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RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

VOLUME 18, NUMBER 1, SPRING 1984
(ISSN 0099-9059)

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Provo, Utah

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Dr. Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 18

SPRING 1984

No. 1

HISTORY AND PRESENT STATUS OF SWAINSON'S HAWKS IN SOUTHEAST OREGON

ARROLL D. LITTLEFIELD, STEVEN P. THOMPSON AND BRADLEY D. EHLERS

ABSTRACT - Similar to other isolated localities, Swainson's Hawks have declined in southeast Oregon. Formerly, the most commonly nesting *Buteo* in the Malheur-Harney Lakes Basin, the species became uncommon after the 1950's. Population declines have also been noted during migration. Reasons for the decline are unknown, but several theories are presented.

Declines in Swainson's Hawk (*Buteo swainsoni*) numbers have been reported from California (Bloom 1980), Nevada (Herron and Lucas 1968) and southern Saskatchewan (Houston and Bechard 1983). Here, we report a similar decline in southeast Oregon. A summary of the species' nesting and migratory status is given from 1875 through 1983, based on U.S. Fish and Wildlife Service (FWS) files, and reports by early ornithologists who worked in the Malheur-Harney Lakes Basin. Data were limited in certain periods, but enough accounts have accumulated to provide a general trend for the region.

STUDY AREA

Most information has been collected on or near Malheur National Wildlife Refuge Harney Co., Oregon (Figure 1). The refuge consists of 73,219 ha of freshwater marshes, two large lakes and uplands with big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp.) and/or greasewood (*Sarcobatus vermiculatus*). Many km of riparian habitat are available along water systems, particularly in the southern portion of the refuge. The main units are Malheur, Harney and Mud lakes, Double O and Blitzen Valley. The Blitzen Valley contains the most important habitat for Swainson's Hawks because of the amount of riparian vegetation present. The valley extends south from Malheur Lake about 67 km.

Surrounding the refuge are great expanses of shrub-steppe. Big sagebrush is the dominant plant, but in many regions western juniper (*Juniperus occidentalis*) is characteristic (Franklin and Dryness 1973). Within this shrub-steppe region the Bureau of Land Management (BLM), in cooperation with the U.S. Fish and Wildlife Service, conducted a nesting raptor inventory from 1976 through 1980. Malheur NWR was located within the 26,379 km² raptor inventory area; however, most of the study area was on lands administered by the BLM (Figure 1). Information from the BLM study are included in this report.

Southeast Oregon is within the Basin and Range province, and is a continuation of this physiological province in Utah, Nevada, Arizona, New Mexico and California. The province is mostly about 1200 m elevation, with north-south trending fault-block mountains and basins of internal drainage (Baldwin 1964). The

highest point in southeast Oregon is Steens Mountain, Harney Co., which attains an elevation of 2958 m.

Nesting habitat for Swainson's Hawks has been riparian zones on Malheur NWR, and widely scattered junipers throughout the surrounding uplands. In the spring, the species is usually seen near agricultural areas, while in the fall principle feeding habitat is newly mowed meadows where an abundance of rodents, particularly montane voles (*Microtus montanus*), are left exposed.

MATERIALS AND METHODS

Most records were obtained from Malheur NWR files and early documents from ornithologists who worked in the region from 1875 through 1932. From 1940 through 1983 information was primarily from Malheur NWR Annual Narrative Reports (NR). Beginning in 1975, 360 km of raptor road counts were initiated on and surrounding the refuge (Figure 2). During the periods when Swainson's Hawks were in the basin, surveys were conducted in April, June and August 1975, 1977, 1979, 1980, 1982 and 1983. Transects were driven at 32 kph with stops for 3 min every 1.6 km. Counts were completed between 10:00 and 15:30.

RESULTS

1875-1939. — Swainson's Hawks were first recorded in southeast Oregon in 1875 when Charles Bendire found the species quite common in the Malheur-Harney Lakes Basin (Brewer 1875). Bendire (1877) later considered it a common summer resident, generally distributed throughout the basin. They were found nesting in willows (*Salix* spp.) along streams and in isolated junipers and pine trees on the edge of the forest. He collected 25 egg sets which usually numbered 2, and rarely 3/ clutch.

We know of no additional records until brief mention was made of several being seen in 1915 (refuge files). Willett (1919) saw 2 individuals near Malheur Lake on 26 June 1918 and 2 additional birds on 27 June. The species was considered fairly common in August 1918, but these could have been migrants. Willett further reported that between

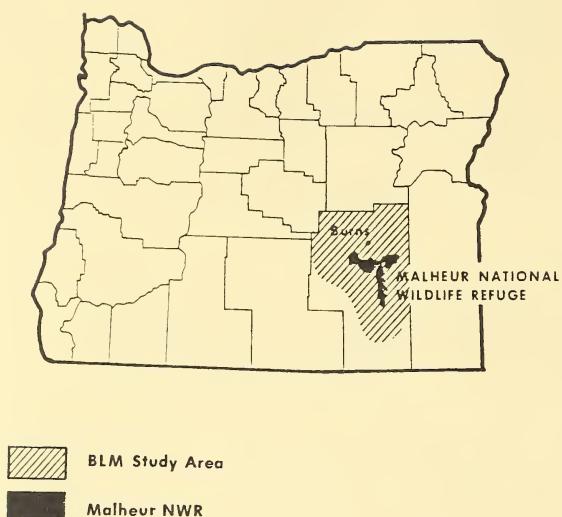


Figure 1. Location of Bureau of Land Management's nesting raptor inventory study area, in respect to Malheur National Wildlife, Oregon.

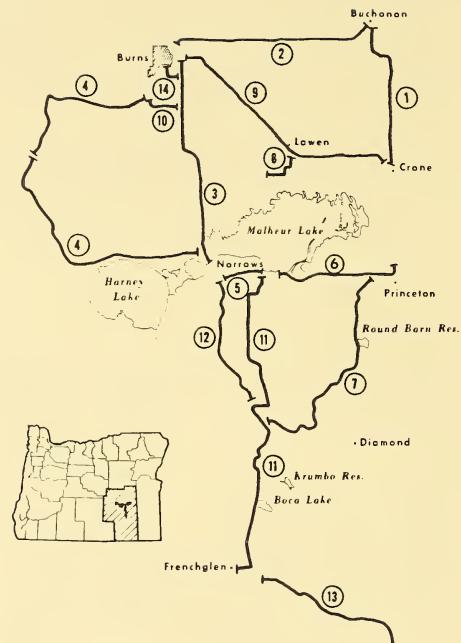


Figure 2. Locations of raptor road transects in the Malheur-Harney Lakes Basin, Oregon.

Malheur NWR and Klamath Falls, Klamath Co., Oregon the species was common along most of the route, and particularly abundant in canyons and slopes on Warner Mountains, in Lake Co. On 24 May 1920, 27 were counted as they perched on fence posts along one side of an alfalfa (*Medicago sativa*) field near Burns, Harney Co. The field contained numerous ground squirrels, and the hawks were catching rodents for food (Gabrielson 1922). Based on the lateness of the season, these birds probably represented locally nesting individuals. Prill (1922) found the species very common near Burns and as far south as Wright's Point (16 km S of Burns) from 25 May to 15 June 1921. They were commonly nesting in trees on the surrounding hills. In 1922, the Swainson's Hawk was considered the most common of the large hawks in the basin during the summer months. The species nested in junipers bordering Harney Valley where it consumed large numbers of 2 species of ground squirrels (FWS files).

Jewett (1936) considered the Swainson's Hawk as equal in numbers with the Red-tailed Hawk (*B.*

jamicaensis), indicating the species had declined somewhat between 1922 and 1932. Gabrielson and Jewett (1940) reported it was once one of the most common raptorial birds in eastern Oregon, and could still be considered a common summer resident despite a noticeable decrease in numbers during recent years. Preferred nesting habitat was reported as gnarled, twisted junipers. Forty-two egg sets collected in Oregon between 1924 through 1960, on deposit at the Western Foundation of Vertebrate Zoology, showed 64.3% in junipers, 16.6% in willows, and 19.1% in other tree species (L. Kiff, pers. comm.).

1940-1959. — Swainson's Hawks were still common in southeast Oregon in the 1940's. An estimated 150 individuals were present on Malheur NWR in the summer of 1941, from which 12 nestlings were banded. At this time some pairs were nesting in sagebrush in the northern portion of the Blitzen Valley. This nesting habitat continued to be used through the mid-1940's. From 1944 through 1947 the nesting population remained unchanged.

Table 1. Number of Swainson's(SW) and Red-tailed(RT) Hawks observed on raptor transects in the Malheur-Harney Lakes Basin, Oregon.

Month		TOTALS (#(KM)					
		1975	1977	1979	1980	1982	1983
April	SW	4 (.011)	2 (.006)	1 (.003)	0 (.000)	13 (.036)	2 (.006)
	RT	26 (.072)	21 (.058)	16 (.044)	31 (.086)	38 (.106)	56 (.156)
June	SW	2 (.006)	20 (.060)	8 (.020)	18 (.050)	4 (.011)	7 (.019)
	RT	14 (.039)	46 (.128)	29 (.081)	67 (.186)	63 (.175)	36 (.100)
August	SW	7 (.020)	16 (.040)	20 (.060)	30 (.080)	26 (.072)	23 (.064)
	RT	46 (.128)	55 (.153)	67 (.186)	96 (.267)	60 (.167)	31 (.086)

In 1947, it was still the most commonly seen raptor with an estimated 150 individuals. No information was available from 1948 through 1957, but there was no indication of change in the species' status.

In the late 1950's the population began to decline. In 1958, several pairs nested in willows on Malheur NWR. A rodent infestation occurred from May through August, but no Swainson's Hawk increase was noted on the refuge. However, neighboring valleys had larger populations of both Swainson's and Red-tailed Hawks. In 1959, a reduction in the local nesting population was reported (Refuge N.R.)

1960-1983. — In the 1960's, low populations of Swainson's Hawks persisted. The species increased by 2 pairs on the refuge in 1960, but their numbers were low compared with those of previous decades. By 1962 there were only 2 nesting pairs. Pair numbers fluctuated through the 1960's, with the highest number recorded in 1966 with 5 pairs. Four pairs were present in 1967, and for the first time in recorded history there were no nesting Swainson's Hawks on Malheur NWR in 1968. However, in 1969 and 1970, 2 pairs were present, increasing to 3 pairs in 1971. This was the last nesting record in willows, and the last until 1979 in any habitat on Malheur NWR. The 1979 nesting effort was in a juniper and unsuccessful. Eggs were incubated but did not hatch.

In the BLM study area (Fig. 1), 18 Swainson's Hawk breeding territories were located in 1980. Densities were one pair/1,465 km² on the BLM study area. The nearest nesting pair to Malheur NWR was 9.6 km east. Johnstone, et al. (1980) re-

ported all 18 nests were in western juniper. Mean tree height was 5.5 m and mean nest height was 5.0 m. Nesting trees were mostly isolated, near or in stands of low structured vegetation such as crested wheatgrass (*Agropyron cristatum*), alfalfa, or cheatgrass (*Bromus tectorum*). The majority of nests located in the past 7 years has been near sagebrush removal projects. Prey remains collected at the nests indicated their major prey was Horned Larks (*Eremophila alpestris*), Western Meadowlarks (*Sturnella neglecta*), ground squirrels, various small mammals and insects (Johnstone, et al. 1980).

Swainson's Hawk numbers have varied on June raptor transects (Table 1), and consisted of single individuals or pairs. Single individuals were assumed to have a mate incubating or brooding at the time the transect was conducted. In 1975, only 2 birds were recorded, but 20 were noted in 1977. Seven were seen on the 1983 transects. Most of these birds were associated with agricultural or crested wheatgrass areas located east and west of Burns, Oregon. None was recorded in riparian habitat. Most Swainson's Hawks seen on the 1977, 1979 and 1980 transects were members of pairs whose nests had been previously located by BLM personnel during nesting raptor inventory studies.

