974). Because various species of raptors differ in observability in some habitat types and a single species is often more detectable in more open habitats than in forest, these indices should be used with caution.

RESULTS AND DISCUSSION

Raptor diversity and abundance varied greatly among survey routes. The greatest variety (17 species) and the highest species diversity index ($H' = 1.020$) were found in a region of mixed riparian gallery forests, savanna, and pastures in western Venezuela. By contrast, only two species (present in

low densities) were found in the Atacama Desert and the high elevation montane scrub habitats of Peru and Ecuador. In other, less harsh environments, raptor density typically varied inversely with raptor diversity. Raptors were most abundant in modified or open habitats and in association with human activities such as animal husbandry. In such areas, vultures and Crested Caracaras (*Polyborus plancus*) predominated. For example, a Chilean survey route (No. 18, Table 2) through cropland and pasture habitat had the greatest concentration of raptors observed (0.65 km per individual), but only two species were represented (diversity index $H' = 0.163$). Similarly, certain raptors were observed in dense concentrations in agricultural habitats in Venezuela, Paraguay, Brazil, and Peru. Surveys with high raptor variety and abundance were typically in mixed habitat, ranging from highly stratified dense forest to relatively open savannas or second growth forest.

Results of the three point counts also varied greatly. Eight species were recorded on point counts B and C, but only two species on point count A, although A and C were both in dense montane forests. Three problems were encountered for point counts. First, we found it difficult to identify raptors readily observed at distances greater than 1 km. Second, we could not accurately tally the total number of individuals because birds often repeatedly soared through the observation zone. Finally, it proved impractical to observe birds in dense forest. Because of these difficulties, we de-emphasized point counts in favor of road surveys.

Roadside raptor surveys proved efficient in detecting and counting common raptors in non-forested habitats. For all counts combined, we recorded 41 (47%) of the 87 diurnal raptor species that occur in South America. This included all of the Cathartid vultures and most other species that soar regularly.

Raptors of the deep forest are much more difficult to observe and our roadside counts in forest habitats certainly underestimate both diversity and abundance of raptor communities. Most of the raptors counted on routes through rainforest habitats in Venezuela and Brazil (RC 5–8) also normally occur in secondary forest habitat and were probably seen because of their association with the secondary growth forest of the roadside swath. By contrast, many species of obligate forest raptors (e.g., *Harpia*, *Morphnus*, *Micrastur*) were never recorded during counts nor seen while traveling between survey locations. We suggest that occurrence and abundance estimates

for these will ultimately come from species-specific counting techniques such as listening to early morning calls or mark and recapture methods used for forest falcons (*Micrastur*; Klein and Bierregaard 1988). Other species will require mist nets, radio-telemetry, systematic searches, and other more time-consuming methods (Fuller and Mosher 1981, 1987, Thiollay 1989, Vannini 1989).

As primary forests are converted to open agricultural areas, forest-dwelling raptors, especially the large eagles, disappear while migrants and savanna-dwelling species increase (Harris 1984). In southern Brazil, Reichholz (1974) found that as forests were cut and replaced by agricultural and grazing lands, the diversity of highly rapacious species decreased while scavengers (i.e., vultures and caracaras) increased. Thiollay (1985) reported similar changes in raptor diversity and abundance in a survey of seven habitat classes in the southern Ivory Coast of Africa and four habitat classes in the neotropics. By contrast, in arid regions, the introduction of irrigation may benefit some raptors. Fields and croplands provide foraging areas; trees provide nesting and roosting habitat. Sheep and cattle ranching can also result in local concentrations of caracaras and other scavengers that forage on carcasses and offal (e.g., road counts RC3, RC15, and RC17–18, Table 2).

CONCLUSIONS AND SUMMARY

Our survey work, and the studies of Reichholz (1974) and others, demonstrate the feasibility of roadside counts in estimating relative abundance and determining species composition of diurnal raptor communities in relatively open neotropical habitats. The efficiency of roadside surveys is, however, extremely limited for owls (we detected only one species) and for other raptors that live primarily beneath the forest canopy.

Our results suggest that total raptor diversity and relative abundance were frequently inversely correlated. The most diverse raptor species assemblages observed during roadside counts were in mixed savanna and dense forest habitats. By contrast, the greatest number of scavengers were found in association with agricultural fields and rangelands. In addition, while diversity of forest raptor communities often decreases as natural habitats are modified, agricultural development in arid environments tends to increase primary productivity, biotic diversity, and food supply. These changes, in turn, result in local increases in raptor abundance and diversity. Such

localized increases, however, fail to compensate for the loss of raptor diversity that is the direct result of widespread neotropical deforestation.

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RESPONSE OF NORTHERN GOSHAWKS TO TAPED CONSPECIFIC AND GREAT HORNED OWL CALLS

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ABSTRACT.—We compared responses of Northern Goshawks (*Accipiter gentilis*) to conspecific “kakking” and Great Horned Owl (*Bubo virginianus*) “hooting” calls during the 1989 breeding season in Pennsylvania. Calls were played 150 and 300 m from active goshawk nests during nestling (7 nests, $N = 27$ trials) and fledgling (7 nests, $N = 28$ trials) periods. Five nests were tested during both nestling and fledgling periods. Response rate of goshawks to calls played at 150 m was highest for conspecific calls during the nestling period (0.71) and lowest for owl calls during the fledgling period (0.14). Goshawk response rate to conspecific calls at 300 m during nestling and fledgling periods was 0.29 each, and no response was detected to owl calls at 300 m during either period. Response rates of goshawks differed significantly both for type of call and broadcast distance, due largely to the lack of response by goshawks to owl calls at 300 m. During the nestling period, goshawks responded in significantly less time to conspecific (median = 13 sec) than to owl calls (95 sec) at 150 m. There were no differences in response rates relative to time of day or period of breeding season, but adult goshawks were observed near nests more frequently during the nestling versus the fledgling period. Based on our findings, we recommend that conspecific “kakking” calls be used for censuses of Northern Goshawks during nestling and early fledgling periods, and that calls be played along transects that are spaced no more than 300 m apart.

Respuestas de Gavilán Azor (*Accipiter gentilis*) a reproducciones de grabaciones de las llamadas de su misma especie, ó, a las de las llamadas del buho de la especie *Bubo virginianus*

EXTRACTO.—Hemos comparado las respuestas de Gavilán Azor (*Accipiter gentilis*) a las llamadas (“kak-kak”) grabadas de su misma especie, con las respuestas a las llamadas (“jut-jut”) grabadas del buho de la especie *Bubo virginianus*, durante la época de reproducción en 1989, en Pennsylvania. Las grabaciones fueron reproducidas a distancias de 150 y 300 metros de nidos activos de los gavilanes tanto durante los períodos de cría de los polluelos (7 nidos, $N = 27$ pruebas), como durante los períodos de los primeros vuelos (7 nidos, $N = 28$ pruebas). Las pruebas se realizaron con cinco nidos durante esos dos períodos. La proporción de las respuestas de los gavilanes, a las llamadas reproducidas a 150 metros, fue más alta con llamadas de su misma especie durante el período de cría de los polluelos en el nido (0.71), y más baja con llamadas de buhos (*Bubo virginianus*) durante el período de los primeros vuelos (0.14). La proporción de las respuestas a reproducciones de llamadas de su especie, a una distancia de 300 metros, durante el período de crianza y el de los primeros vuelos, fue de 0.29 cada una. No se detectó respuesta alguna a reproducciones de las llamadas (“jut-jut”) de buho, para ninguno de estos períodos y a la misma distancia. Las proporciones de respuesta de los gavilanes fueron, significativamente diferentes, en el caso de las pruebas con el tipo de llamada (de la misma especie o de especie diferente) y en el de las pruebas de distancia de la llamada, debido mayormente a la falta de respuestas a las llamadas de buhos, emitidas a 300 metros del nido. Durante el período de cría en el nido, a 150 metros de distancia, los gavilanes respondieron en un tiempo significativamente menor, a las emisiones de las llamadas de su misma especie (media = 13 segundos), que a las emisiones de las llamadas de buhos (95 segundos). No se notaron diferencias en la proporción de las respuestas, en relación con la hora del día o el tiempo del período de reproducción; pero sí se observó que los gavilanes adultos estaban cerca a sus nidos más frecuentemente durante el período de crianza, que durante el período de los primeros vuelos. Basados en nuestros resultados, recomendamos que para censar Gavilanes Azor (*Accipiter gentilis*) sean usadas grabaciones de las llamadas (“kak-kak”) emitidas por la misma especie, tanto durante el período de crianza de los polluelos como a principios del período de los primeros vuelos. También recomendamos que las llamadas sean emitidas en secciones espaciadas a no más de 300 metros entre ellas.

[Traducción de Eudoxio Paredes-Ruiz]

Taped calls of avian vocalizations have been used to detect a variety of raptor species (Fuller and Mosher 1981, Johnson et al. 1981). Red-shouldered (*Buteo lineatus*), Broad-winged (*B. platypterus*), Red-

Tailed (*B. jamaicensis*), Sharp-shinned (*Accipiter striatus*), and Cooper’s Hawks (*A. cooperii*) respond to broadcasts of conspecific vocalizations (Balding and Dibble 1984, Fuller and Mosher 1981, 1987,

TIME OF DAY					
	Early a.m.	Late a.m.	Early p.m.	Late p.m.	
1	NEST A GOS-150	NEST B OWL-150	NEST A OWL-300	NEST B GOS-300	
D	2	NEST B OWL-300	NEST A GOS-300	NEST B GOS-150	NEST A OWL-150
A	3	NEST C OWL-150	NEST D GOS-150	NEST C GOS-300	NEST D OWL-300
Y	4	NEST D GOS-300	NEST C OWL-300	NEST D OWL-150	NEST C GOS-150

Figure 1. Modified Latin square used to schedule trials for testing response of Northern Goshawks to taped calls played near active nests. Conspecific (GOS) and Great Horned Owl (OWL) calls were played at 150 and 300 m from nests.

Rosenfield et al. 1985, 1988). Fuller and Mosher (1987) reported that Red-shouldered and Cooper's Hawks responded as readily to taped calls of the Great Horned Owl (*Bubo virginianus*) as to conspecific calls. They also noted the value of using the call of a single species, such as that of the Great Horned Owl, to increase the efficiency of surveys intended for multiple raptor species.

Despite the fact that Northern Goshawks (*Accipiter gentilis*) also are known to respond to taped calls (Hennessy 1978, Fuller and Mosher 1981), little information is available regarding the application of this technique for goshawk surveys or censuses. Our objectives were to (1) compare responses of goshawks to taped conspecific and Great Horned Owl calls played at two distances from active nests, and (2) evaluate the effects of time of day and period of breeding season on response rates of goshawks to these calls. Results of our study will be useful in developing a standard census technique for nesting goshawks.

MATERIALS AND METHODS

The study was conducted at nine active nests of Northern Goshawks located in six counties in central and northern Pennsylvania, USA, in 1989. Five of the nine nests were used for trials during both nestling and fledgling periods.

A modified Latin square design was used to schedule trials at nests (Fig. 1). This design maximized independence of the four experimental factors (Sokal and Rohlf 1981:393) and helped control for possible variation in response rate due to sequential visitation of nests to conduct trials. Experimental factors considered for each trial were type of call (defensive "kakking" call of a Northern Goshawk or territorial "hooting" call of a Great Horned Owl), distance from nest (150 or 300 m), time of day (early

morning 0800–1000 H, late morning 1001–1200 H, early afternoon 1201–1500 H, or late afternoon 1501–1800 H), and period of breeding season (nestling or fledgling period).

A balanced design required grouping nests in sets of four (i.e., two pairs), with trials at each pair conducted twice daily for 2 consecutive days. Our goal was to test taped calls at two sets of four nests (i.e., eight nests) during both nestling and fledgling periods. However, the widely dispersed nature of goshawk nests combined with nest failure of several nests limited the number of nests for use in our study and resulted in trials being conducted at only seven nests during each period. Twenty-seven trials were conducted during the nestling period (30 May–16 June, mean estimated age of young = 28 d, range = 21–37 d), and 28 trials were conducted during the fledgling period (14 June–4 July; mean estimated age of young = 53 d, range = 46–64 d). Only three trials were conducted at the Warren Co. #4 nest during the nestling period. An owl call was not played at 300 m from this nest because an adult goshawk detected us and vocally responded as we approached the broadcast station; we were unable to complete this trial at a later date.

Logistics of travelling between nests to conduct trials required the grouping of nests in pairs based on geographic proximity. Thus, complete randomization of nests within the experimental design was not feasible. However, pairs of nests were assigned randomly within the design.

Recordings of Northern Goshawk and Great Horned Owl calls were obtained from the Cornell Library of Natural Sounds (Laboratory of Ornithology, Cornell University, Ithaca, New York) and were broadcast with a portable Realistic CRT-7 cassette tape player and Half-Mile Hailer (Perma Power Electronics, Inc., 5615 West Howard Ave., Chicago, Illinois). Audio output was adjusted to 100–110 db at 1 m in front of the speaker (after Fuller and Mosher 1987) using a Realistic sound level meter set on C-weighting and slow-response.

Broadcast stations were established 150 and 300 m from active goshawk nests at least one week prior to experimental trials, and each was marked with vinyl flagging. Stations were situated so that the slope of a straight line between the station and the nest did not exceed 10% and the area between station and nest was continuous forest and unobstructed by terrain. None of the nests used for experimentation was located initially with taped calls, but all were reported to us by various sources (bird-watchers, foresters, etc.).

We wore camouflage clothing during each trial to avoid detection by goshawks. After arriving at a station, we waited quietly for 5 min before beginning the trial. Each trial consisted of playing six bouts of goshawk calls (25–30 "kaks" over 7 sec) or owl calls (seven "hoots" over 2 sec) spaced evenly over a 5-min period (Fuller and Mosher 1987) with the speaker oriented toward the nest. We recorded type of response (approach but no vocalization, vocalization but no detectable approach, or approach and vocalization), time (sec) from initiation of playback to detection of response, and sex and age of responding bird(s) for all detectable goshawk responses. If no responses were detected, we waited quietly for an additional 5 min and approached the nest to determine the presence of adult or young goshawks.

Table 1. Response rates of Northern Goshawks to taped calls (proportion of trials with detectable responses) at nine active nests in Pennsylvania, 1989. Trials during nestling and fledgling periods consisted of four call-distance combinations (conspecific and Great Horned Owl calls at 150 and 300 m) played at each nest at four times of day. Results of trials when adults were known or presumed to be near nests are shown in parentheses.

NEST	PERIOD OF BREEDING SEASON			
	NESTLING		FLEDGLING	
	N = 27 (N = 20)	N = 28 (N = 14)		
Elk Co. #2	0.50	(0.67)	0.25	(0.25)
Elk Co. #6 ^a	0.50	(0.50)	—	(—)
Forest Co. #3 ^b	—	(—)	0.00	(0.00) ^c
McKean Co. #1	0.00	(0.00) ^c	0.25	(1.00)
Potter Co. #3	0.50	(1.00)	0.00	(—) ^d
Snyder Co. #1 ^b	—	(—)	0.25	(1.00)
Warren Co. #4 ^a	0.67 ^e	(1.00)	—	(—)
Warren Co. #6	0.50	(0.50)	0.75	(0.75)
Warren Co. #7	0.25	(0.50)	0.25	(1.00)

^a No trials conducted during fledgling period due to nest failure.

^b Nest discovered during fledgling period.

^c Adults presumed to be present near nest during 3 trials.

^d Adult(s) not observed near nest during or following any trials.

^e Only 3 trials; no Great Horned Owl call played at 300 m.

Response rate of goshawks to calls was defined as the proportion of trials for which goshawk responses were detected. Differences in response between or among levels of experimental factors were tested using Fisher's exact test or a *G*-test of independence, depending on size of cells (Sokal and Rohlf 1981:735). Difference in median time for detectable goshawk response to owl versus conspecific calls was tested with a two-tailed Wilcoxon two-sample test (Sokal and Rohlf 1981:432) and reported as a Chi-square approximation. Statistical significance was $P < 0.05$ for all tests.

We presumed that adult goshawks were not present near nests during some trials. Evidence for this was the apparent absence of adults at some nest sites when we approached nests after trials with no detectable responses. Because we were uncertain of the location of adults during trials that yielded no detectable responses (i.e., adults might have left before, or arrived shortly after, the end of a trial), response rates were evaluated both for all trials conducted (hereafter referred to as "total trials") and for only those trials when adults were known or presumed to be near nests ("trials with adults present").

RESULTS

Goshawk responses to taped calls were detected for 18 of 55 (33%) total trials (Table 1). We attempted to determine the presence of adult goshawks near nests following 36 of the 37 trials for which no responses were detected. Adults were observed near

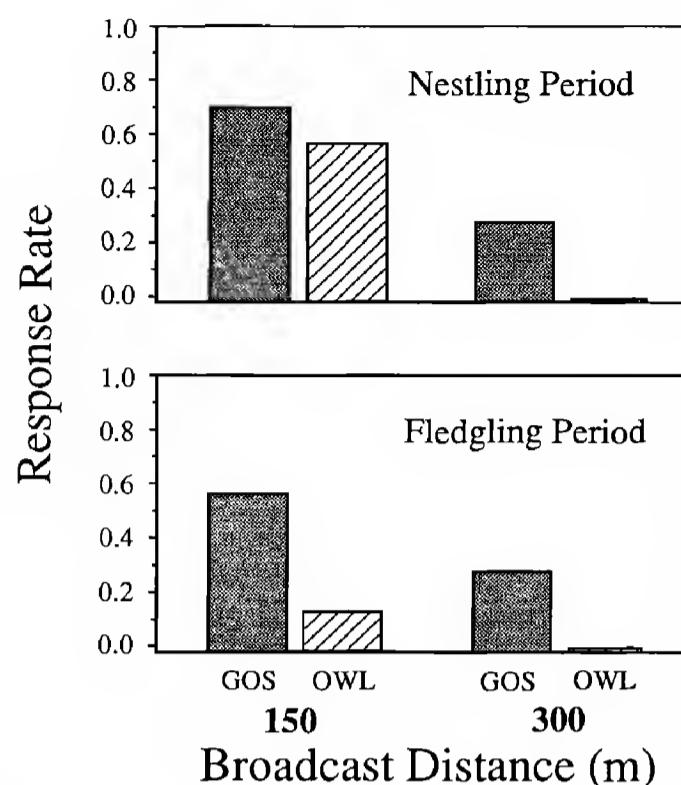


Figure 2. Response rates of Northern Goshawks to conspecific (GOS) and Great Horned Owl (OWL) calls played at 150 and 300 m from active goshawk nests during nestling and fledgling periods ($N = 55$ trials).

nests following 9 of 15 (60%) and 7 of 21 (33%) of these trials during nestling and fledgling periods, respectively. Thus, responses were detected for 18 of the 34 (53%) trials with adults present. Response rates by goshawks at any given nest per period of the breeding season (4 call-distance combinations combined) ranged from 0.0 to 0.75 for total trials and 0.0 to 1.0 for trials with adults present (Table 1).

Behavior of goshawks responding to taped calls ranged from silent approach to approach with vocalization, and 15 of the 18 (83%) detectable responses included vocalizations. Vocal responses to conspecific and owl calls, respectively, included five and one without approach and six and three with approach. Seventeen of the 18 (94%) detectable responses were by single adult goshawks, presumed in most cases to be females of the breeding pairs. One response was a non-vocal approach by a fledgling 20 sec after termination of a conspecific broadcast at 150 m.