Migrational Accounts. — Little historical information was available on Swainson's Hawk migration in southeast Oregon. Leopold (1942) observed 37 (0.58/km) in August 1941 on a single trip through the Blitzen Valley, and reported the species as the most commonly seen raptor on Malheur NWR. A total of 56 individuals was seen on 1 August and 50 on 1 September 1947 (Refuge N.R.).

Road transects conducted in April and August 1975, 1977, 1979, 1980, 1982 and 1983 (Table 1) indicated Swainson's Hawks were no longer a common species during spring and fall migration in the Malheur-Harney Lakes Basin. Before the 1960's the species was considered more common than the Red-tailed Hawk. When comparing the two from transect data, Red-tailed Hawks were more common than the Swainson's Hawk (Table 1).

DISCUSSION

Reductions in the Swainson's Hawk nesting population in southeast Oregon, Nevada and northeast California are presently unexplained. In southeast Oregon, juniper and riparian habitats are available and appear adequate for nesting sites, therefore, other factors are apparently involved. A recent increase in the Great Horned Owl (*Bubo virginianus*) in riparian habitat on Malheur NWR could be responsible for the disappearance of nesting Swainson's Hawks in willows. An active nest in 1962 was taken over by a Great Horned Owl pair in 1963. Swainson's Hawks have not nested in this area since. In 1966, there was an active hawk nest 1.6 km east of the site and it could have been the displaced pair. Newton (1979) reported Swainson's Hawks nesting close to Great Horned Owls had significantly less success than those nesting in tree clumps lacking these predators. In Washington, Fitzner (1980) reported distances between Swainson's Hawk and Great Horned Owl nests ranged from 2.2 to 3.1 km indicating less tolerance to Great Horned Owls than to other raptorial birds. Smith and Murphy (1973) also found the species nested far from Great Horned Owls (mean distance 3.54 km). Both of these studies reported a low tolerance between the two species.

Another possible factor for the species' decrease is a reduction in foraging sites within a pair's territory. Yensen (1980) reported vegetation in southwest Idaho was once a mosaic dominated by open stands of sagebrush with an understory of perennial grasses. The vegetation was severely damaged by sheep and cattle in the late 1800's and early 1900's. Added to a 14-year dry period, culminating in the severe drought of 1934, the native grass understory was virtually eliminated. A similar condition occurred in southeast Oregon. As native grasses disappeared because of overgrazing, sagebrush became the dominant plant. Accompanied with fire suppression by federal agencies, large monotypic stands of sagebrush have been per-

petuated. Bechard (1980, 1982) reported hunting sites by Swainson's Hawks in Washington was not based on prey density, but more likely on vulnerability of prey to predation. With dense stands of sagebrush the vulnerability of prey for the species probably was reduced, resulting in Swainson's Hawks abandoning many regions of southeast Oregon. The 18 territories reported by Johnstone, et al. (1980) were mostly near low structured vegetation and away from dense monotypic shrubs.

Another possibility is the local nesting population is being limited either in migration or on their wintering areas. The species has been reported as having difficulty in their Argentine wintering regions where large scale use of pesticides has been used for locust control (N. Smith, pers. comm., Olrog 1967). Locust are apparently an important prey base for Swainson's Hawks in Argentina. If this agricultural activity is occurring in localized regions, the Great Basin population could be wintering in such an area. This might account for the decrease in nesting pairs in southeast Oregon, northeast California and Nevada when compared with other populations in western North America. Henny and Kaiser (1979) found low levels of DDT and its metabolites in Swainson's Hawk eggs in northeast Oregon. Low levels of DDT were also found in eggs collected in northeast California in 1982 and 1983 (R. Schlorff, pers. comm.). Therefore, it is reasonable to assume DDT is not responsible for the decline of Swainson's Hawks in the northern Great Basin, but other pesticides might be involved. Only 6 years data are available from raptor transects, but there appears to have been a decline in spring migrants (except in 1982). However, migrant counts in August have remained relatively stable since 1979 (Table 1). If the same migration corridors were used by individuals in spring (April) and fall (August), a major loss of Swainson's Hawks is occurring south of the Malheur-Harney Lakes Basin.

ACKNOWLEDGMENTS

We thank Larry Ditto, Charles Henny, Gary Ivey, Joseph Mazzoni and David Paullin for reviewing, correcting and making suggestions concerning the manuscript, and Dee Dee Ehlers for typing assistance. Numerous employees of the U.S. Biological Survey and U.S. Fish and Wildlife Service collected and recorded data on the species, and to them we are deeply grateful. Lloyd Kiff provided egg set data from the Western Foundation of Vertebrate Zoology, Los Angeles, California.

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Received 26 December 1982; Accepted 1 March 1984.

Raptor Research Foundation Meeting. The 1984 annual meeting of the Raptor Research Foundation, Inc., will be held October 25-28 at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. The tentative schedule is:

26-27	October	Paper and Poster Sessions
27	October	Banquet
28	October	Open

For further information, program suggestions, or space requests, contact: Dr. Jim Fraser, Department of Fish & Wildl. Sci., VPI & SU, Blacksburg, VA 24061

NESTING BIOLOGY OF BROAD-WINGED HAWKS IN WISCONSIN

ROBERT N. ROSENFIELD

ABSTRACT — Seventy-two nestings in 56 Broad-winged Hawk (*Buteo platypterus*) nesting areas were investigated in Wisconsin from 1976 through 1981. Trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) supported 51% and 29% of all nests, respectively. A reoccupancy rate of 0.60 was found for 16 nesting areas. Mean distances between nests on an intensive study area were 1.5 km (1976; n=9), 1.7 km (1980; n=9), and 1.1 km (1981; n=10). Density in 1981 on 23.7 km² was 1/2.4 km². Means of 2.4 eggs laid, 1.8 hatched, and 1.5 young fledged were found for 70 active nests. Fifty-five of 70 (79%) nests fledged young. The major factors reducing productivity occurred before hatching.

Relatively little has been published on the nesting ecology of the Broad-winged Hawk (*Buteo platypterus*). There are few productivity and density data for this common breeding raptor of North America's eastern deciduous forests. The first review of Broad-winged Hawk biology by Burns (1911) was general, though extensive. Recent studies of various aspects of Broadwing nesting ecology have reported data from relatively few nests: Rusch and Doerr (1972) 5 nests in Alberta; Fitch (1974) 3 nests in Kansas; and Matray (1974) 14 nests in New York. Keran (1978) presented habitat data from 29 nests in Minnesota and Wisconsin. Intensive studies of nest habitat by Titus and Mosher (1981), and nesting biology by Janik and Mosher (1982) are based on 24 and 36 nests, respectively, in Maryland. This paper presents data from 72 Broad-winged Hawk nests in Wisconsin from 1976 through 1981. The objectives of my study were to determine the spacing of nests, density of nesting pairs, and productivity.

STUDY AREA AND METHODS

In 1976, 1980, and 1981, I intensively searched for Broadwing nests in an area approximately 1.6 km north of Merrill, Wisconsin, 45°10' lat 89°40'W long. Here, I did not establish study area boundaries and completely search the interior in 1976 and 1980; instead, I conducted an intensive nest search and then established a boundary around the area I was able to inventory, resulting in 18.1 km² and 17.5 km², respectively (Fig. 1). In 1981 I established a 23.7 km² study area prior to nest searching (Fig. 1). I am confident that I found all Broadwing nests on the Merrill study area in 1976, 1980, and 1981 (Fig. 1).

In 1977 through 1979 I searched for nests in areas similar to known nest habitat within 10 km east, west and north of the Merrill study area; in 1977 through 1981 I revisited known nesting areas to determine reoccupancy. Nests were also found incidental to other research on the Nicolet National Forest, 120 km northeast of Merrill, and on 2 other areas, one 266 km south and another 190 km northwest of Merrill, respectively. Calling Broad-winged Hawks led me to nesting areas; fresh greenery on nests indicated recent use.

The 1981 Merrill study area was nearly level, ranging from 399 to 412 m in elevation. Its habitat included 39% upland hardwoods, 36% farmland, 10% alder (*Alnus rugosa*) thicket, 8% bog, 2.5% permanent water, 2.5% residential, 1.2% swampland, and 0.7%

red pine (*Pinus resinosa*) plantation. Ground moraine soils were poorly drained, and small (2-10 m²) woodland pools of water were common throughout spring and summer. The typical upland hardwood was trembling aspen (*Populus tremuloides*) which existed in pure stands or mixed with white birch (*Betula papyrifera*) and balsalm fir (*Abies balsamea*). Black ash (*Fraxinus nigra*), black spruce (*Picea mariana*), and tamarack (*Larix laricina*) were common in permanently wet areas.

An active nest or nesting attempt was one in which eggs were laid; an occupied nest was one in which 2 adults were present near a recently constructed nest with fresh greenery on top (Postupalsky 1974). A nesting area was that area within a radius of 250 m of a nest. A nesting area was considered reoccupied if, in subsequent years, an active or occupied nest was found within 250 m of a previously used Broad-winged Hawk nest, or if a nest was reused by Broadwings.

Mean distances between nests on the Merrill study area were determined in 1976, 1980, and 1981 in the manner reported by Reynolds and Wight (1978). Productivity was determined by climbing to each active nest once during mid-to-late incubation and again about 2 w later to record the clutch size and the number of nestlings, respectively. I returned to nests to determine fledging rates when I estimated young to be > 30 d old.

RESULTS AND DISCUSSION

I found 70 active and 2 occupied Broad-winged Hawk nests; 28 by intensive searching, 12 by searching habitat similar to known nest habitat, 17 by revisiting nesting areas in subsequent years, and 15 as incidental finds. Broad-winged Hawks nest in a variety of hardwood tree species across their breeding range. The majority of nests in my study were supported by trembling aspen (51%) and white birch (29%). Matray (1974) reported 86% of 14 nests in yellow birch (*Betula alleghaniensis*) in New York. In Maryland, Titus and Mosher (1981) found 79% of 24 nests in various oaks, predominantly white oak (*Quercus alba*) (50%). Burns (1911: 246) reported American chestnut (*Castanea dentata*) as the most "popular" nest tree in the northeastern United States. Keran (1978) reported 21% of 29 nests in Minnesota and Wisconsin in aspen and 41% in oak. Diameter at breast height and height of nests in trees in my study were less than those reported in other studies (Table 1).

Table 1. Comparison of diameter at breast height (DBH) of nest trees and height of Broad-winged Hawk nests ($\bar{x} \pm$ S.D., (range)).

Source	N	DBH	Nest Height (M)
This study	72	31.5 ± 6.3 (21.1 - 48.8)	8.2 ± 2.7 (3.9 - 15.4)
Burns (1911)	167	-	10.1
Matray (1974)	14	54.1 ± 8.3 (42.1 - 74.2)	13.3 ± 1.4 (11.0 - 15.5)
Titus and Mosher(1981)	24	38.0 ± 9.5 (25.0 - 62.0)	13.7 ± 3.0 (9.5 - 20.6)

Twenty-nine of 56 (52%) Broad-winged Hawk nesting areas in this study contained 1 or more other stick nests. This suggests that a nest area, not just a nest tree, has some important characteristics, such as the interspersion of habitat types, that may

be related to the high nesting density (see below). The importance of certain areas for nesting is further indicated by the reoccupancy rate. I revisited 16 nesting areas (including nest areas on the Merrill study area) 47 times in subsequent years and

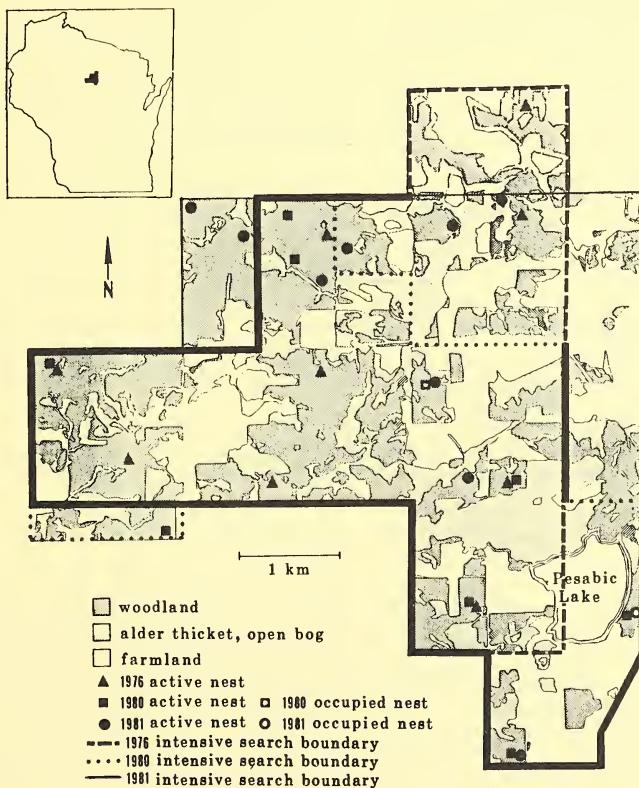


Figure 1. Distribution of Broad-winged Hawk nests on the Merrill, Wisconsin study area. Thickened line indicates where 2 or more years formed the study area boundary.

found them reoccupied on 28 occasions, resulting in a reoccupancy rate (number reoccupied/number revisited) of 0.60. Broadwings usually built a new nest in a different tree in a reoccupied nesting area. Broad-winged Hawk nests were reused on only 5 occasions; 3 the next year, 2 the second year.