Effects of Experimental Factors. Response rates for total trials generally were lower during the fledgling period, particularly for the owl call (Fig. 2). Also, adult goshawks were detected near nests more frequently during the nestling period than during the fledgling period ($G = 4.3$, $P = 0.04$). Nonetheless, differences in response rates between nestling and

Table 2. Frequencies of detectable responses by Northern Goshawks to taped calls in Pennsylvania, 1989, in relation to four experimental factors ($N = 55$ trials). Frequencies of responses for trials when adults were known or presumed to be near nests ($N = 34$) are shown in parentheses.

EXPERIMENTAL FACTOR	GOSHAWK RESPONSE DETECTED	
	YES	NO
Period of breeding season		
Nestling	11 (11)	16 (9)
Fledgling	7 (7)	21 (7)
Type of call		
Northern Goshawk	13 (13)	15 (6)
Great Horned Owl	5 (5)	22 (10)
Broadcast distance		
150 m	14 (14)	14 (4)
300 m	4 (4)	23 (12)
Time of day		
Early a.m.	3 (3)	11 (3)
Late a.m.	5 (5)	8 (4)
Early p.m.	4 (4)	10 (6)
Late p.m.	6 (6)	8 (3)
Sequence of broadcast trials		
Trial 1	4 (4)	9 (3)
Trial 2	5 (5)	9 (4)
Trial 3	4 (4)	10 (4)
Trial 4	5 (5)	9 (5)

fledgling periods (Table 2) were not significant for total trials ($G = 1.6$, $P = 0.21$) or for trials with adults present ($G = 0.1$, $P = 0.77$). Similarly, there were no significant differences in response rates between nestling and fledgling periods (total trials) for conspecific ($G = 0.1$, $P = 0.71$) or for owl calls (Fisher's exact test, $P = 0.17$).

There was no difference among times of day for adult goshawks to be observed near nests ($G = 2.4$, 3 df, $P = 0.49$). Response rates among times of day (Table 2) did not differ for total trials (Fisher's exact test, $P = 0.64$) or for trials with adults present (Fisher's exact test, $P = 0.73$). During the nestling period, response rates to total trials were lowest in early morning and higher in late morning and late afternoon (Fig. 3); however, differences among times of day during the nestling period were not significant for total trials (Fisher's exact test, $P = 0.22$) or for trials with adults present (Fisher's exact test, $P = 0.71$).

Response rates did not vary among four sequential

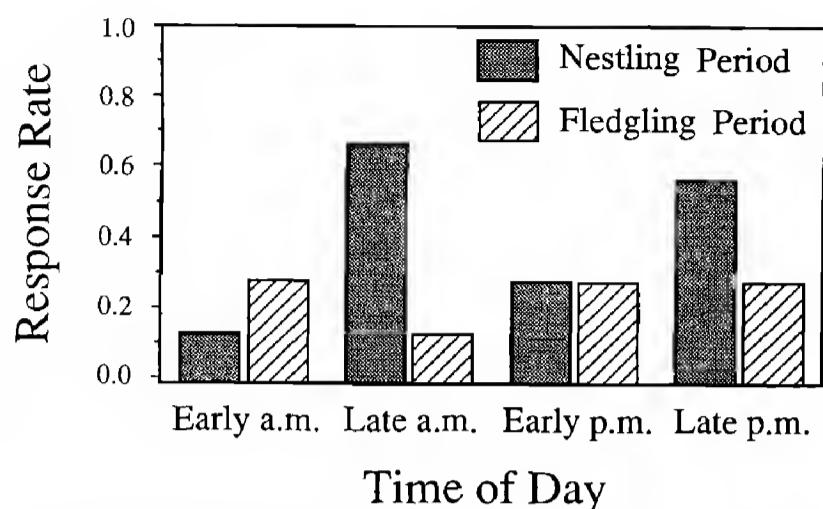


Figure 3. Response rates of Northern Goshawks to taped calls played at four times of day during nestling and fledgling periods ($N = 55$ trials).

visits to nests (Table 2) for total trials ($G = 0.3$, 3 df, $P = 0.97$) or trials with adults present (Fisher's exact test, $P = 1.0$). Thus, goshawks apparently did not habituate or become conditioned to taped calls played during four trials over a 2-d period.

Response rates of goshawks to conspecific calls versus owl calls (broadcast distances and periods of breeding season combined) (Table 2) differed significantly for total trials ($G = 5.0$, $P = 0.03$) and for trials with adults present ($G = 4.2$, $P = 0.04$). The highest response rate for a given call-distance combination and period of breeding season (Fig. 2) was to goshawk calls at 150 m during the nestling period (0.71). No responses were detected to owl calls at 300 m during either nestling or fledgling periods.

Taped calls elicited higher response rates at 150 versus 300 m (calls and periods of breeding season combined) for total trials ($G = 8.1$, $P = 0.004$) and for trials with adults present ($G = 10.0$, $P = 0.002$) (Table 2). Response rates to owl calls at 150 versus 300 m differed significantly for total trials (Fisher's exact test, $P = 0.04$) and for trials with adults present (Fisher's exact test, $P = 0.03$). Response rates of goshawks to conspecific calls at 150 versus 300 m did not differ for total trials ($G = 3.7$, $P = 0.055$) or for trials with adults present (Fisher's exact test, $P = 0.057$). Although these differences were not statistically significant, we feel they were biologically important and probably reflected an expected decrease in detectability of goshawks to taped calls played at greater distances from the nest.

Time for Response. Goshawks responded quicker to conspecific calls than to owl calls, particularly during the nestling period. Because no goshawk responses were detected to owl calls at 300 m, com-

parisons of time for response were limited to responses at 150 m (Table 3). Median time for response to conspecific calls during the nestling period differed significantly from that to owl calls for any detectable responses ($\chi^2 = 6.0, P = 0.02$) and for vocal responses only ($\chi^2 = 5.0, P = 0.03$). The difference in median time for vocal responses to conspecific versus owl calls (nestling and fledgling periods combined) approached significance ($\chi^2 = 3.83, P = 0.050$). Median time for goshawk responses to conspecific calls played at 300 m was 76 sec ($N = 4$, range = 30–660 sec).

DISCUSSION

Marion et al. (1981) indicated that taped calls can be particularly useful for facilitating censuses of elusive and secretive birds. The Northern Goshawk is a shy and inconspicuous woodland raptor, except during the breeding season, when it typically defends its nesting territory from intruders using vocal and aggressive behaviors (Bent 1937). Because censuses of accipiters are best conducted during the breeding season (Reynolds 1982), the use of taped calls should be helpful for increasing detectability of nesting goshawks.

This study demonstrated that the "kakking" call of the goshawk was more effective for detecting nesting goshawks than the "hooting" call of a Great Horned Owl. The conspecific call elicited detectable responses at higher rates, at greater distances, and in less time than the owl call. Moreover, the conspecific call was almost equally effective during nestling and fledgling periods. Thus, we recommend that the goshawk call be used for censuses or surveys of nesting Northern Goshawks.

Our results indicated that a majority of adult goshawks tending nests with young (perhaps 70% or more during the nestling period) may be detected when conspecific calls are broadcasted within 150–200 m of nests. Therefore, if a complete census of breeding pairs in a prescribed area is desired, we recommend that transects be spaced no more than 300 m apart and that taped calls be played at broadcast stations spaced every 150–200 m along transects. Further, we recommend that at least two full bouts of "kaks" be played alternately to each side of the transect at each station and that the minimum duration of a broadcast at a station be 1 min (including periods of silence between bouts of "kaks").

Despite apparent variation in response rates of goshawks to taped calls among four times of day during the nestling period, we found no significant

Table 3. Range, sample size (N), and median time (sec) for detectable responses by Northern Goshawks to conspecific and Great Horned Owl calls played at 150 m from active nests during the nestling and fledgling periods in Pennsylvania, 1989.

PERIOD OF BREEDING SEASON TYPE OF RESPONSE	TYPE OF CALL	
	CONSPECIFIC	OWL
Nestling period		
Vocal response		
Range	10–65	68–455
N	5	3
Median	13	120
Any detectable response		
Range	10–65	68–455
N	5	4
Median	13	95
Fledgling period		
Vocal response		
Range	44–175	70
N	3	1
Median	70	70
Any detectable response		
Range	44–320	70
N	4	1
Median	123	70
Both periods pooled		
Vocal response		
Range	10–175	68–455
N	8	4
Median	52	95
Any detectable response		
Range	10–320	68–455
N	9	5
Median	60	70

difference. Balding and Dibble (1984) believed that Red-tailed, Red-shouldered, and Broad-winged Hawks responded more often to taped calls in mid-morning, and Fuller and Mosher (1987) suggested that surveys of woodland hawks using taped calls should be conducted in morning. It is possible that accipiters and buteos might respond differently to taped calls relative to time of day, because buteos rely heavily on mid-day thermals for soaring flights that function in part for territorial defense (Newton 1979).

We tested taped calls only during nestling and

fledgling periods. This experiment could be repeated to evaluate response of goshawks to taped calls at other times of the breeding season, such as before and during incubation. Potential advantages of using taped calls for censuses earlier in the breeding season include greater visibility and better sound transmission through the forest prior to leaf-out (Morton 1975). However, raptors generally respond less to taped calls during incubation than at other times during the breeding season (Fuller and Mosher 1981). Red-shouldered and Cooper's Hawks respond to taped calls prior to incubation (Fuller and Mosher 1981, Rosenfield et al. 1985), and we expect goshawks also would respond to taped calls at this time. Goshawks might even respond to taped calls at greater distances prior to incubation, because nests would not yet contain eggs or young. However, responses to taped calls at this time may be less vocal (and thus less detectable) than responses later in the breeding season (M. Root and P. DeSimone, unpubl. data).