Mean distances between nests on the Merrill study area were: 1976-1.5 km (range = 1.1-2.2 km, SD = 0.37 km), 1980-1.7 km (range = 0.6-3.1 km, SD = 0.72 km), and 1981-1.1 km (range = 0.5-2.4 km, SD = 0.62 km). The smaller mean distance in 1981 was due to the close spacing of the 6 most northerly nests (Fig. 1) that were in locally wet areas.

Density on the Merrill study area in 1981 was 1 pair/2.4 km². Variously derived densities in other studies were a maximum of 1 pair/23.3 km² estimated by Rusch and Doerr (1972) in Alberta, 1 pair/5.2 km² estimated by Burns (1911: 176) in Massachusetts, and 1 pair/2 mi² (this converts to 5.2 km² rather than 3.2 km² as stated) reported by Keran (1978) in Minnesota. Wisconsin density is high when compared to other studies.

I suggest that the relatively high density of nesting Broad-winged Hawks in 1981 is related to the interspersion of habitat types on the Merrill study area, which lies between extensive northern forests and an intensively farmed central region of Wisconsin. The partial conversion of forests to farmland in this area has created more upland openings and edge habitat than were originally present. Keran (1978) suggested that such openings may be important to nesting Broad-winged Hawks because they are utilized as primary hunting sites. Fuller (1979) found Broadwings in field-forest edge more than would be expected by chance when this habitat type occurred in their home ranges. Further, 5 of 6 Nicolet Forest nests were within 50 m of roadways, which perhaps served as primary hunting sites in an extensively forested area. Titus and Mosher (1981) indicated that Broad-winged Hawks nested closer to both water and forest openings than would be expected by chance. Matray (1974) stated that Broadwings seemed to prefer nesting on poorly drained sites. The importance of wet areas is suggested by the close spacing of the aforementioned 6 nests which corresponded with the occurrence of wet habitat in the Merrill study area.

Means of 2.4 eggs laid, 1.8 hatched, and 1.5 young fledged per nest attempt were found in this study (Table 2). A one-way analysis of variance revealed no significant ($P > 0.05$) differences among

Table 2. Mean number of eggs laid, hatched and young fledged per nest attempt¹.

Year	N	Eggs laid ²	Eggs hatched	Young fledged
1976	9	2.2	1.9	1.8
1977	10	2.0	1.3	1.1
1978	14	2.3	1.9	1.7
1979	12	2.3	1.7	1.3
1980	10	2.5	2.1	1.5
1981	15	2.6	2.0	1.7
Total	70	2.4	1.8	1.5

¹A nest attempt was one in which eggs were laid.

²The distribution of clutch sizes was 2 clutches of 1 egg, 43 of 2, 23 of 3, and 2 of 4.

the yearly means, even though there was considerable variability. Janik and Mosher (1982) reported Broad-winged Hawk productivity data for a 3 y study in Maryland, but they did not report yearly means. I do not know if the annual fluctuations found in my study are common for the species or if they are a function of the relatively small number of nests analyzed each year.

Fifty-five of the 70 (79%) active nests fledged young. The major factors that decreased Broad-winged Hawk productivity occurred before hatching (38 eggs were lost compared to 20 young). I could not determine the cause of all egg and nestling losses, but I suspected mammalian predation of 4 eggs (2 nests) and of 6 nestlings (5 nests), and avian predation of 3 eggs (1 nest). Destruction of 2 nests by windstorms caused the loss of 2 eggs and 3 nestlings. My extended visit may have caused a female to desert another nest with 3 eggs. The incubating adult at 1 nest may have kicked 1 of 2 eggs out of the nest cup, as an ejected egg was found embedded within the nest structure. Fifteen (14 nests) of the 165 eggs laid, including 2 complete clutches, did not hatch for unknown reasons. The cause of loss of 10 eggs (6 nests) and 11 nestlings (10 nests) was unknown. Suspected predators of Broadwing nests were the Raccoon (*Procyon lotor*) and Common Crow (*Corvus brachyrhynchos*).

My study further supported the importance of both woodland openings and wet areas to Broadwing nesting habitat. Wisconsin productivity data provide some basis for understanding the popula-

tion dynamics of Broad-winged Hawks. However, the number of young produced in any one year that is necessary to maintain a stable population is a factor of the age structure and mortality rates of nesting adults (Henny and White 1972). Such data do not exist for the Broad-winged Hawk. Future studies should include long-term trapping and marking of breeding adults to determine age structure and turnover rate of nesting populations.

ACKNOWLEDGMENTS

This paper is based in part on a thesis submitted to the College of Natural Resources, University of Wisconsin-Stevens Point, in partial fulfillment of the requirements for the Master of Science degree. My graduate committee, R. Anderson, M. Fuller, and F. and F. Hamerstrom, greatly improved the manuscript by their suggestions. S. Postupalsky reviewed an earlier draft. R. Burton assisted with figure preparation. I am grateful to many field assistants, particularly L. Carson, M. Gratson, C. Harris, A. Kanvik, G. Kristensen, R. Murphy, and A. Rosenfield. D. Ledger provided field headquarters. I especially thank my wife, C. Rosenfield, for both her support and encouragement throughout this study.

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Received 15 July 1983; Accepted 31 May 1984

Anderson Award. The 2nd annual William C. Anderson Award for the best student paper was presented at the 1983 Raptor Research Foundation meeting in St. Louis, Missouri. The winner was Mr. Jim Duncan of the MacDonald Raptor Research Center, McGill University. Jim's paper was entitled "Mate Selection in Captive Kestrels: I. Siblings vs. Strangers."

Students wishing to be considered for the 1984 ANDERSON AWARD must indicate their eligibility when submitting abstracts. Eligibility criteria were published in *Raptor Research* 16(1):30-32. Questions regarding the 1984 award should be directed to: Dr. Robert Kennedy, Director, Raptor Information Center, National Wildlife Federation, 9412 16th Street, NW, Washington, D.C. 20036.

Attention RRF Members Past and Present!! The Raptor Research Foundation, Inc., is approaching its 20th Anniversary. In honor of this memorable occasion, I am compiling a twenty-year history of the Foundation to be presented in Sacramento at the 1985 annual meeting. In addition, plans are to compose a monograph detailing the Foundation's history from beginning to present. I request the assistance of you, the membership, both past and present, in accomplishing this task. Please contact me if you have any pertinent information in your files, such as photographs, correspondence, etc., that you would be willing to loan to me. All such material will be acknowledged in publications, of course, and I will make copies of the materials for my use and return the originals immediately. If you have anything you wish to contribute, please contact me as follows: Jimmie R. Parrish, Department of Zoology, 159 WIDB, Brigham Young University, Provo, Utah 84602, USA.

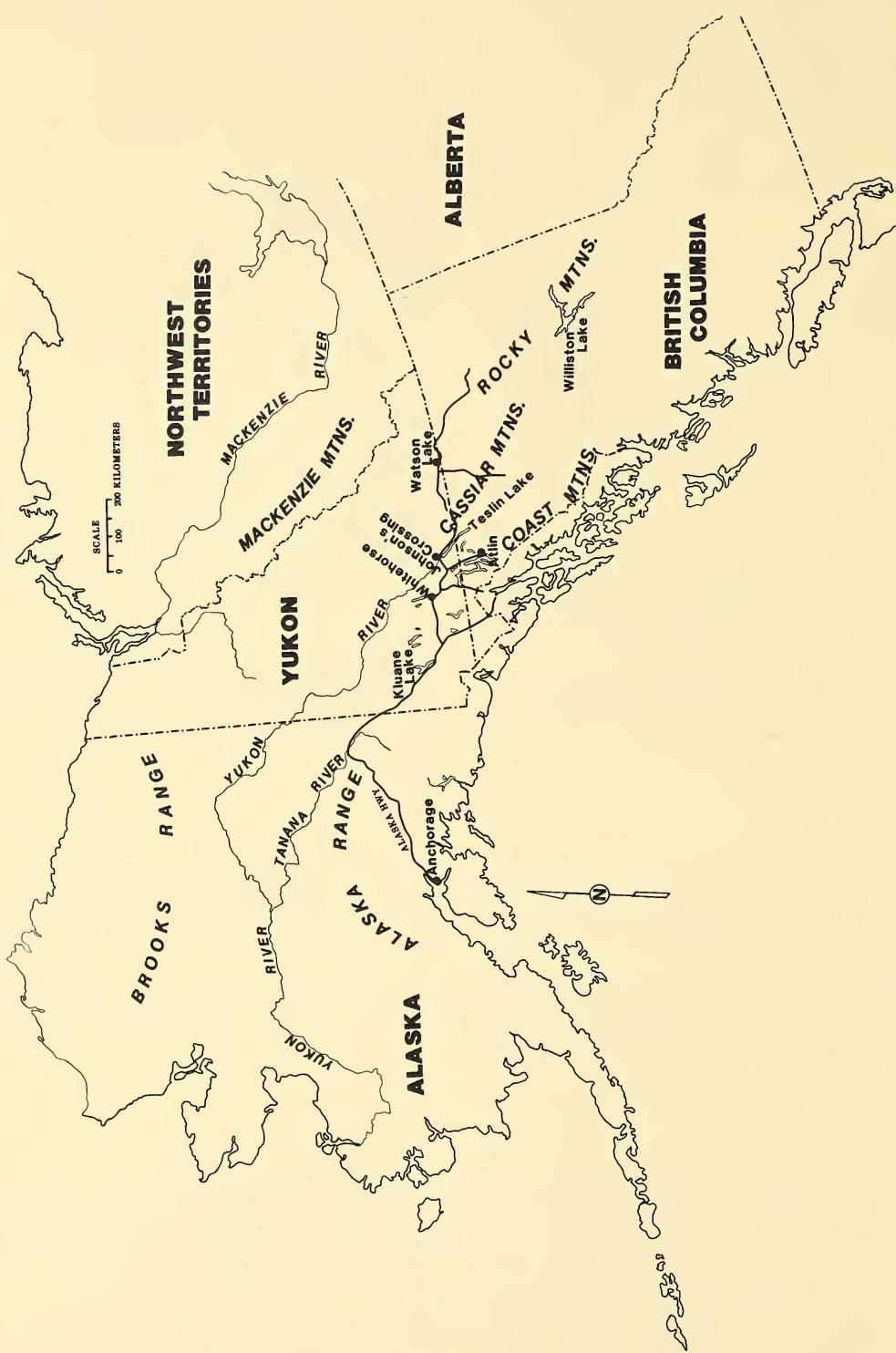


Figure 1. Map of Canadian and Alaskan observation sites visited during Spring 1982 raptor migration.

RAPTOR MIGRATION IN NORTHWESTERN CANADA AND EASTERN ALASKA, SPRING 1982

DAVID P. MINDELL AND MARGARET H. MINDELL

ABSTRACT - Searches for migrant raptors in northern British Columbia, southern Yukon Territory and eastern Alaska were made between 29 March and 29 April 1982 at locations accessible by road along 3 potential, broadfront, migratory routes. Migration activity occurred within an intermountain route, passing between the Rocky and Pelly Mountains on the east and Coast and St. Elias Mountains on the west. We saw no migrant raptors coming from a coastal route north over Chilkat or White passes, or coming from a Canadian prairie route, east of the Rocky Mountains, over the pass along the Alaska Highway in the Summit Lake vicinity. We found concentrations of migrant raptors along the Lina Range by Atlin Lake, British Columbia, and at Johnson's Crossing and in the Takhini River valley of southern Yukon Territory. Northern Harriers (*Circus cyaneus*) were most frequently seen, followed in decreasing order by Red-tailed Hawks (*Buteo jamaicensis*), Golden Eagles (*Aquila chrysaetos*), Rough-legged Hawks (*Buteo lagopus*), Bald Eagles (*Haliaeetus leucocephalus*), and Peregrine Falcons (*Falco peregrinus*). Comparison with other studies suggest that migrant buteos and Golden Eagles make greater use of an intermountain route through northwestern Canada than of a coastal route along the Gulf of Alaska, while migrant Sharp-shinned Hawks (*Accipiter striatus*) more frequently use the coastal route.

Migrating raptors seeking the most direct overland route to breeding areas in extreme northwestern North America are funneled into areas of northwestern British Columbia, southwestern Yukon Territory, southeast and southcentral Alaska. Movements of migrant raptors to and from Alaska and northwestern Canada have been little studied although tens of thousands of raptors pass through this region biannually.

The north-south oriented ranges of the Rocky, Cassiar and Coast Mountains along with the Pacific shoreline delineate 3 broadscale, potential migration routes (Fig. 1) described as follows: 1) Coastal - along the west coast of British Columbia, and southeast Alaska, then either inland over mountain passes or continuing northwest along the Alaska coast south of the Chugach Mountains into central Alaska via the Copper River drainage, Portage Pass or other overland routes; 2) Intermountain - through the intermountain trenches in northern British Columbia and southwestern Yukon Territory into the Yukon and Tanana River drainages; and 3) Canadian prairies - through Alberta and northeastern British Columbia east of the Rocky Mountains, then crossing the Rocky Mountains, and heading northwest through British Columbia and/or Yukon Territory similar to the intermountain route. These 3 principal routes, all or in part, have been described previously by West et al. (1968) as apparent routes for migrating Lapland Longspurs (*Calcarius lapponicus*).

Raptor migration is generally a broadfront passage, occurring to some degree over nearly all land regions of the temperate zone. The distribution of visible migrants, however, is not random, partly due to topographic features either discouraging or

inducing travel in a particular direction. Gauthreaux (1979) has pointed out that despite the prominence of migration in avian lifestyles, routes, rates and calendars of migration are known for few species aside from waterfowl. The purpose of this study was to learn about distribution of migrant raptors moving through northwestern Canada and eastern Alaska, to locate specific areas of migrant concentration for future study, and to learn about timing of regional migration.

STUDY AREA AND METHODS

Between 29 March and 29 April 1982, 3970 km were driven between Dease Lake on Rt. 37 in British Columbia, Summit Lake on Rt. 97 in British Columbia and Anchorage, Alaska. Observations were made in 3 potential, broadscale, raptor migration routes to compare their relative use. We attempted to observe in areas physiographically conducive to concentrating migrants, such as along major rivers, lakes, southeast to northwest trending ridges, and mountain passes. Observations were made from roads or within 3 km hiking distance of roads, using binoculars or a 20X spotting scope to search for and identify migrants. Some of the most promising areas were rechecked on 2-3 non-consecutive days to reduce bias associated with varying weather conditions. Once an area was perceived to be used, we moved to another location. No attempt was made to count large numbers of birds or to determine magnitude of the migration.

Raptor migration in interior western North America occurs along a broader front (Hoffman 1981, and in press) with smaller local concentrations of birds compared to eastern North America (Heintzelman 1975) and elsewhere (Smith 1980, Christensen et al. 1982). We use the term "route" to denote a broadscale, dispersed movement, and do not suggest that lack of sightings in any area indicates complete lack of use by migrants. We attempted to spend sufficient time at different locations in each of the 3 possible routes mentioned, to enable comparison of their relative use.

The possibility of migrants departing from the general coastal route by moving northward through Lynn Canal and then into

mainland areas was checked by observing at Haines (Lentnikof Cove, Flat Bay) and Chilkat and White Passes. The intermountain route was sampled by observing at numerous locations along the Alaska Highway between Watson and Kluane Lakes (Fig. 1) and along Rt. 3 to Haines, Rt. 2 to Carcross, and Rt. 7 to Atlin. The possibility of migrants crossing the Rocky Mountains along the route of the Alaska Highway was checked from lookouts in the vicinity of Muncho and Summit Lakes, British Columbia. We distinguished migrants from possible residents by behavior. Sedentary birds or birds moving south or east were not counted unless they were south of their breeding range (e.g., Rough-legged Hawks (*Buteo lagopus*)).

RESULTS AND DISCUSSION

ROUTE USE.—All migrant activity seen occurred within the intermountain route, passing between the Rocky Mountains on the east and the St. Elias and Coast Mountains on the west. No migrant raptors were seen coming from a coastal route north over Chilkat or White Passes or from east of the Rocky Mountains over the pass travelled by the Alaska Highway in the Summit Lake vicinity. Migrant Northern Harriers (*Circus cyaneus*), Red-tailed Hawks (*Buteo jamaicensis*), Rough-legged Hawks and Golden Eagles (*Aquila chrysaetos*) were seen in the intermountain route (Takhini River valley west of Whitehorse) before, during, and after observations at Summit Lake and Chilkat and White Passes (Table 1), suggesting that the lower abundance of migrants coming over the passes and at Summit Lake was not due only to timing of observations.

Migrants passing through southern Yukon Territory in mid-April were apparently approaching

from northwestern and northcentral British Columbia and the intermountain route rather than from a coastal or a Canadian prairies route through northeastern British Columbia. Late April weather conditions were still severe in Chilkat and White Passes and along the route of the Alaska Highway (Rt. 97) through the Rocky Mountains with 1 to 3 m of snow cover, whereas the Takhini River valley and much of the intermountain route were more temperate with some bare ground showing by late April. This is not to imply that no migration occurs through these passes or areas with snow cover. Several groups of 3-6 Sharp-shinned Hawks (*Accipiter striatus*) were seen heading south through Chilkat Pass on 7 October 1980. Weather in these mountain passes may be generally milder during the fall migration than during the spring, and use by migrants may be correlated with the difference.

On 27 and 28 March 1982 an apparent vanguard of the Canada Goose (*Branta canadensis*) migration (over 440 individuals) was seen resting along the last unfrozen sections of the Fraser River in central British Columbia, between Lac La Hache and Quesnel. Six Red-tailed Hawks were also seen 40 to 30 km south of Quesnel on 28 March 1982. No migrant raptors or geese were observed during the subsequent 7 days spent driving north to Watson Lake and observing in the area between Watson and Teslin Lakes. On this basis, it seems unlikely that large numbers of raptors passed through northwestern British Columbia or southwestern Yukon Territory before observations began.

Table 1. Observation sites, date, and total raptor sightings for Spring 1982 migration in northwestern Canada and Eastern Alaska. (B.C. = British Columbia; Y.T. = Yukon Territory.)

Location	Dates	No. migrant raptors seen
Summit Lake, B.C.	16-18 Apr	0
Johnson's Crossing, Y.T.	1, 14, 15, 19-21 Apr	73
Atlin Lake, B.C.	21-23 Apr	142
White Pass, B.C.	3, 24, 25 Apr.	0
Chilkat Pass, B.C.	8, 12, 13 Apr.	0
Haines area, Alaska ¹	9-12 Apr	0
Takhini River valley, Y.T.	5, 6, 13, 14, 26 Apr	53
Other ²	5-28 Apr	46

¹Lentnikof Cove, Flat Bay.

²<3 migrant raptors were seen at any one location, and all locations were within the intermountain route.

Based on physiographic features, 3 sub-routes can be distinguished within the broader intermountain route: 1) between the Rocky and Cassiar Mountains, entering Yukon Territory near Watson Lake, 2) between the Pelly and Cassiar Mountains and the St. Elias and Coast Mountains, entering Yukon Territory near Teslin, and 3) along the east slope of the Coast Mountains and Atlin or Tagish Lakes entering the Yukon River drainage near Whitehorse. Observed migrant activity was greater in sub-routes 2) and 3).

Recoveries of Alaskan banded birds show that at least some Peregrine Falcons (*Falco peregrinus*) (Ambrose et al. 1983) and Rough-legged Hawks (Kessel and Cade 1958) cross the Rocky Mountains, and many Alaskan breeding Red-tailed Hawks do so as well. Migrants cross the Rocky Mountains in many regions, however, Williston Lake west of Dawson Creek, British Columbia and the Jasper and Banff areas may be worthy of future study.

A coastal route through southeastern and south-central Alaska, along the Gulf of Alaska is used by many raptors based on observations by Islieb and Kessel (1973) and Swem (1982a, 1982b). Dates of migrant passage recorded by Swem (1982a) were such that if large numbers flew from the coastal migratory route north up Lynn Canal and over Chilkat or White Passes we would likely have seen some of them.

Specific Locations of Migrant Activity. — Within the intermountain route relatively high concentrations of migrants were found at 3 locations. On 22 April we counted 117 raptors in 6 hrs, flying north along the Lina Range on the east side of Atlin Lake, British Columbia. This included 65 Northern Harriers, 21 Golden Eagles, 18 Red-tailed Hawks, 8 *Buteo* sp., 4 Bald Eagles (*Haliaeetus leucocephalus*), and 1 Peregrine Falcon. The Lina Range rises 900 m above Atlin Lake, and most of the migrants were

observed from 300 m above the range to half-way down the slope.

At Johnson's Crossing, Yukon Territory we counted 73 raptors during 15.2 total hrs of observation during portions of 5 days between 14 and 21 April. Johnson's Crossing is at the outlet of Teslin Lake, a northwest trending lake approximately 80 km northeast of Atlin Lake. In descending order of abundance the migrants were: Red-tailed Hawks, Northern Harriers, *Buteo* sp., Rough-legged Hawks and Golden and Bald Eagles.

On 13 and 14 April 23 migrants were seen during 5.5 hrs of slow driving and observation in the Takhini River valley, 10 to 50 km west of Whitehorse. The Takhini River valley receives migrants that have come northwest along Teslin Lake, Atlin Lake, and Tagish Lake (intermountain route). The Takhini River valley is broad, however, we saw raptors from observation spots on Rt. 1, 3 km east of Champagne, 2 km east of the Kusawa Lake turnoff and at the Takhini River Crossing. We saw a total of 10 migrants during fast travel through the Takhini River valley on 5 and 26 April. Migrants proceeding through the intermountain route could pass along Kluane Lake, however, our observations there were after the bulk of the Northern Harrier and *Buteo* migrations had passed. We saw only a few migrants along the Tagish River at Tagish, Yukon Territory, and the Tanana River near Tetlin Junction, Alaska.

Species Abundances. — The Northern Harrier was the most frequently seen migrant (Table 2). At each of the 3 main areas of migrant activity, either the Northern Harrier or the 2 buteos as a group were most abundant. The largest flight of Northern Harriers and Golden Eagles was seen along Atlin Lake (Lina Range), while the largest flights of Red-tailed and Rough-legged Hawks were seen at Johnson's Crossing.

Table 2. Species percentages of migrant raptors (n=314) seen in northwestern Canada and eastern Alaska 5-18 April 1982.