Although this study was not intended to evaluate the effect of recent nest failure on response of goshawks to taped calls, we played goshawk and owl calls six and four times, respectively, at four failed nests. Two nests failed due to presumed predation of goshawk young by Great Horned Owls, one due to probable predation of eggs by a raccoon (*Procyon lotor*), and one due to nest destruction by high winds. These trials were conducted an estimated 1–2 wk following nest failure, and none resulted in detectable response by goshawks. If goshawks cease defending nests subsequent to nest failure, censuses using taped calls late in the breeding season might underestimate the number of breeding pairs that were present at the start of the breeding season.

Raptor censuses generally are expensive and labor intensive (Fuller and Mosher 1981). Reynolds (1982) recommended searching a minimum area of 9000 to 12,000 ha to determine densities of nesting accipiter hawks. Techniques that maximize the effective search area of individuals conducting raptor censuses are needed to make raptor population studies more feasible. The use of taped calls, perhaps coupled with stratification of large study areas using a predictive habitat model, may provide wildlife biologists with an approach to conduct more efficient and effective censuses of nesting Northern Goshawks.

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CLINICAL HEMATOLOGY AND BLOOD CHEMISTRY VALUES FOR THE COMMON BUZZARD (*Buteo buteo*)

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ABSTRACT.—Clinical hematology and serum chemistry values for 23 clinically normal Common Buzzards (*Buteo buteo*) have provided reference values for use in clinical pathology. Hematological values, including red and white blood cell counts, hematocrit, hemoglobin concentration, leukocyte differential count and red cell indices were established. Reference values of blood chemical parameters, including total plasma protein, total plasma solids, fibrinogen, glucose, aspartate aminotransferase (AST, SGOT), alanine aminotransferase (ALT, SGPT), gamma glutamyltransferase (γ -GT), creatine kinase (CK), lactate dehydrogenase (LDH), creatinine, uric acid, calcium and phosphorus were also established and compared to results obtained by other authors.

Valores de hematología y bioquímica sanguínea de ratoneros comunes (*Buteo buteo*)

EXTRACTO.—Los valores de hematología y bioquímica sanguínea de 23 ratoneros comunes (*Buteo buteo*) sanos proporcionaron valores de referencia para su uso rutinario en patología clínica. Los valores de hematología que se determinaron fueron: recuento de eritrocitos y leucocitos, hematocrito, concentración de hemoglobina, recuento diferencial de leucocitos e índices eritrocitarios. Los valores de bioquímica sanguínea determinados fueron: proteínas plasmáticas totales, sólidos plasmáticos totales, fibrinógeno, glucosa, aspartato aminotransferasa (AST, SGOT), alanino aminotransferasa (ALT, SGPT), gamma glutamil transferasa (γ -GT), creatina quinasa (CK), lactato deshidrogenasa (LDH), ácido úrico, creatinina, calcio y fósforo. Los resultados obtenidos se discuten con los de otros autores.

Clinical hematology and blood chemistry are useful diagnostic tools (Woerpel and Rosskopf 1984, Campbell and Dein 1984, Campbell 1988). In recent years, normal hematologic values for both pet and wild birds (Hawkey et al. 1983, 1985, Lumeij and de Bruijne 1985) and hematological changes in response to disease (Hawkey et al. 1984, O'Halloran et al. 1988) have been reported. Tissue enzyme profiles for some avian species have also been established (Lumeij and Wolfswinkel 1988, Lumeij et al. 1988a) and changes in plasma levels of selected enzymes as a result of disease have been reviewed (Lumeij et al. 1988b, Lumeij and Westerhof 1987).

Nevertheless, such tests are of limited clinical usefulness in raptors because of the lack of data for reference values in many species (Redig 1978) and the limited number of parameters and individuals for those species that have been tested (Cooper 1972, Elliot et al. 1974, Cooper 1975, Redig 1978, Kirkwood et al. 1979, Halliwell 1981, Ivins et al. 1985, Hawkey and Hart 1988).

The Common Buzzard (*Buteo buteo*) is one of the most frequently injured birds of prey in Spain. Data

from physiological values of selected hematologic tests could be of great value for both diagnostic and prognostic purposes. Nevertheless, very few data have been found through the literature on hematologic values for this species (Veil 1978, Lepoutre 1982, Lepoutre et al. 1983) and no information is available on the normal plasma concentrations of enzymes commonly used in avian medicine. This paper deals with the normal clinical hematology and blood chemistry values for the Common Buzzard and their application as diagnostic aids in clinical practice.

METHODS

Blood samples were collected from 23 normal adult Common Buzzards housed in outdoor enclosures at the Centro de Especies Protegidas de Buitrago, belonging to the Comunidad Autónoma de Madrid.

Thirteen of the birds were imprinted adults of unknown age. Time spent in the Center ranged from 6 months to 2 years. Ten additional birds were illegally taken as nestlings, confiscated by the authorities and kept in the Center until their release into the wild some weeks after sampling. Three of these birds were 1 year old and the remaining seven birds were 2 years old.

Birds were housed in 15 × 7 × 3 or 10 × 5 × 3 meter

Table 1. Hematological values for captive Common Buzzards. The number of samples (N), mean value (\bar{X}), standard deviation (SD) and observed range are given for each parameter.

PARAMETER	N	\bar{X}	SD	RANGE
TRBC ($\times 10^6/\mu\text{l}$)	22	2.94	0.82	5.44–2.06
TWBC ($\times 10^3/\mu\text{l}$)	23	8.04	1.77	10.6–4.6
PCV (%)	22	40.8	4.4	49–36
Hemoglobin (g/dl)	22	12.7	2.4	17.7–9.3
Heterophils (%)	23	63	13.1	75–45
Band (%)	23	0	0	—
Lymphocytes (%)	23	20	9.5	48–10
Eosinophils (%)	23	16	13.8	37–0
Monocytes (%)	23	0	1.0	4–0
Basophils (%)	23	0	0.7	3–0
Heterophils ($\times 10^3/\mu\text{l}$)	23	4.58	1.2	5.8–2.3
Band ($\times 10^3/\mu\text{l}$)	23	0	0	0
Lymphocytes ($\times 10^3/\mu\text{l}$)	23	1.4	0.73	2.9–0.2
Eosinophils ($\times 10^3/\mu\text{l}$)	23	1.2	1.1	3.4–0
Monocytes ($\times 10^3/\mu\text{l}$)	23	0.05	0.08	0.3–0
Basophils ($\times 10^3/\mu\text{l}$)	23	0.6	0.1	0.2–0
MCV (fl)	22	145.1	25.0	171.4–90.0
MCH (pg)	22	48.3	10.2	65.7–32.5
MCHC (g/dl)	22	32.4	6.7	45.3–22.6

pens with sides and top covered by wire netting and equipped with wooden perches. No birds were known to be sick or seriously injured during their stay in the Center. Birds with leg or wing injuries, skin wounds, bumblefoot and any other disease, or birds showing unusual behavior were not considered for the study. The buzzards were fed once a day either with chicken carcasses or day-old chicks and water was provided *ad libitum*.

Blood samples were taken in May, June and July 1989 at the same time each day (1100–1230 H) to eliminate diurnal fluctuations. Birds were always bled before being fed. Birds were physically restrained with the aid of a falconer's hood and a towel. Blood was taken by venipuncture from the basilic vein using disposable 23-gauge needles and 2 ml plastic syringes. After removing the needle, 1 ml of whole blood for hematology was placed in a commercially available plastic tube containing EDTA. The remaining blood for blood chemistry determinations was placed in another plastic tube containing 5% lithium heparin. Only one sample was taken per bird. The blood was tested within 3 hr of collection.

Total red and white blood cell counts (TRBC and TWBC) were performed with the Natt-Herrick solution (1:200 dilution) and Neubauer hemocytometer (Campbell 1988). The hematocrit value (PCV) was obtained by the standard microhematocrit method. Hemoglobin concentration was estimated in duplicate by the cyanomethemoglobin method and red cell indices (MCV, MCH and MCHC) were calculated by using the standard formulas (Campbell 1988). The leukocyte differential count was performed by the routine microscopic procedure in a smear stained with May-Grünwald Giemsa (Hawkey et al. 1983).

Polychromasia and anisocytosis were estimated by examining blood smears in order to assess erythropoietic activity. Biochemical methods used in blood chemistry determinations are summarized in the Appendix 1.

RESULTS

The values obtained are presented in Table 1 (hematology) and in Table 2 (blood chemistry). No distinction was made by sex, age, origin of the bird or the length of time in captivity. A slight anisocytosis and a certain number of polychromatic erythrocytes (usually a mean of 3% of the erythrocytes in one 100 × oil field) were regarded as normal. The tendency of thrombocytes to clump precluded the use of the Neubauer hemocytometer for counting them and thus their number, estimated in a smear, was reported as "decreased," "normal" (about a mean of 2 thrombocytes per 100X oil field of good cellularity) or "increased." White cell morphology in the Common Buzzard was similar to that described by Hawkey et al. (1983), Campbell (1988) and Hawkey and Dennet (1989) for other birds.

Normal plasma color varied from clear to yellow. No hemolysis due to the EDTA was found in the samples as has been reported in other bird species (Hawkey et al. 1983, Campbell 1988). Total plasma solids (TPS) values obtained by the refractometric

Table 2. Blood chemistry values for captive Common Buzzards.