	Red-tailed Hawk	Rough-legged Hawk	Northern Harrier	Golden Eagle	Bald Eagle	Peregrine Falcon
% of total sightings	29.1	9.4	40.2	15.7	5.2	0.4

Comparing our study with another conducted during the spring of 1982 along the Gulf of Alaska coast at Sitkagi Beach, west of Yakutat Bay (Swem 1982a), the Northern Harrier was the most abundant species along both the intermountain route and the coastal route passing Sitkagi Beach. Sharp-shinned Hawks, however, were the second most abundant species along the coastal route (26.5% of total) while none were seen in the intermountain route. Rough-legged and Red-tailed Hawks combined accounted for only 1.8% of the total sightings along the Gulf of Alaska at Sitkagi Beach, compared to 38.5% in the intermountain route. Golden Eagles were also comparatively rare along the coastal route, comprising 0.4% of total sightings, compared to 15.7% in the intermountain route.

Greater use of the coastal route by migrant Sharp-shinned Hawks and greater use of the intermountain route by migrant buteos and Golden Eagles is supported by Swarth (1924, and 1926) who found that Sharp-shinned Hawks were "never common in the Atlin, British Columbia region, not even in the fall after southward migration had begun", and by Islieb and Kessel (1973) who described Rough-legged Hawks and Golden Eagles as rare migrants, Red-tailed Hawks as casual migrants and Sharp-shinned Hawks as fairly common migrants along the Gulf of Alaska and in the Prince William Sound region. Swarth did observe migrating Sharp-shinned Hawks at Hazelton in the Skeena River valley of westcentral British Columbia, although hawks in this area may have been headed for the coast. A tendency for Sharp-shinned Hawks to migrate in greater numbers along the Pacific coast or along the southern edge of the boreal forest might help to explain the relative scarcity of migrant Sharp-shinned Hawks in inland western North America compared to inland sites in eastern North America such as Hawk Mountain, Pennsylvania, as suggested by Hoffman (in press).

Islieb and Kessel (1973) also described Red-tailed Hawks as regular fall migrants in southcentral Alaska along the Glenn Highway between King and Sheep Mountains in late September and early October. This corresponds with fall migration observations we made along the Glenn Highway in 1980 and 1981, and with observations by Bob Dittrick (pers. comm.).

Peregrines represented 0.8% of the sightings along the Gulf of Alaska, and 0.4% in the intermountain route. Swarth (1926) also saw migrant Peregrines within the intermountain route at

Tagish and Teslin Lakes. On the east side of the Rocky Mountains migrant Peregrines are consistently observed in spring passing through the Edmonton, Alberta region (Dekker 1979). The observed fall passage there is considerably less, suggesting seasonal difference in distribution of migrant Peregrines. Although no migrant Merlin (*Falco columbarius*) were seen during our study they have been seen both along the coastal route (Swem 1982a) and within the intermountain route (Swarth 1924, and 1926).

Chronology. — The first migrant Rough-legged Hawks, Red-tailed Hawks and Golden Eagles were all seen on 5 April in 1982. The first Northern Harriers were not seen until 14 April. Similarity in timing of migration for Rough-legged and Red-tailed Hawks is reflected in similar breeding chronologies in portions of Alaska (Gabrielson and Lincoln 1959, Mindell 1983).

Although the present study was not designed to determine timing of peak migration, the main migration of buteos in the intermountain route through southwestern Yukon Territory and northwestern British Columbia appeared to be over by 25 April, while some Northern Harriers were still passing through. This corresponds with average laying dates over a 4-yr period of 17 May for Rough-legged Hawks and 16 May for Red-tailed Hawks along the Kuskokwim River in western Alaska (Mindell 1983). On 23 April 1982 we observed a Red-tailed Hawk nest building at Tarfu Lake near the northern end of Atlin Lake. Swem (1982a) found the peak abundance of migrating raptors passing Sitkagi Beach near Yakutat Bay to be on 28 April, with stragglers of 7 species going by as late as 8 May.

ACKNOWLEDGEMENTS

We thank Mark Fuller for providing helpful comments on an earlier draft of this paper.

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Received 2 December 1982; Accepted 1 May 1983

Position Available — NATURALIST/STAFF BIOLOGIST. Hawk Mountain Sanctuary Association seeks a naturalist/staff biologist for a two-year position beginning in August 1984. Responsible for all field studies, including fall raptor migration count. Will also participate as resource person in education program. Excellent opportunity to initiate new studies and analyze migration statistics. Computer system available. Minimum qualifications are M.S. in biology or related field, experience in conducting field studies and data analysis/write-up, experience with raptor identification, and ability and interest in working with volunteers and general public. Computer experience strongly preferred. Salary plus housing on grounds. **APPLY TO STANLEY E. SENNER, EXECUTIVE DIRECTOR, HAWK MOUNTAIN SANCTUARY ASSOCIATION, RT. 2, KEMPTON, PA 19529.**

Hawk Mountain Research Awards. The Hawk Mountain Sanctuary Association is accepting applications for its eighth annual award for raptor research. To apply for the \$500 award, students should submit a description of their research program, a curriculum vita, and 2 letters of recommendation by 30 September 1984, to James J. Brett, Curator, Hawk Mountain Sanctuary, Rt. 2, Kempton, Pennsylvania 19529. The Association's Board of Directors will make a final decision late in 1984. Only students enrolled in a degree-granting institution are eligible. Both undergraduate and graduate students are invited to apply. The award will be granted on the basis of a project's potential to improve understanding of raptor biology and its ultimate relevance to conservation of North American raptor populations.

THE EFFECT OF MINING AND BLASTING ON BREEDING PRAIRIE FALCON (*Falco mexicanus*) OCCUPANCY IN THE CABALLO MOUNTAINS, NEW MEXICO

JAMES C. BEDNARZ

ABSTRACT - I surveyed 3 small isolated mountain ranges in southcentral New Mexico for the presence of breeding Prairie Falcons (*Falco mexicanus*). Of these, the Caballo Mountains were intensively impacted by mining and blasting activity, while the other 2 were essentially undisturbed. No falcons were found in the disturbed mountain range, but a total of 8 nests were documented in the 2 control ranges. The 3 areas were extremely similar in all respects except for the number of mining claims.

Almost no published information is available concerning the impacts of mining and blasting on birds of prey. The limited data available are restricted to observation of short-term impacts on actively nesting raptors (Stahlecker and Alldredge 1976). Several works (Allen 1979, Call 1979, Becker and Ball 1981) contain speculation about the impending impacts of mining operations on raptors and offer suggestions to minimize potentially adverse effects. Follow-up or controlled experimental studies of such impacts are virtually nonexistent.

Herein I report the numbers of breeding Prairie Falcons observed during a survey of 3 small and very similar mountain ranges in southcentral New Mexico. One of these ranges, the Caballo Mountains, has been intensively impacted by mining operations and associated human intrusions for several years. The other 2, the Fra Cristobal and Florida mountains, have minimal or no disturbance from mining. If mining and the associated blasting has no influence on Prairie Falcon nest occupancy, I would expect the numbers of breeding falcons at all 3 study areas to be similar. The habitat and number of cliffs at all 3 mountain ranges seems comparable.

STUDY AREAS AND METHODS

I surveyed the Fra Cristobal Mountains on 15-18 April and 19-23 May 1980, the Florida Mountains on 21-25 April 1980, and the Caballo Mountains on 5-9 May 1980. These ranges were searched for raptors as part of a larger statewide survey with emphasis on endangered raptors on lands administered by the Bureau of Land Management (BLM). These 3 ranges are isolated, but located in relatively close proximity (Fig. 1). The climate of all 3 ranges is similar; all are extremely dry with summer daytime temp often exceeding 38°C and winter temp commonly dropping below 0°C at night. The vegetation in all 3 study areas can be characterized as creosote bush (*Larrea tridentata*) dominated shrubland on the lower slopes grading into a sparse juniper-oak (*Juniperus* spp.; *Quercus* spp.) woodland on the summits and upper, north-facing slopes (Table 1). Elements of Chihuahuan desert vegetation (e.g. *Prosopis glandulosa*, *Yucca* spp., *Opuntia* spp.) are more common in the Florida Mountains. Suitable cliff habitat, elevation and topographic relief above basins are comparable for all 3 study areas (Table 1). Area of suitable cliff habitat (Table 1)

includes only that contiguous mountain habitat that contains cliffs potentially usable as nest sites. Foothill habitats without cliffs surrounding mountain ranges were not included in this area measurement.

Geologically, the Fra Cristobal and the Caballo mountains are nearly identical, consisting primarily of marine sedimentary rock resulting from an uplift along the Rio Grande Rift (Kelly and Silver 1952). The Florida Mountains differ in this respect as they are of a rhyolitic formation.

Field surveys in all 3 areas emphasized the most prominent cliffs, which in my experience are preferred by Prairie Falcons for nest sites. I have found that cliffs < 50 m in height are generally used only in New Mexico when larger cliffs are not available. During this study I examined numerous smaller cliffs (< 50 m in height) but none contained active Prairie Falcon nests. Surveys were accomplished by climbing to an observation point that allowed observation of 1 or more large cliffs (> 50 m of vertical or near vertical rock). I studied cliffs for falcon-like excrement ("whitewash") with binoculars and spotting scope and watched for falcon activity for periods of several hours as outlined by Bond et al. (1977) and Call (1978). Cliff observations were made in the early morning or late afternoon. After cliffs were watched for at least 2 h without success, I approached from below and attempted to disturb (by shouting and clapping hands) any previously unobserved raptor. Observations were discontinued at cliff sites when nests of the Golden Eagle (*Aquila chrysaetos*) or Prairie Falcon were located. Field examinations in all areas were conducted when falcons were expected to be incubating or possibly tending small young.

Accessibility of mountain ranges differed considerably. The Caballo range had numerous roads on talus slopes providing easy access to excellent observation perches close to prominent cliffs. On the other hand, the Fra Cristobal range was extremely remote and almost no roads approach the foothills. Although I spent nearly twice as many field days in this area, most of the additional time was used in travel. Access roads circled around the Florida Mountains, but generally stopped at the base of the talus. Search and observation effort at all 3 ranges was comparable (Table 2).

RESULTS AND DISCUSSION

I located 5 active Prairie Falcon nests in the Florida range and 3 active sites in the Fra Cristobal range (Table 2). No nests or large falcons were observed in the Caballo Mountains. I also found 2 Golden Eagle nests in the Fra Cristobal range. In all observable physical and ecological characteristics, except for the intensity of mining, the 3 mountain

Table 1. Characteristics of 3 mountain study areas in southcentral New Mexico.

	Fra Cristobal Mountains	Caballo Mountains	Florida Mountains
Approx. area of suitable cliff habitat (km ²)	36	26	34
Maximum elevation (m)	2083	2301	2270
Elevation relief above basin (m)	730	1000	915
Primary rock type	marine sedimentary	marine sedimentary	rhyolite
Dominant vegetation community on slopes	creosote shrubland	creosote shrubland	creosote-mesquite shrubland
Dominant vegetation community at summit	juniper-oak woodland	juniper-oak woodland	juniper-oak woodland

ranges appeared to be extremely similar (Tables 1 and 2).

The area I surveyed (26 km²) in the Caballo Mountains contained 125 active mining claims (mining claim records dt 21 June 1980, BLM State Office, Santa Fe, New Mexico). I witnessed blasting

during 1 of my 5 field survey days in this area. Numerous shallow shafts were blasted into rock walls and talus slopes throughout the range. These blast shafts were concentrated at or just above the base of both large and small cliffs examined. In addition, several ladders were bolted to the vertical

Table 2. Results of field survey for Prairie Falcon nests and active mining claims in 3 mountain study areas in southcentral New Mexico.

	Fra Cristobal Mountains	Caballo Mountains	Florida Mountains
Field days	9	5	5
Cliff observation (time h)	25.9	25.0	25.0
# of major cliffs examined (> 50 m in height)	10	8	9
# of major cliffs not examined (> 50 m in height)	3	3	4
# nests located	3	0	5
Mining claims recorded at BLM office	0	125	29
Mining activity observed	none	intense	none

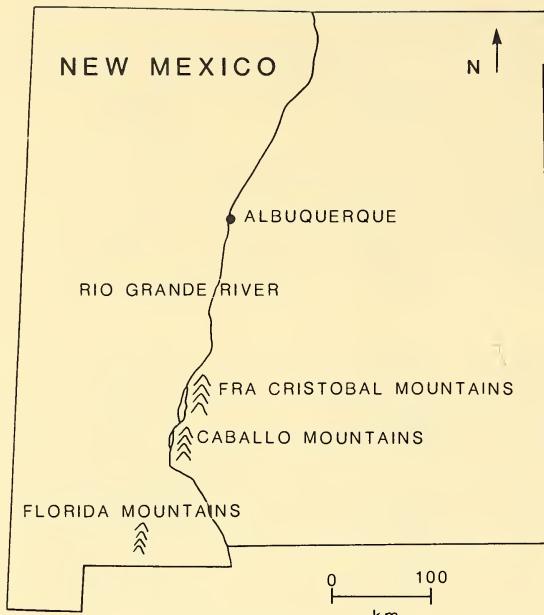


Fig. 1. Location of 3 mountain study areas in southcentral New Mexico.

rock walls and 2 compressors were parked high on the talus slopes adjacent to cliffs.

In the Florida Mountains, with 29 mining claims in the area surveyed (34 km^2), I observed no evidence of active mining. I did note 1 probable mining road leading up the talus slope on the north side of the mountain range. No evidence of mining activity was observed in the Fra Cristobal range.

The absence of nesting Prairie Falcons from the Caballo range was an unexpected finding. Prominent cliffs in the 2 control study areas provided habitat for 8 pairs of breeding falcons. Evidence of mining activity and related human disturbance was obvious in the Caballo Mountains, but minimal in the 2 control ranges.

Breeding falcons may have occurred in the Caballo Mountains in 1980, but if so, they must have occupied the smaller, less preferred cliffs. Given that I did not observe any Prairie Falcons, during the field survey, I suspect that few, if any, breeding falcons were present. No historical data on raptor breeding populations are available for any of the 3 ranges surveyed.

A possible alternative explanation is that low numbers of available prey made the Caballo range unsuitable as falcon breeding habitat in 1980. I feel,

however, this is unlikely because the Fra Cristobal Range 30 km to the north and the Florida range 90 km to the south provided enough prey to support at least 8 pairs. The vegetative cover in the vicinity of all ranges was extremely similar in all appearances. An absence of Prairie Falcons from the Caballo Mountains could only be caused by an extreme depression in prey populations in a very localized area around these mountains, which seems highly improbable.

The Florida Mountains were used by almost twice as many falcon pairs (5 vs 3) as the Fra Cristobal Mountains. This difference may be due to the dispersion of cliffs in the respective ranges. Prominent cliffs in the Florida range were uniformly distributed along the west face, whereas in the Fra Cristobal range, cliffs were aggregated in 2 relatively small parts of the range (1 aggregation in the north portion and the other in the south). The uniform cliff dispersion probably enables more falcons to use a small mountain range without intruding into defended areas around neighboring eyries. The cliffs in the Caballo range are distributed in a manner similar to that found in the Florida Mountains. Therefore, I would expect to find between 3-5 Prairie Falcon nests if the Caballo Mountains were undisturbed.

All raptors have individual differences in the amount of disturbance that will be endured. I am aware of 1 case in Wyoming where a pair of Prairie Falcons tolerated intensive coal mining activity including blasting, heavy equipment operation, and settling pond construction within 75 m of the nest (S. Platt, pers. comm.). Falcons returned to the same general area for 3 consecutive years (1981-1983) following the disturbance. These birds were not successful in producing young in any of the years monitored, but adverse weather conditions may have been a factor (S. Platt, pers. comm.). In this case the primary disturbance was limited to 1 breeding season and was apparently of similar intensity throughout the disturbance period. Tolerant falcons may more readily habituate to a steady, predictable intensity of disturbance. In contrast, mining and blasting activity in the impacted range surveyed during this study was probably of a highly variable and unpredictable nature.

Blasting and mining operations in the Caballo Mountains are primarily the endeavors of individual prospectors or small part-time mining partnerships. One larger corporation was mining barite at the time of my survey, but this mining was

in the foothills >3 km from the area of suitable nesting cliffs. Since the climate in this area is relatively mild and there are no restrictions on blasting, I assume that all active claims are worked periodically throughout the year. All mining in the survey area seemed to be on a part-time basis. Placer gold was probably the principle mineral that was being extracted. Also, much of the mining activity is suspected to be treasure hunting in search of legendary "Spanish gold" thought to be hidden in the Caballo Mountains (T. Custer, BLM Geologist, White Sands Resource Area; pers. comm.). Treasure hunters may pursue their hobby under the facade of a mining claim which allows them to legally blast natural cliff faces. The combination of mining and treasure hunting has resulted in an extremely high intensity of blasting in the Caballo Mountains.

In conclusion, I believe the data presented here suggest that there is a difference in Prairie Falcon nest occupancy between the Caballo Mountains and the 2 control ranges most likely due to blasting and mining or associated human activities. To my knowledge, no study has examined the long-term effects of mining or blasting on occupancy of raptor nest sites, but short-term impacts have been documented (Stahlecker and Alldredge 1976). Ellis (1981), based on a 2 y study of simulated sonic boom noise, implied that both adverse short-term and long-term impacts of such activities were probably negligible on nesting raptors. My results indicate that this conclusion cannot be extended to more intensive blasting and mining activities, and I urge further observation, and particularly, controlled experimental studies to address the long-term impacts of such disturbances on breeding raptors.

ACKNOWLEDGEMENTS

I thank Gregory Schmitt, Marshall C. Conway, and John P. Hubbard for providing encouragement during the course of field surveys. Pat L. Kennedy, George Anne Thibodeau, Buck Cully, Dale W. Stahlecker, and John P. Hubbard thoroughly reviewed earlier drafts. Steve Platt shared with me some of his data and thoughts on the impacts of mining on raptors. Mr. Joe Williams, Mr. Crawford, and other ranchers gave me permission to enter and camp on their land. This work was supported by the Bureau of Land Management and the New Mexico Department of Game and Fish, Endangered Species Program.

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Received 17 December 1983; Accepted 27 April 1984

RESULTS OF A HELICOPTER SURVEY OF CLIFF NESTING RAPTORS IN A DEEP CANYON IN SOUTHERN IDAHO

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ABSTRACT - In 1980 a helicopter survey of cliff nesting raptors was conducted along Salmon Falls Creek, a deep canyon in southern Idaho. The most numerous species recorded was the Red-tailed Hawk (*Buteo jamaicensis*) followed by the Golden Eagle (*Aquila chrysaetos*), Prairie Falcon (*Falco mexicanus*), and Common Raven (*Corvus corax*). Great Horned Owls (*Bubo virginianus*), Barn Owls (*Tyto alba*), and Turkey Vultures (*Cathartes aura*) were recorded when they flushed from cliff faces. Numbers of Prairie Falcon nests and Barn Owls flushed may have been related to land use practices near the canyon. Inter-nest distances, productivity, nest exposure and the behavioral response of nesting adults are presented for the 4 principle nesting raptors. A comparison of the results of a simultaneous boat survey revealed that the helicopter survey was faster and more accurate in determining total active and inactive nests.

Nesting densities of raptors in the intermountain west have been determined for several locations (Platt 1971, Smith and Murphy 1973, Howard et al. 1976, Seibert et al. 1976, Thurow et al. 1980). However, except in the Snake River Birds of Prey Area (BPSA), few nesting surveys have been conducted in deep canyons in this region (USDI 1979a). The data reported herein were gathered in 1980 during a helicopter survey of Salmon Falls Creek, a deep canyon in southern Idaho.

STUDY AREA AND METHODS

The northern part of Salmon Falls Creek flows for approximately 103 km from the Nevada border north to its confluence with the Snake River in Idaho. The creek is small with a mean daily flow in water-year 1980 of 4.59 m³/sec (provisional information from the U.S. Geological Survey, Boise, Idaho). The area around the creek is cool desert (Odum 1971) dominated by shrubs where native vegetation remains. Native habitat has largely been replaced by introduced grass seedings (primarily *Agropyron cristatum*) or agriculture over large portions of the study area.

The study area was divided into 4 segments based on vegetation and physiographic features, and distances (creek-km) were measured beginning at the Nevada border. The southernmost segment (1) is characterized by a meandering stream and a 20 km long reservoir contained within a relatively shallow (50 ± 11 m) cliff-lined boundary. It is surrounded by *Artemesia arbuscula*/grass seedings. The Salmon Falls Creek Dam marks the northern end of segment 1. Beginning at the dam, the creek flows through a deep (145 ± 26 m) gorge to creek-km 62 (segment 2) and is surrounded predominantly by *Artemesia tridentata*/grass seedings to at least 3.5 km away from its rim. In the succeeding segment (3) the vegetation bordering the east side of the creek is agriculture, while the west side is covered with *A. tridentata*/grass seedings. The final segment (4) begins at creek-km 81 and is bordered on the east predominantly by agriculture and on the west by a mixture of *A. tridentata*/grass seedings and agriculture.

In 1980 from 28-30 May and on 5 June we flew in a Hiller 12E helicopter for about 16 h inventorying cliff nesting raptors in the gorge. Nesting data were collected on all raptor species except American Kestrels (*Falco sparverius*). Nest location, status (an active nest was one where adults or young were present or which obviously had recently fledged young), estimated exposure, and the behavior of adults toward the helicopter were recorded. To

minimize flight time and disturbance to raptors, nest parameters were not recorded for every inactive nest, and we did not tarry at active nest sites if we were unable to count nestlings immediately.

Because cavity nests are difficult to find, we did not attempt to determine nest sites of Barn Owls, Great Horned Owls, or Turkey Vultures, but did record them when we flushed these birds from cliffs. Nests of Prairie Falcons were recorded when adults were flushed near a pothole or ledge (usually with white-wash beneath it), when young were observed, or when adult(s) defended against the helicopter.

Nest site characteristics and distances between nests were measured on topographic maps, and nest elevations were determined on maps at a point on the canyon rim above the nest. It should be noted that when 2 nests were close together and neither was close to another, the effect on our data was to double the inter-nest distance in calculation of the mean. Because we recorded nest exposure in 16 directions our sample size was too small for statistical analysis. Therefore, we lumped this information into 4 general directions to increase sample size.

Gross vegetational patterns were determined by placing a grid of 144 randomly selected spots (after Marcum and Loftsgaarden 1980) on aerial photographs of the study area in each major vegetation type. The percents of spots falling on: 1) agriculture, 2) *A. tridentata*/grass seeding, 3) *A. arbuscula*/grass seeding, and 4) other (roads, canyon, water) were then calculated. The grid used to select the 144 random spots covered a square area (approximately 92.16 km²), the corners of which (farthest random point possible) were about 6.8 km from the center of the canyon.

RESULTS AND DISCUSSION

Nesting Density. — The most numerous nesting raptors in the canyon were Red-tailed Hawks, Golden Eagles, Prairie Falcons, and Common Ravens (Table 1). A comparison with the BPSA reveals that Salmon Falls Creek is an area of lower raptor density. The diversity of nesting raptors is also lower since no Ferruginous Hawks (*Buteo regalis*) were found nesting on cliffs in Salmon Falls Creek (Table 2). The density of nesting raptors in Salmon Falls Creek is, however, larger than reported for the Rio Grande River Gorge (Ponton 1980).

Table 1. Distribution of Raptor Nests/km (N), RaptorsFlushed/km (F) and Vegetational Coverage in Salmon Falls Creek, Idaho.