PARAMETER	N	\bar{X}	SD	RANGE
TPS (g/dl)	21	4.6	0.8	5.89–2.3
TPP (g/dl)	21	3.1	1.5	5.3–1.1
Fibrinogen (g/dl)	21	1.5	0.8	2.9–0.3
Glucose (mg/dl)	20	301.1	53.1	370–173
AST (SGOT) (IU/liter)	21	227.7	155.5	365–66.9
ALT (SGPT) (IU/liter)	18	13.1	5.9	28.9–5.17
γ -GT (IU/liter)	18	3.5	0.7	5.1–<2.8
CK (IU/liter)	20	393.2	187.8	766–119
LDH (IU/liter)	14	631.5	153.0	820–300
Uric acid (mg/dl)	20	6.0	1.5	8.5–2.89
Creatinine (mg/dl)	19	0.9	0.3	1.4–<0.5
Calcium (mg/dl)	16	11.2	2.5	16.6–7.9
Phosphorus (mg/dl)	10	4.6	3.3	9.4–1.3

method were found higher than total plasma protein (TPP) values obtained by the Biuret method.

DISCUSSION

Total red blood cell counts (TRBC), hemoglobin concentration and PCV values were found similar to those described by other authors for the Common Buzzard (Leonard 1969, Veil 1978, Lepoutre 1982, Lepoutre et al. 1983), and for other raptor species (Cooper 1972, Balasch et al. 1973, Elliot et al. 1974, Cooper 1975, Redig 1978, Kirkwood et al. 1979, Gee et al. 1981).

The number of circulating erythrocytes, and thus values of TRBC, are influenced by a number of factors such as sex, age, and altitude (Leonard 1969, Stoskopf et al. 1983, Campbell and Dein 1984, Amand 1985). Nevertheless, in our study the wide range of variation of TRBC values may be due to the technical error inherent in the hemocytometer method (Steel et al. 1977, Smith and Lience 1977). The use of an electronic particle counter could minimize this error. PCV values are less subject to technical error and therefore are of greater clinical value.

Additionally, the PCV in conjunction with total plasma protein (TPP) was the easiest and least time-consuming means of assessing the hydration and anemic status of a bird (Campbell and Dein 1984, Jenkins 1987).

No reticulocyte counts were performed since significance of high reticulocyte numbers in bird circulating blood remains unknown (Hawkey et al. 1983). On the other hand, erythropoietic activity could be assessed estimating in the smear the number of polychromatic erythrocytes. These cells, unlike

the mature erythrocytes, appear more rounded and have more basophilic cytoplasm (Campbell and Dein 1984).

The cyanomethemoglobin method is the most accurate method for estimating the hemoglobin concentration in both mammalian and avian blood (Smith and Lience 1977, Amand 1985). Since the red cell indices (MCV, MCH and MCHC) are calculated from the PCV, hemoglobin concentration and TRBC, their validity is influenced by the accuracy of the TRBC, the hemoglobin determination and PCV value (Amand 1985). MCV and MCH fall within the range of variation described for wild birds (Leonard 1969, Balasch et al. 1973, Hawkey et al. 1983). Nevertheless, the wide range of MCV and MCH values found in our study could be due to the inaccuracy of the hemocytometer method for red blood cell counts. The normal ranges for MCHC values are similar in all mammals and birds (Hawkey et al. 1983).

Several methods have been proposed for determining avian WBC counts (Campbell and Dein 1984, Amand 1985, Russo et al. 1986). Among them, the most accurate and widely used techniques are the eosinophil Unopette 5877 system (Becton-Dickinson and Co., Rutherford, New Jersey) and the Natt-Herrick solution. The method employed for the Unopette system is semi-indirect and involves the use of the eosinophil Unopette diluent, composed of phloxine and propylene glycol, and a Neubauer hemocytometer. The diluent phloxine only stains the granulocytes. Therefore, the count obtained must be corrected since mononuclear cells are not included (Campbell and Dein 1984). This is done by deter-

mining the ratio of granulocytes to mononuclear cells in a stained blood smear (Amand 1985). The Natt-Herrick solution stains only mononuclear cells, granulocytes, and thrombocytes, permitting direct count of these cells with a hemocytometer (Russo et al. 1986).

Direct hemocytometer counts are more accurate than WBC estimates determined by the Unopette system method because of the variation in differential counts (Russo et al. 1986). Both are subject to the technical error of the hemocytometer method, and changes in the WBC count may be caused by the variability inherent in the method of enumeration (Russo et al. 1986). Part of this error may be decreased by standardizing the technique (using the same chamber, coverslip and pipette and having the same person perform the counts) (Russo et al. 1986). In our study cell counts were performed by the same person and by the same procedure.

Total white cell counts were found to be similar to those described previously for the species (Leonard 1969, Veil 1978, Lepoutre et al. 1983) and within the range of variation described in pet and other wild birds (Hawkey et al. 1982, 1983, 1984, Woerpel and Rosskopf 1984, Calle and Stewart 1987).

No band heterophils have been found in the circulating blood of healthy buzzards. Thus, a certain number of these cells (left shift) should be considered as abnormal because they are indicative of a peripheral consumption of heterophils (Schalm et al. 1975).

High eosinophil counts have been found in buzzard blood (Veil 1978, Lepoutre 1982, Lepoutre et al. 1983). High counts are thought to be associated with intestinal parasitism (Hawkey et al. 1983). Nevertheless, Lepoutre et al. (1983) demonstrated that raptors, and the Common Buzzard in particular, are characterized by high numbers of eosinophils in circulating blood and this finding is not associated with a clinical condition. Blood chemistry values for a variety of species, including raptors, have been reported (Gee et al. 1981, Lepoutre 1982, Lepoutre et al. 1983, Ivins et al. 1985, Ferrer et al. 1987).

The refractometric method is being used for the determination of plasma protein concentration (total plasma solids) by avian practitioners. Nevertheless, Lumeij and de Bruijne (1985) demonstrated that the refractometric method is unreliable for determination of plasma protein concentration in avian blood since substances other than protein contribute substantially to the refractive index (Lumeij 1987). In

this study, TPS were higher than TPP values obtained by the Biuret method. TPP values fell within the range described for both pet and wild birds (Gee et al. 1981, Woerpel and Rosskopf 1984, Ivins et al 1985).

Hawkey and Hart (1988) proved that fibrinogen level is one of the most useful tests for both confirming infection and other inflammatory diseases, and following the patient's progress. Nevertheless, data for only a limited number of raptor species are now available. Our results on the Common Buzzard are within the range described by these authors for raptors.

The glucose values obtained from buzzards in this study are within the normal range of variation observed in birds (Lepoutre et al. 1983). Blood glucose levels could be indicative of the general health status of the bird. Low glucose values result from hepatopathies, septicemia or endocrinopathies rather than from starvation since starved raptors do not show hypoglycemia and may even be hyperglycemic (Lumeij 1988).

No information is available on the normal range of variation of AST, LDH, CK, ALT and γ -GT values in the Common Buzzard (Gee et al. 1981, Halliwell 1981, Ivins et al. 1985). Aspartate aminotransferase (AST, formerly SGOT) is widely distributed in avian tissues and its relative distribution varies from one genus to another (Lumeij and Westerhof 1987). AST values in this study compare well with those described for pet and other birds (Gee et al. 1981, Woerpel and Rosskopf 1984, Ivins et al. 1985, Calle and Stewart 1987). Lactate dehydrogenase (LDH) also occurs in most avian tissues (Lumeij and Westerhof 1987) and the blood concentration found in the buzzard shows a wider range and a higher mean value than those described for psittacines (Woerpel and Rosskopf 1984) but similar to those for raptors (Gee et al. 1981, Ivins et al. 1985). LDH values varied more than AST values. Creatine kinase (CK) is mainly found in muscle, and small amounts are found in kidney and duodenum (Lumeij and Wolfwinkel 1988, Lumeij et al. 1988). No information has been reported about normal levels of CK in raptor blood (Gee et al. 1981, Ivins et al. 1985). CK values in buzzards were higher than those observed for racing pigeons (Lumeij and de Bruijne 1985).

Alanine aminotransferase (ALT, formerly SGPT) is mainly found in liver and kidney in pigeons (Lumeij et al. 1988). Nevertheless, its low activity in

plasma, high activity in erythrocytes and seasonal variation (Lewandowski et al. 1986, Lumeij and Westerhof 1987) limits its use for diagnostic purposes. ALT values in this study were found lower than those observed in raptors (Gee et al. 1981) but similar to racing pigeons' plasma levels (Lumeij and de Bruijne 1985). Gamma glutamyl transferase (γ -GT) is almost entirely nephrospecific in birds (Lumeij and Wolfswinkel 1988). Enzymes occurring in the kidney might be of limited clinical value since these enzymes are largely eliminated via the urine after kidney damage (Lumeij and Wolfswinkel 1988). γ -GT values were found similar to those previously reported (Gee et al. 1981).

Plasma calcium and phosphorus levels were within the range of variation found for the species (Ferrer et al. 1987, Lepoutre 1982). Since there is an albumin-bound calcium fraction, it is necessary to consider calcium levels in conjunction with TPP levels (Ivins et al. 1985). Both calcium and phosphorus levels may be indicators of renal function and may help to evaluate nutritional deficiencies.

Uric acid is the major end product of deamination of amino acids in avian species and is excreted by the kidney mainly by tubular excretion (Lewandowski et al. 1986, Lumeij 1987). Since the rate of secretion is largely independent of the state of hydration, the measure of uric acid is the most reliable method to assess renal function in birds (Amand 1985, Lumeij and de Bruijne 1985, Lewandowski et al. 1986, Lumeij 1987). The Common Buzzard has lower values than other raptors and other birds (Gee et al. 1981, Lepoutre 1982, Woerpel and Rosskopf 1984, Ivins et al. 1985).