Segment	Golden Eagle (N)	Prairie Falcon(N)	Red-Tailed Hawk(N)	Common Raven(N)	Great-Horned Owl(F)	Barn Owl(F)	Turkey Vulture(F)	Estimated Vegetational Cover			
								Agriculture	Artemesia tridentata/seedings	Artemesia arbuscula/seedings	Other
1	0.13	0.7*	0.13	0.13	0.10	0.00*	0.03	0%	0%	88%	12%
2	0.28	0.27*	0.15	0.12	0.09	0.00*	0.00	0%	92%	0%	8%
3	0.21	0.31*	0.31	0.16	0.21	0.16*	0.00	29%	61%	0%	10%
4	0.10	0.05*	0.33	0.05	0.14	0.19*	0.00	70%	21%	0%	9%
Total	0.18	0.17	0.21	0.12	0.13	0.07	0.01				
Total Observations:	19	18	22	12	13	7	1				

*Statistical significance ($P < 0.05$), χ^2 test.

There were more active eagle nests in the parts of the canyon bordered by *A. tridentata*/grass seedings, but more Red-tailed Hawk nests in the part of the canyon bordered by agricultural lands, although neither were significantly higher ($P > 0.05$). An important prey of Golden Eagles near our study area is the Black-tailed Jack Rabbit (*Lepus californicus*) (Seibert et al. 1976, USDI 1979a), a lagomorph that is dependent upon native sagebrush communities (USDI 1979a) like those in segments 2 and 3. Red-tailed Hawks, on the other hand, are a more diverse feeder and may be better able to utilize areas of the canyon bordered by agriculture.

There was a significant difference in the number of Prairie Falcon nests and Barn Owls flushed in different segments of the creek. Prairie Falcons

were noted more frequently in areas bordered by *A. tridentata*/grass seedings than in parts bordered by *A. arbuscula*/grass seedings or agriculture. Barn Owls on the other hand, were flushed from the canyon walls only in segments bordered by agricultural lands. These results may reflect a response to some environmental factor, such as climate, since segment 1 is higher and cooler than segment 4. However, Prairie Falcons feed on small mammals which can be adversely affected by agriculture (USDI 1979a), while Barn Owls may prefer nest sites near agricultural lands (USDI 1979b). There was no significant difference in the numbers of Great Horned Owls and Turkey Vultures flushed or Common Raven nests and vacant stick nests seen in different segments of the canyon.

Inter-nest distances. — Distances between con-

Table 2. A Comparison of Nesting Density (Nests/km) of Selected Raptors and Total Raptor Diversity Among 3 River Gorges in the western United States.

	Salmon Falls Creek Idaho	Snake River Birds of Prey Study Area Idaho	Rio Grande Gorge Colorado and New Mexico
Golden Eagle	0.18	0.19	0.04
Prairie Falcon	0.17	1.32	0.10
Red-tailed Hawk	0.21	0.37	0.18
Common Raven	0.12	0.76	0.12
Total	0.68	2.64	0.44
# of species found	9	10	5

Table 3. Straight-Line Inter-nest Distances in Km of Adjacent Conspecific Raptor Nests in Salmon Falls Creek, Idaho, and Average Inter-nest Distances in Km for Adjacent Conspecifics in the Snake River Birds of Prey Study Area Over 8 years (After USDI 1979a).

	Salmon Falls Creek $\bar{x} \pm S.D.$ (min.)	BPSA Inter-nest distance (smallest min.)
Golden Eagle	4.39 ± 2.3(1.56)	3.46(0.97)
Prairie Falcon	4.13 ± 3.7(0.58)	0.65(0.09)
Red-tailed Hawk	3.91 ± 3.0(0.32)	2.08(0.35)
Common Raven	7.48 ± 7.3(0.10)	Not recorded

specific nests were variable (Table 3). Mean and min. inter-nest distances, especially for Prairie Falcons, are larger than observed in the BPSA and reflect the difference in raptor densities of the 2 areas (USDI 1979a). It should be noted that because the Snake River Canyon is comparatively wide, territorial spacing of raptors along the canyon is probably minimized.

The greatest mean conspecific inter-nest distance in our study area was among Common Raven nests. Ravens also showed the smallest min. nesting distance (0.1/km) of any conspecific nesting pair, perhaps reflecting weak intraspecific territoriality in ravens as noted by Knight and Call (1980). Common Ravens also nested close to Red-tailed Hawks and Prairie Falcons (Table 4). Close nesting of ravens to raptors has been noted elsewhere, hypothesizing a commensal relationship (Knight and Call 1980). Golden Eagles displayed the greatest \bar{x} distances to their nearest neighbors in Salmon Falls Creek.

Productivity. — We recorded the number of young (most were late nestlings) in nests of 2 species. The mean number of young in 16 Golden Eagle nests was 1.94 ± 0.68 (range 1-3) which is comparable to the mean number of young fledged per successful nesting attempt (1.62) of Golden Eagles in the BPSA and comparison area (USDI 1979a). We observed a mean of 2.79 ± 0.79 (range 2-4) young for 19 Red-tailed Hawk nests. A similar figure (# of young fledged-successful nesting attempt = 2.70) has been noted in the BPSA (USDI 1979a).

Nest Exposure. — Nest exposures for all active and many vacant stick nests are contained in Table 5. The 2 rows of data resulted when we arbitrarily lumped the observed 16 exposures into quadrants which correspond nearly to NW, NE, SE, SW and then rotated the boundaries of our quadrants 45° so that the easterly and northeasterly exposures were not divided.

In the first treatment of the data, nests were oriented significantly more to the quadrant bet-

Table 4. Inter-nest Distances (\bar{x} km + S.D.) of nearest neighboring raptor nests in Salmon Falls Creek, Idaho.

Species:	Golden Eagle	Red-tailed Hawk	Prairie Falcon	Common Raven
Nearest Neighbors:				
Golden Eagle	0	1.46 ± 0.80 N = 4	1.06 ± 0.54 N = 5	1.68 ± 0.73 N = 4
Prairie Falcon	0.75 ± 0.17 N = 7	0.73 ± 0.51 N = 6	0.73 ± 0.25 N = 2	0.35 N = 1
Red Tailed Hawk	1.53 ± 0.77 N = 8	0.84 ± 0.45 N = 6	0.75 ± 0.55 N = 8	0.58 ± 0.32 N = 5
Common Raven	0.18 ± 0.63 N = 4	0.48 ± 0.32 N = 6	0.75 ± 0.38 N = 3	0.10 N = 2

Table 5. Exposures of Active and Inactive Stick Nests in 4 Segments of Salmon Falls Creek as Determined by 2 arbitrary analyses.

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Segment 1		Segment 2		Segment 3		Segment 4	
N	NNE	N	NNE	N	NNE	N	NNE
8	5	6	10	4	9	7	13
17*	8	12	10	8	4	6	13
8	NE ENE	7	NE ENE	7	NE ENE	4	NE ENE
10	7	5	13	7	7	8	19*
13		13		4		8	

*Statistically significant ($P = 0.05$), Chi-square test.

ween south and west-northwest in segment 1. Therefore, it appears that the Red-tailed Hawks and Golden Eagles, which built most of these nests, oriented them in a southwesterly direction. When the quadrant boundaries were rotated, a significant number of nests in segment 4, the lowest part of the canyon (elevations in segment 4 are about 500 m lower than in segment 1) are oriented nearly to the east. This may indicate that nest exposure and elevation (and thus temp) are related in Salmon Falls Creek. Seibert et al. (1976) found that Golden Eagles in northern Nevada avoided building nests with a northern exposure in a significant number of cases. Similarly, Mosher and White (1976) have shown that exposure of Golden Eagle nests at higher elevations, or in more northerly latitudes, are exposed to the south, while the reverse is true for nests at lower elevations, or in southerly latitudes.

Behavioral Response to the Helicopter. — Behavioral responses were observed at 29 Golden Eagle, Red-tailed Hawk, and Prairie Falcon nests. No adults were seen at the remaining 30 active nests.

We observed Golden Eagles near active nest sites on 6 occasions, always perching almost motionless while watching the helicopter pass-by. Page and Seibert (1973) have reported similar behavior in nesting Golden Eagles. Prairie Falcons, by contrast, flew about the helicopter calling 9 times (we could see their mouths open and close) or on 6 occasions flushed from the cliff and flew away. Once we observed Prairie Falcons near a nest diving on a Black-billed Magpie (*Pica pica*) perched well away from the cliff. This activity may have been redirected behavior (Wallace 1979) induced by our presence. Red-tailed Hawks exhibited the greatest variability in their responses to the helicopter.

Adults either defended by circling and calling (once), perched near the nest and watched the helicopter (on 4 occasions) or sat tightly on the nest (on 3 occasions). The latter response may have occurred due to adults still brooding young, since Carrier and Melquist (1976) observed a similar response to helicopters by incubating Osprey (*Pandion haliaetus*). Lee (1980) found that most raptors which were perched or nesting on transmission towers were tolerant of a helicopter used in nest surveys, although some Red-tailed Hawks tried to attack the helicopter as it approached their nest site. He also noted that birds which were on nests containing eggs or young remained on the nest when the helicopter flew past.

The Helicopter Survey and a Boat Survey Compared. — Two other biologists surveyed Salmon Falls Creek Reservoir by boat (Alan Sands and Sam Mattise, pers. comm.) while we surveyed the reservoir by helicopter. In addition to being a faster technique, other advantages of the helicopter in raptor surveys are reflected in comparison of survey results. We observed 40 active and inactive raptor nests from the helicopter, while from the boat only 31 were noted. Five different locations were thought to be possible Prairie Falcon nests by the boat survey team because of the presence of white-wash. From the helicopter these were found to be either perches or stick nests not visible from the boat due to the low angle of observation. The same 3 Red-tailed Hawk nests and 3 Golden Eagle nests were found by both survey techniques, but the boat surveyors mistook an alternate nest site for the actual Golden Eagle nest. Four raven nests were found by the boat survey while 3 were located from the helicopter. Both survey techniques produced 1 active Prairie Falcon nest, although they were at 2 different locations, illustrating the difficulty in detecting active cavity nests from the air. The greatest disparity in the results of the 2 techniques is that only 15 of 30 vacant stick nests observed from the helicopter were found by the boat survey team. Three of the stick nests recorded on the boat survey were not found from the air, but 11 recorded from the helicopter were not found by boat.

The angle of observation is the most important factor in differences between the 2 techniques. However, since the boat survey took longer, more time was allowed to see and hear nesting raptors, so that the same number of active stick nests and an additional cavity nest was found by the boat survey team.

ACKNOWLEDGMENTS

The field work for this report was funded by the Bureau of Land Management, Burley District Office, Burley, Idaho, through a contract to Western Environmental Research Associates, Pocatello, Idaho. We acknowledge K. Lynn Bennett, Willis Bird, Mike Kochert, Sam Mattise, Linda Parsons, Fred Rose and Alan Sands for help with aspects of this field work and/or manuscript preparation. We also thank Tim Zarkos for piloting the helicopter with extraordinary skill, Alan Sands and Sam Mattise for allowing us to use their boat survey data, and Fred Dautermann for his help with computer analysis of nest distances.

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Received 10 May 1983; Accepted 16 April 1984



USE OF INTRODUCED PERCHES BY RAPTORS: EXPERIMENTAL RESULTS AND MANAGEMENT IMPLICATIONS

STEVEN E. REINERT

ABSTRACT - Fourteen dead trees and 9 man-made perches were placed in the Sachuest Point National Wildlife Refuge, Rhode Island between 1977 and 1979 for use by the open country raptor community that inhabits the area during fall and winter. On 120 days during fall and winter 1978-79 and 1979-1980 raptors were observed on the introduced perches 525 times. American Kestrels (*Falco sparverius*), Short-eared Owls (*Asio flammeus*) and Northern Harriers (*Circus cyaneus*) in that order were the most frequent users. In all, 10 raptor species used the dead trees and 4 species used man-made perches. Kestrels displayed a preference for trees over constructed perches in 1979-80, but not in 1978-79. Kestrels used the perches for hunting, resting and prey consumption, but other raptors used them mostly for resting. These results suggest that introduced perches could play an important role in raptor conservation efforts.