Plasma creatinine concentration is of questionable value in evaluating renal function in birds (Lewandowski et al. 1986, Lumeij 1987). The amount of creatinine formed from creatine is negligible and creatinine value measured by conventional methods includes pseudocreatinines, such as glucose, protein, ascorbic acid and pyruvic acid and may not reflect glomerular function (Lewandowski et al. 1986, Lumeij 1987). Creatinine levels in this study were within the range of variation found in raptors (Gee et al. 1981, Ivins et al. 1985) and considerably higher than values observed in pet birds (Woerpel and Rosskopf 1984).

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Appendix 1. Blood chemistry test methods used for analysis of Common Buzzard blood.

TEST	METHOD AND SOURCE
Total plasma solids (TPS)	Refractometer.
Total plasma protein (TPP)	Colorimetric Biuret Method. Weichselbaum, T.E. Amer. J. Clin. Path. 16 (1946): 40. ^a
Fibrinogen	Protein precipitated by the microhematocrit at 56° C. ^b
Glucose	GOD-POD Method. Trasch, H., P. Koller, W. Tritschler, Clin. Chem. 30 (1984):969. ^a
Aspartate aminotransferase (AST, SGOT)	GOT-POD Method. 25°. Deneke, V., W. Rittersdorf, W. Werner, Clin. Chem. 31 (1985):921. ^a
Alanine aminotransferase (ALT, SGPT)	GPT-POD Method. 25°. Deneke, V., W. Rittersdorf, Clin. Chem. 30 (1984): 1009. ^a
γ-Glutamyl transferase (γ-GT)	Reduction of 6[Fe(CN) ₆] ⁴⁻ . 25°. Deneke, V., K. D. Willamowski, W. Tritschler. Clin. Chem. 30 (1984):1010. ^a
Lactic dehydrogenase (LDH)	Reduction of NAD. 30°. Z. Klin. Chem. u. Klin. Biochem. 10 (1972):182. ^a
Creatine kinase (CK)	Oxidation of 6-Phosphogluconate. 30°. Gruber, W. Clin. Chem. 24 (1978): 177. ^a
Uric acid	Uricase-POD Method. Merdes, H., W. Rittersdorf, W. Werner, J. Clin. Chem. Clin. Biochem. 28 (1985):608. ^a
Creatinine	Peroxidase Oxidation. Wahbfeld, A., G. Hozt and H. Bergmeyer. Page 1834 in H. Bergmeyer [Ed.], Methoden der Enzymatischen Analyse. 3rd ed. Vol. II. Verlag Chemie. Weinheim. ^a
Calcium	Methylthymol Blue Method. Gener, J., Vila, J. and Concstell, E. Lab. Knicherbocker S.A.E. (1971). ^c
Phosphorus	Phosphomolybdate Method. Drewes, P.A. Clin. Chim. Acta 39 (1972):81. ^c

^a Boehringer Mannheim GmbH Diagnostica, Mannheim, Germany.^b Hawkey et al. 1983.^c Knicherbocker Reagents, Knicherbocker Lab., Barcelona, Spain.

IS THE OPERATIONAL USE OF STRYCHNINE TO CONTROL GROUND SQUIRRELS DETRIMENTAL TO BURROWING OWLS?

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ABSTRACT.—We evaluated the potential impact of the use of strychnine-coated grain to control Richardson's Ground Squirrels (*Spermophilus richardsonii*) on breeding Burrowing Owls (*Athene cunicularia*) in southern Saskatchewan during 1988. Adult owl survival, breeding success (percent of pairs producing at least 1 chick), number of chicks produced per successful nest or nest attempt, and chick weights were not significantly different between 8 operationally poisoned and 7 control pastures. Adult owl weights, however, were significantly higher on the control pastures indicating a possible sublethal effect. We conclude that the use of strychnine-coated grain, applied to control ground squirrels as indicated by the manufacturer, is not detrimental to breeding Burrowing Owls in the short term. Other potential sublethal effects, however, were not investigated. Non-target species were observed feeding or attempting to feed on the dead ground squirrels.

Es el uso de estricnina para controlar ardillas de tierra Richardson (*Spermophilus richardsonii*), perjudicial a los buhos de la especie *Athene cunicularia*?

EXTRACTO.—Hemos evaluado el potencial efecto que tiene el control de ardillas de tierra Richardson (*Spermophilus richardsonii*), envenenadas con granos cubiertos de estricnina, en buhos de la especie *Athene cunicularia* en época de reproducción, en el sur de Saskatchewan durante 1988. La sobrevivencia de estos buhos en estado adulto, los exitosos apareamientos (porcentaje de parejas que producen por lo menos 1 polluelo), los números de crías por nido, y los pesos de los polluelos, no fueron significativamente diferentes al comparar los resultados de 8 áreas de pastos tratadas con el veneno y 7 áreas de pastos de control (no tratadas). Los pesos de los buhos adultos, sin embargo, fueron significativamente mayores en estas áreas de control, lo que indicaba un posible efecto sub-letal. Concluimos que el control de ardillas de tierra, por medio de granos tratados con estricnina de acuerdo con las instrucciones del fabricante, a corto plazo, no es perjudicial a los buhos de la especie *Athene cunicularia*. Sin embargo, otros efectos sub-letrales no han sido investigados. También informamos sobre observaciones hechas en otras especies de aves de presa, que se alimentaban o trataban de alimentarse con cadáveres de ardillas de tierra.

[Traducción de Eudoxio Paredes-Ruiz]

The use of strychnine for rodent control was first reported by Aristotle in 350 B.C.; it is still in widespread use today. Significant secondary hazards of strychnine to scavenger and predatory animals have been assumed, but few data are available to substantiate these assumptions (e.g., Hegdal and Gatz 1976, Bortolotti 1984, Schafer 1984, Barnes et al. 1985, Wobeser and Blakley 1987). This is particularly true for birds of prey (Newton 1979, Redig et al. 1982, Cheney et al. 1987, Wiemeyer 1989).

The Burrowing Owl (*Athene cunicularia*) has been "Blue-Listed" in the United States since 1972. This list is intended to provide early warning of North American bird species undergoing population or range reductions (Arbib 1971). In Canada, the Burrowing Owl is classified as "threatened," indicating that it is likely to become endangered if the factors affecting its vulnerability are not reversed. One of the factors potentially affecting its numbers is secondary poisoning via rodenticides, including strychn-

nine, that are used for rodent control. Again, however, secondary poisoning of Burrowing Owls has usually been inferred with little or no substantiating data (Butts 1973, Eckert 1974, Zarn 1974, Ehrlich et al. 1988). The possibility exists because the owls nest in close association with ground squirrels, and even occasionally take them as prey. This is particularly true in Saskatchewan, where the main provider of nest holes for Burrowing Owls is the Richardson's Ground Squirrel (*Spermophilus richardsonii*).

In 1987, we conducted a survey of 62 farmers who had breeding Burrowing Owls on their land. Forty-seven percent of them reported that they used rodenticides to control numbers of ground squirrels on Burrowing Owl pastures and 97% of these farmers used strychnine. The objective of the present study was to evaluate the potential impact of this poisoning on Burrowing Owls.

STUDY AREA

The study was conducted in an area of approximately 100,000 ha on the Regina Plain south of Regina, Saskatchewan (50°27'N, 104°37'W) during the summer of 1988. The Plain occurs within the Grassland Ecoregion of Saskatchewan (Harris et al. 1983), and is intensively cultivated for cereal production. This has resulted in the preferred breeding habitat of Burrowing Owls being highly fragmented and dispersed. Most of the owls in the area breed on the relatively few remaining heavily-grazed pastures, most of which are not native.

METHODS

We compared breeding owl survival and reproduction between control pastures and pastures operationally poisoned with strychnine. Seven control pastures containing 28 pairs of owls and 8 treated pastures containing 27 pairs were used for this purpose. A 2% solution of commercially-available strychnine (Gopher-Cop, Saskchem Inc.) was prepared and applied according to label specifications. Strychnine was mixed with wheat grain to provide a final concentration of 2.5 mg/g dry grain bait. Approximately 10 g (one tablespoon) of treated seed was placed into every hole on the treated pastures ($N \approx 3000$). A similar amount of untreated grain was placed into every hole on the control pastures ($N \approx 3000$) to ensure that both pasture types were equally disturbed. Baiting took place in the early morning between 9 and 19 May. Following baiting, the treated pastures were kept under close observation until early evening when dead ground squirrels were picked up for disposal. The numbers of owls and ground squirrels on the pastures were counted 1 hr before and the day after the application at the same time of day by using instantaneous counts every 15 minutes. In addition, notes were kept of feeding and attempted feeding behavior by non-target species on dead ground squirrels. The pastures were monitored during the remainder of the summer and the number of young produced by each owl pair was noted. In addition, adults and chicks were livetrapped between

20 May and 28 July, banded, weighed to the nearest g, and their wings measured to the nearest mm. As the age of chicks was variable and unknown, their masses were standardized for age by dividing by their respective wing lengths resulting in a chick mass index which could be compared between treated and control pastures.

RESULTS

No breeding owls were lost on either the treated or control pastures following treatment (Table 1). In addition, breeding success (percent of pairs raising at least one chick), number of chicks produced per nest attempt or successful pair, and chick mass index were not significantly different between treated and control pastures (Table 1). Mean adult mass, however, was significantly higher on the control pastures (Table 1). The mean \pm SD maximum number of ground squirrels counted on the 8 treated pastures declined significantly from 6.0 ± 3.7 prior to poisoning to 0.8 ± 1.4 one day after poisoning (Mann-Whitney *U*-test, $P < 0.005$). Forty-one dead ground squirrels were picked up from the treated pastures; it is assumed that the majority of animals died underground. Six non-target species were recorded feeding or attempting to feed on dead ground squirrels on 11 occasions (Table 2). None of these individuals were seen to be adversely affected by the poisoned ground squirrels.

DISCUSSION

The results indicate that the use of strychnine for ground squirrel control is not detrimental to breeding Burrowing Owls. No owls were killed as a result of the poisoning and their reproductive success was not significantly affected (Table 1). The owls almost entirely ignored the dead and dying ground squirrels. The one owl that did feed on a dead ground squirrel rejected the gastrointestinal tract, thereby avoiding the greatest amount of strychnine residue. Other researchers have noted this for both Burrowing Owls and other raptors (see Schmutz et al. 1989). Some owls, however, were also seen feeding on microtine rodents which may have been killed by the treatment. Significant sublethal effects of strychnine on behavior have been demonstrated in other raptors (Cheney et al. 1987) so we cannot dismiss the possibility that some owls were affected in this way. This may explain why breeding success and adult masses were higher on the control pastures, the latter significantly so. The removal of some unknown portion of the small rodent prey base also may have had some influence on adult owl masses. However, one

Table 1. Adult survival, breeding success, number of chicks produced, chick masses, and adult masses of Burrowing Owls on control pastures and pastures poisoned with strychnine. Sample sizes in parentheses.

PARAMETER	POISONED	CONTROL	P
Adult survival (%)	100.0 (54)	100.0 (56)	NS ^a
Breeding success (%)	77.8 (27)	92.9 (28)	NS ^a
No. chicks produced per nest attempt (Mean ± SD)	4.0 ± 2.6 (27)	5.0 ± 2.2 (28)	NS ^b
No. chicks produced per successful pair (Mean ± SD)	5.2 ± 1.6 (21)	5.4 ± 1.7 (26)	NS ^b
Chick mass index (Mean ± SD)	1.1 ± 0.2 (51)	1.1 ± 0.3 (85)	NS ^b
Adult mass (Mean ± SD)	160 ± 11.5 (29)	168 ± 16.2 (37)	<0.05 ^c

^a Chi-square test.

^b Wilcoxon test.

^c t-test.

study of foraging behavior using radiotelemetry showed that Burrowing Owls in Saskatchewan spend little time foraging on the breeding pasture itself (Haug and Oliphant 1990). Our removal of the dead ground squirrels also may have had some unknown influence on the outcome of the study.

The number and diversity of non-target species attracted to the treated pastures indicates that a potential risk to these species exists (Table 2). Again, none were killed by feeding on poisoned ground

squirrels although sublethal effects may have occurred. It is also possible that, they too, rejected the gastrointestinal tracts. The poisoned grain was placed into the holes. It is likely that the gulls and corvids would have fed on the grain had it been placed above ground, thereby substantially increasing their chances of mortality (Wobeser and Blakley 1987). In 1983, the United States Environmental Protection Agency banned outdoor above ground use of strychnine bait due to risks to non-target wildlife. The agency now permits strychnine use for rodent control if baits are placed below ground.

This study indicates that the use of strychnine for ground squirrel control is not lethal to Burrowing Owls if poison is applied below ground. The finding is noteworthy because of the conservation status of Burrowing Owls in both the United States and Canada. Long-term reduction of ground squirrels through poisoning, however, may still have a significant impact on the owls. In Saskatchewan, for example, the majority of owls use old ground squirrel holes for breeding purposes. The removal of such holes over a period of years will ultimately result in fewer owls. Further study is therefore needed to evaluate the long-term implications of ground squirrel control on Burrowing Owl populations.

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Table 2. The number of observations of non-target bird species that fed, or attempted to feed, on dead ground squirrels poisoned with strychnine.

SPECIES	NUMBER OF OBSER- VATIONS	TOTAL INDIVIDUALS
American Crow <i>Corvus brachyrhynchos</i>	4	14
Black-billed Magpie <i>Pica pica</i>	2	5
Swainson's Hawk <i>Buteo swainsoni</i>	2	2
California Gull <i>Larus californicus</i>	1	2
Northern Harrier <i>Circus cyaneus</i>	1	1
Burrowing Owl <i>Athene cunicularia</i>	1	1

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SHORT COMMUNICATION

GOLDEN EAGLES TAKE UP TERRITORIES ABANDONED BY BONELLI'S EAGLES IN NORTHERN SPAIN

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In some areas of mediterranean Europe, Golden Eagles (*Aquila chrysaetos*) and Bonelli's Eagles (*Hieraetus fasciatus*) coexist. In Navarra, in northern Spain, the eagles are non-migratory and maintain exclusive territories spacing themselves uniformly (Fernández and Insausti 1986, Donázar et al. 1989). Our study area (10,420 km²) extended from the Pyrenees to the Ebro valley and lies at the northern limit of the range of Bonelli's Eagles. Here, the breeding of all pairs of Bonelli's Eagles (Insausti 1986) and Golden Eagles (Fernández 1988) has been monitored annually since 1982. Over this period we have documented a marked decline in the population of Bonelli's Eagles. From seven pairs in 1970 the number dropped to two breeding pairs in 1989. In contrast, Golden Eagles have maintained a healthy population. Thirty-three pairs nested in 1982 and this number has increased by 6.1% in the last seven years (Fernández 1988).

Of the five pairs of Bonelli's Eagles lost, two disappeared through robbery at the nest and shooting of the adults in 1972 and 1978 (Insausti 1986); one through electrocution of both adults in 1989 and the remaining two (in 1976 and 1987) for unknown causes. The territory abandoned in 1972 was taken over in 1985 by a pair of Golden Eagles, which since then has bred each year. The home range abandoned in 1978 was occupied by Golden Eagles in 1984. The Golden Eagles used one of the old nests of Bonelli's Eagles. A third home range probably is being colonized. An adult Golden Eagle has been observed in the area in 1988 and 1989, but was not breeding. The more recently abandoned territories have remained unoccupied.

Substitution of territories between different species of raptors is a relatively well known occurrence (Newton 1979) and has already been reported for Golden and Bonelli's eagles (Cheylan 1973, Austruy and Cugnasse 1981, Clouet and Goar 1984). Recently interspecific competition between these two eagles has been shown by different authors (Cheylan 1973, Jordano 1981, Clouet and Goar

1984). We have shown that this competition appears to be largely based on food (Fernández and Insausti 1986) rather than nest sites (Donázar et al. 1989).

We believe that the colonization of vacated territories was passive rather than an active competitive displacement. This was suggested by the long interval during which the territories remained vacant. Interspecific competition, therefore, does not appear to be the cause of the alarming decline of Bonelli's Eagles. However, colonization of abandoned territories by Golden Eagles could be detrimental to the declining Bonelli's Eagle population by making future recolonization of abandoned areas more difficult. In this sense we could speak of a passive competitive displacement that could be contributing to the disappearance of Bonelli's Eagles from our region.

The mechanics of this displacement require further clarification. There is indirect evidence for interspecific territoriality from the uniform distribution of home ranges, and from aggressive behavior between members of both species (Fernández and Insausti 1986). Also the rapid replacement of adult Golden Eagles disappearing from the breeding population (Fernández 1988) suggests an existence of young and subadult Golden Eagle floaters. In addition, the spatial saturation by Golden Eagles (Fernández 1988) could force new pairs to use home ranges abandoned by Bonelli's Eagles. Thus the occupancy of Bonelli's Eagles' home ranges by Golden Eagles would be facilitated by the decline in the population of Bonelli's Eagles and the presence of floaters in the Golden Eagle population.

The decline of the population of Bonelli's Eagles itself appears to have diverse causes which include major changes in human land use, recent rural electrification and shooting. The high breeding productivity observed in the region (Insausti 1986) would indicate that the decline in breeding pairs is due more to low adult and juvenile survival rates than to breeding problems. Radiotracking in Catalonia, in northeast Spain, by J. Real (*pers. comm.*) indicates that electrocution and shooting are the main causes of mortality for juvenile and adult Bonelli's Eagles. Also, changes in land use could have favored a species that hunts in open areas on mammals, such as the Golden Eagle (Watson et

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al. 1987), and be detrimental to a woodland bird eater, the Bonelli's Eagle (Jordano 1981, Clouet and Goar 1984, Fernández and Insausti 1986).

RESUMEN.—Desde 1982 se viene observando en Navarra (Norte de España) una progresiva colonización por el Aguila Real de los territorios abandonados por el Aguila Perdicera. Las causas no están claras pero puede deberse a cambios rurales que perjudicarían en mayor medida al Aguila Perdicera. Aunque no se trate de un desplazamiento competitivo activo estas sustituciones pueden suponer, en un futuro, una dificultad añadida para la recuperación de la población de Aguilas Perdiceras actualmente en declive.

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LETTERS

American Kestrel Kills Least Sandpiper. On 4 October 1988, while netting shorebirds at Windsor Reservoir (Weld County) in northeast Colorado, we observed approximately 100 shorebirds foraging on an extensive mudflat. Most birds were present in small (about 12 individuals) inter-specific flocks composed mainly of dowitchers (*Limnodromus* sp.), Baird's Sandpipers (*Calidris bairdii*) and Least Sandpipers (*Calidris minutilla*). Between 1000 H and 1120 H we observed three attacks upon these flocks by a female kestrel (*Falco sparverius*). In the first attack the kestrel gained altitude and stooped at a flock in flight. After two unsuccessful stoops, the kestrel returned to a perch in a Peachleaf Willow (*Salix amygdaloidea*) tree. In the second attack the kestrel stooped upon a different flock and successfully separated a small sandpiper from the flock. The kestrel chased this shorebird for approximately 45 seconds. During the chase, the kestrel worked the bird out over the reservoir and stooped 6 times as if trying to force the sandpiper lower. The sandpiper maintained an altitude of 30–35 m, however, and the kestrel discontinued pursuit and perched in a Plains Cottonwood (*Populus sargentii*) tree. At 1120 H the kestrel twice attacked a third flock, stooping from about 20 m, apparently trying to separate one individual from a flock of 4 Baird's Sandpipers and 1 Least Sandpiper. The Least Sandpiper became separated from the flock and flew over the water. The kestrel made a third stoop at this individual from a lower altitude (about 5 m) and came very close to it, perhaps half a meter. At this time the sandpiper was only a few decimeters above the water. On its fourth stoop the kestrel caught the sandpiper in the air, returning with it to a perch in a cottonwood.

Only one previous description of an American Kestrel hunting Least Sandpipers has been published (in California; G. Page and B.F. Whitacre, 1975, *Condor* 77:73–83). Our observation differs from Page and Whitacre's description in three respects. First, they observed male but not female kestrels hunting shorebirds. Second, kestrels in that study hunted over a salt marsh and not over mud flats. Finally, they observed kestrels hunting by plummeting to the ground and taking prey in thick vegetation. Although the American Kestrel may hunt and prey on shorebirds more often than previously thought, this predatory behavior is poorly known and deserves further attention.—**Gonzalo Castro and James A. Sedgwick, National Ecology Research Center, U.S. Fish and Wildlife Service, 4512 McMurray Avenue, Fort Collins, CO 80525-3400. Present address of Gonzalo Castro: Manomet Bird Observatory, P.O. Box 936, Manomet, MA 02345.**

THESIS ABSTRACTS

FACTORS INFLUENCING LOCAL VARIATION OF BALD EAGLE DENSITY IN NORTH-CENTRAL SASKATCHEWAN

The influence of nesting habitat, prey resources and human activity on local variations of Bald Eagle (*Haliaeetus leucocephalus*) density was examined in 1986 and 1987 on Besnard and Nemeiben Lakes in north-central Saskatchewan. Eagle density and the number of active breeding areas on Besnard Lake was two to three times greater than on Nemeiben Lake. Differences in water area or area of forest within 200 m of shore accounts for a factor of 1.14 of the variation in eagle numbers, leaving the majority of the density differences to be explained by other factors.

Bald Eagles preferred to nest in large trees close to shore in mixed-wood stands dominated by coniferous trees. Treed rock, muskeg and even-aged coniferous stands were avoided. Trembling aspen (*Populus tremuloides*) was the preferred species for nesting on the mainland, while white spruce (*Picea glauca*) was preferred on islands. Percent of suitable forest habitat within the zone in which most eagles nest (200 m from shore) was almost identical on Besnard (35%) and Nemeiben (36%) Lakes and thus forest nesting habitat was not likely a factor limiting eagle numbers.

I investigated food resource levels by netting fish in both lakes, and examining records on commercial/sports-fisheries, and biological surveys. Cisco (*Coregonus artedii*), an important prey species for eagles, were more numerous and larger on Besnard Lake. Other indices of aquatic fauna and fish populations portray Besnard Lake as much more productive. Differences in the prey base was the most likely factor limiting eagle density on Nemeiben Lake.

I compared eaglet growth and hatching order of the sexes on Nemeiben Lake to that on Besnard Lake. Inflection points in growth curves and feather emergence were earlier in males than females. Second-hatched females, in mixed-sex broods, on Nemeiben Lake gained weight slower than males on both lakes, and had inflection points which were much later than those of females on Besnard Lake. Mixed-sex broods, with females hatching second, were rare on Besnard Lake, but common on Nemeiben Lake; the production of such broods may be an adaptive response to lower food levels.

I investigated human activity on the lakes through questionnaires distributed to cottage owners and analysis of campground occupancy. Human activity has been more intense on Nemeiben Lake for a longer period than on Besnard Lake. Human activity may have influenced the eagle populations, but did not account for all of the variation. **Elston H. Dzus, 1988. M.Sc. thesis, Department of Zoology, University of Manitoba, Winnipeg, MB, Canada. Present address: Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7N 0W0.**

PRE-INCUBATION BEHAVIOR AND PATERNITY ASSURANCE IN THE COOPER'S HAWK (*Accipiter cooperii*)

Male Cooper's Hawks (*Accipiter cooperii*) provide most of the food for their mates during the prezygotic period, hunt prey away from the nest site, and thus must leave females unattended for part of the day. Unattended females could be inseminated by other males ("cuckoldry"). Mated males should thus attempt to assure paternity because, as in other monogamous bird species in which both parents help to rear young, cuckolded males would waste their reproductive investment and lose individual fitness.

As part of a ten-year study of the nesting ecology of the Cooper's Hawk in Wisconsin, I obtained data on pre-incubation behavior during 1986–89. I investigated paternity assurance through a quantitative analysis of copulatory behavior and related activities during the prezygotic period.

Forty-seven mated pairs of Cooper's Hawks at 28 nesting areas were observed during 84 observational episodes ($\bar{X} = 87$ min/episode). Observation periods were stratified such that most (69 or 82%) ended before 0830 H; observations also were conducted throughout the day until 1820 H. During a prezygotic period of about 30 days, males were more likely to be present during the early morning hours than at other times of the day. Copulations ($N = 20$) occurred throughout the prezygotic period with (as with nest building) a peak of such activity in early morning. I estimated 372 copulations per pair for each clutch. Copulations were strongly associated with nest visits (nest building) by males. Seventy percent of 102 copulations were immediately preceded by nest visits by males. Males made significantly more nest visits and delivered significantly more twigs to nests than did females.

I suggest that the high number of copulations relative to other bird species is an attempt to assure paternity, and that male Cooper's Hawks help assure paternity by being present and copulating frequently with their mates in the morning—the most likely time of fertilization. I also suggest that nest building by males serves as a pre-coital display that induces females to copulate and thus acts to assure paternity. Building of alternate nests, as is common, may serve the same display function among males. **Robert N. Rosenfield. 1990. Ph.D. thesis, Department of Zoology, North Dakota State University, Fargo, ND 58105.**

NEWS AND REVIEWS

REFEREE'S NAMES

The individuals listed below have graciously offered their professional opinion in the evaluation manuscripts submitted for publication to *The Journal of Raptor Research* in 1990.

Daniel Airola, David Andersen, Thomas Balgooyen, Robert Bancroft, Marc Bechard, Dale Becker, James Belthoff, Richard Bierregaard, Keith Bildstein, David Bird, Pete Bloom, Gary Bortolotti, Reed Bowman, David Brinker, Richard Brown, Evelyn Bull, Javier Bustamante, Tom Cade, John Castrale, Thomas Carpenter, Susan Chaplin, Bill Clark, Dick Clark, Jack Clinton-Eitniecear, Charles Collins, Michael Collopy, Erica Craig, Tim Craig, Gregory Czechura, Gustavo Danemann, James Dawson, Dick Dekker, Katherine Duffy, Gary Duke, Jim Duncan, David Ellis, Jim Enderson, Nancy Ertter, Dave Evans, Paolo Fasce, Jim Fitzpatrick, Stephen Flemming, Bruce Fortman, Glen Fox, Jim Fraser, Mark Fuller, Frederick Gelbach, Jon Gerrard, Richard Glinski, Claire Hager, Fran Hamerstrom, Donald Hammer, Al Harmata, Chuck Henny, Borja Heredia, Mauro Hernández, José Carrillo Hidalgo, Denver Holt, David Houston, Stuart Houston, Rich Howard, Grainger Hunt, William Iko, Eduardo Iñigo-Elias, Ronald Jackman, Fabian Jakšić, Paul James, Warren Johnson, Christopher Kellner, Robert Kenward, Paul Kerlinger, Daniel Klem Jr., Mike Kochert, Bill Koonz, Ted Leighton, Jeff Lincer, Carl Marti, Bruce McGillivray, Katherine McKeever, Martin McNichol, Brian Millsap, George Montopoli, Helmut Mueller, Peter Mundy, Joe Murphy, Bob Murphy, Wayne Nelson, Robert Nero, Lynn Oliphant, Tim Osborne, Allen Parker, James Phillips, Alan Poole, Howard Postovit, Sergej Postupalsky, Patricia Rabenold, Arlo Raim, Christopher Reading, Pat Redig, Laura Rodríguez, Ricardo Rodríguez-Estrella, Christoph Rohner, Larry Rymon, William Scharf, Phil Schempf, Wolfgang Scherzinger, Terry Schulz, Chris Shank, Stephen Sherrod, Williston Shor, John Smallwood, Dwight Smith, Navjot Sodhi, Karen Steenhof, Paul Steblein, Peter Tirrell, Jay Vannini, Daniel Varland, Ian Warkentin, Geoff Welch, Clay White, Stanley Wiemeyer, Sanford Wilbur, Fridtjof Ziesemer.

The Tully Memorial Award went to Cynthia Sillis for her work on the effect of supplemental feeding on synchronous hatching in burrowing owls. Cynthia Sillis is a graduate student at Idaho State University.

The Hawk Migration Association of North America Research Award was established to encourage research on raptor migration. Applicants should submit a proposal not longer than five pages. The proposal should describe study objectives, study location and methodology, proposed expenditures, and the applicant's background. Annual awards total \$2000 and up to three projects may be funded each year. Send applications before 15 June 1991 to **Laurie Goodrich, HMANA Research Award, Hawk Mountain Sanctuary, R.D. 2, Kempton, PA 19529.**

The International Osprey Foundation (TIOF) is seeking applications for its second grant to support research activities of a graduate student primarily focusing on ospreys. Work with other raptor species may be considered, however. The award recipient will be expected to provide a report on his or her research and use of the funds within a year of receiving the grant.

Gustavo D. Danemann, a graduate student with the Seabird Program at the Universidad Autonoma de Baja California Sur, Marina Biology Department in La Paz, Mexico, was awarded the first grant. He is studying the breeding ecology, philopatry and dispersion of ospreys in the coastal lagoons of Baja California and the effect of nest density on breeding performance.

Applicants should submit a proposal outlining their project and the intended use of the funds by April 15, 1991. The grant will be awarded on June 1, 1991. Send applications to: **TIOF, Endowment Fund, P.O. Box 250, Sanibel, FL 33957-0250.**

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