Elevated perches are a habitat requirement of most birds of prey for hunting, resting and feeding (Brown and Amadon 1968, Brown 1976). The importance of perches has been documented by several investigators who noted the activity of raptors when first seen (Schnell 1968, Craighead and Craighead 1969, Marion and Ryder 1975, Bildstein 1978). The Red-shouldered Hawk (*Buteo lineatus*), Red-tailed Hawk (*Buteo jamaicensis*), Rough-legged Hawk (*Buteo lagopus*), Golden Eagle (*Aquila chrysaetos*) and American Kestrel (*Falco sparverius*) were perched during 50% or more of the observations of 1 or more of these authors. The importance of perches as a hunting substrate has been shown most clearly for American Kestrels. Several authors (Sparrowe 1972, Collopy 1973, Cruz 1976, Bildstein 1978) have found that kestrel attacks on prey were initiated from a perch in 71% or more of the attempts, and that the attacks initiated from a perch were more successful than attacks initiated from flight.

The erection of man-made perches, especially utility-line towers, has served as a passive raptor management tool by opening up millions of acres of habitat to hunting from stationary perches (Olen-dorff et al. 1980). For example, in Colorado,

Stahlecker (1978) documented a concentration of raptors in the area immediately surrounding a newly constructed transmission line. Such findings have led to the introduction of elevated perches in suitable hunting range where tall perches are lacking (Christensen 1972, Snow 1974, White 1974, Steenhof 1977, Stumpf 1977, Hall et al. 1981). Herein I report the use of 2 types of raptor perches introduced into the Sachuest Point National Wildlife Refuge on the Rhode Island coastline.

STUDY AREA AND METHODS

Sachuest Point is an 86 ha peninsula extending into the Atlantic Ocean from the southeast corner of Aquidneck Island, Rhode Island. The vegetated interior of the point is borded by a 5 km perimeter of rocky shoreline and cobble beaches. Shrub and herbaceous communities, which dominate the peninsula, are interrupted by a network of roads and scattered buildings abandoned by the U.S. Navy. Bayberry (*Myrica pensylvanica*) is the dominant shrub species. It reaches 3 m in height in the northern section of the point where it occurs in clumps (ca 100-300 m²) which are interspersed with shorter, mixed stands of goldenrod (*Solidago tenuifolia*) and blackberry (*Rubus* sp.). In the southern part of the peninsula, bayberry from 0.5 to 1.5 m tall forms dense, isolated stands 0.5 to 3.0 ha in area which are surrounded by an herbaceous community. Grasses, especially Autumn Bent (*Agrostis perennans*) and Red Fescue (*Festuca rubra*), are common and occur either alone or beneath a forb layer dominated by goldenrod (*Solidago* spp.) and Black Knapweed (*Centauria nigra*). Shrubs provide the cover throughout 52% of the vegetated region of the study area

and herbs cover the remaining area. Elevated perches were absent or scarce within all habitats on the refuge prior to the initiation of this study.

Five dead trees (\bar{x} height = 4.8 m, range = 3.7-8.5 m) with numerous horizontal branches were erected on the refuge in the summer of 1977, and 9 more (\bar{x} height = 4.8 m, range = 3.6-6.1 m) in the summer of 1979. Two trees were erected within the tall shrub community and 5 within the shorter, bayberry stands. The remaining 7 were erected within herbaceous habitats. In the summer of 1978, 9 man-made perches were erected. Each man-made perch consisted of a 6-m board, 5 cm x 10 cm size, fitted with two 2.5 cm dia. dowels. The dowels were cut into 65 cm lengths and centered through holes in the boards so that 30 cm of perch space was available on either side. The dowels were placed on each structure at heights of 2.25 m and 4.5 m above ground. Length of board in excess of 4.5 m was buried. Two perches were placed within tall shrubs, 3 within short shrubs, and 4 within herbaceous communities.

Raptors were observed for 1 h periods on 88 d between 1 September 1978 and 12 March 1979, and on 32 d between 12 November 1979 and 29 January 1980, from the roof of a 6 m high abandoned building near the center of the refuge. Thirty-five visits were made at various times in the morning; 85 were made from 1500 to 1700 h. For each observation of a perched raptor a record was made of species, perched height, individual perch number, and purpose for which the perch was used whenever this was apparent.

RESULTS

Five species of raptors were seen during the 2 years (Table 1). During both periods, the Northern Harrier (*Circus cyaneus*), American Kestrel, and Short-eared Owl (*Asio flammeus*) were dominant. Harriers and kestrels were present in varying numbers throughout both study periods. Four Short-

eared Owls arrived in November of 1978 and 1 in December of 1979; each remained until the end of the study period each year. The Sharp-shinned Hawk (*Accipiter striatus*) and Merlin (*Falco columbarius*) occurred only as migrants; they were seen on perches in September and October 1978. Raptors were more abundant during the 1978-79 period, averaging 3.7 individuals/hr observation (range = 0-31). An average of 2.6 individuals/hr (range = 0-6) were seen during the shorter, 1979-80 period.

During the 120 h of observation, I made 525 sightings (4.4 sightings/hr) of raptors using the introduced perches (Table 1). All species except Sharp-shinned Hawks used both perch types at least once; sharp-shins used only dead trees. In addition, the Cooper's Hawk (*Accipiter cooperii*), Red-tailed Hawk, Rough-legged Hawk, Peregrine Falcon (*Falco peregrinus*), and Snowy Owl (*Nyctea scandiaca*) were also sighted on the dead trees.

Chi-square (X^2) tests were conducted using each of the 3 dominant raptor species to determine whether the more natural, dead-tree perches were used more than might have been expected by chance. During 1978-79, there were no significant differences ($P = 0.05$) in the use of natural vs. constructed perches for any of the 3 species. In 1979-80, kestrels used dead trees significantly more than expected ($P < 0.001$) ($X^2 = 15.3$, df = 1).

Raptors nearly always perched as high as possible on a perch. On man-made perches, the higher of 2

Table 1. Raptor Perch-Use Statistics.

Species	Individuals/Day		Percent of Days Present	# Perches Used		# Perch Observations*
	\bar{x}	range		Dead Trees	Constructed	
Sharp-shinned Hawk	0.2	0-10	7	1- 3	-	
Northern Harrier	1.4	0- 5	68	6- 35	6- 32	
American Kestrel	1.2	0-21	67	14-190	8-149	
Merlin	-	0- 1	2	3- 7	1- 1	
Short-eared Owl	1.5	0- 4	43	11- 47	8- 61	
Total				282	243	

*Based on 88 h of observation of 5 dead trees and 9 man-made perches in 1978-79 and 32 h of observation of 14 dead trees and 9 man-made perches in 1979-80.

Table 2. Reported Perch Introduction Experiments.

Source and State	# Perches	Target Species	Raptors Using Perches
Christenson 1972 Utah	3	All Raptors	Swainson's Hawk (<i>Buteo swainsoni</i>) Red-tailed Hawk American Kestrel Great Horned Owl (<i>Bubo virginianus</i>) Long-eared Owl (<i>Asio otus</i>) Golden Eagle
White 1974 Utah	8	Golden Eagle	Golden Eagle
Snow 1974 Colorado	2	All Raptors	Red-tailed Hawk Ferruginous Hawk (<i>Buteo regalis</i>) Golden Eagle Northern Harrier
Harrison 1977 Michigan	50	Grassland Birds	American Kestrel Short-eared Owl
Steenhof 1977 South Dakota	4	Bald Eagle	Bald Eagle
Steenhof 1977 Oregon	1	Bald Eagle	Bald Eagle
Stumpf 1977 Arizona	12	Bald Eagle	Red-tailed Hawk Harris' Hawk (<i>Parabuteo inicitus</i>)
Hall et al. 1981 California	36	All Raptors	White-tailed Kite (<i>Elanus leucurus</i>) Red-tailed Hawk Northern Harrier American Kestrel Common Barn-Owl (<i>Tyto alba</i>) Short-eared Owl Great Horned Owl Burrowing Owl (<i>Athene cunicularia</i>) Northern Harrier Sharp-shinned Hawk* Cooper's Hawk* Red-tailed Hawk* Rough-legged Hawk* American Kestrel Merlin Peregrine Falcon* Snowy Owl* Short-eared Owl
This study Rhode Island	23	All Raptors	

*Used dead trees only.

available perches was selected in 97% of 32 harrier observations, 99% of 149 kestrel observations, and 85% of 61 Short-eared Owl observations. Except when eating prey, raptors perched within the uppermost branches.

I did not see harriers or owls attack prey from, or consume prey on, an introduced perch. These 2

species apparently used the introduced perches as resting sites between hunting forays. I witnessed 16 prey attacks by kestrels, 14 from man-made perches and 2 from dead trees. Six of the attacks from man-made perches and both from trees were successful. Kestrels were observed eating prey on trees and on man-made perches 10 times each. Kestrels

perched more frequently per individual/hr than Short-eared Owls, and owls perched more frequently than harriers.

DISCUSSION

A total of 20 raptor species, representing 2 orders and 4 families, have used perches introduced specifically for their use (Table 2). Although these numbers are impressive, not all attempts at raptor management by perch introduction have been successful. Perches introduced as part of Bald Eagle (*Haliaeetus leucocephalus*) management programs by the U.S. Bureau of Land Management (BLM) (Steenhof 1977) and the U.S. Bureau of Reclamation (Stumpf 1977) were little used by the target species. The BLM had better success with perches introduced for Golden Eagle management; numerous eagles were seen on the perches during the first year after their placement (White 1974). Snow (1974) reports that 4 raptor species used perches placed in a Colorado grassland community, and perches erected in agricultural fields by Hall et al. (1981) received extensive use by 8 species (Table 2).

To determine if introduced perches would serve as a means for enhancing biological control of undesirable rodents, Christensen (1972) placed 3 perches in areas of high pocket gopher (*Thomomys talpoides*) density. Five species of raptors used them (Table 2), and results strongly suggest that gopher numbers were reduced in the area immediately surrounding the perches. Over a broad area, however, the results were inconclusive.

At Sachuest Point I made an average of 1 sighting of a raptor on an introduced perch during each 14 min of observation. The use of the perches by hunting kestrels demonstrates a shift in their hunting strategy as a result of perch introduction, since prior to perch placement aerial hunting was the only method available. Furthermore, the hunting efficiency of kestrels may have improved following perch introduction since several authors have shown that kestrels prefer hunting from a perch rather than hover hunting, and were more successful when hunting from a perch than when hunting aerially in general (Sparrowe 1972, Collopy 1973, Cruz 1976, Bildstein 1978). The perches were also used extensively by kestrels for eating prey.

Despite the substantial documentation of introduced perch, no study has demonstrated an increase in raptor density within managed areas.

Stahlecker (1978), however, censused wintering raptors before and after construction of a transmission line. His results demonstrate that raptor density in the area within 0.4 km of the transmission line (57 km²) became greater than the density in the area beyond 0.4 km (98 km²) as a result of the extensive use of transmission line towers as perches. The increased density within his study area following transmission line construction suggests a lack of perches was limiting raptor use of his study area.

In areas where the scarcity or absence of perches limits raptor numbers, perch introduction could play an important role in raptor management, at least where an increase in density is the goal. Unfortunately, perch requirements of raptors are not well understood, and it is not always evident if a particular raptor population or community would benefit from increased available perches. In areas where habitat destruction threatens raptor populations, it becomes increasingly important to create potential for increased densities in unaffected range. Managers of protected areas (national parks, public and private wildlife preserves, etc.) should assess perch availability and consider supplementation where a scarcity of perches may limit raptor numbers. Such efforts could help maintain stable raptor populations, especially wintering populations, in threatened areas.

Dead trees erected at Sachuest Point were readily accepted by all raptor species and were preferred by some over man-made perches. Dead trees are preferred perches of Bald Eagles (Steenhof 1977, Stumpf 1977) and were listed as one of the preferred perch types of buteos by Errington and Breckenridge (1938). Thus, trees should be considered for use in perch introduction projects where a source is available.

ACKNOWLEDGEMENTS

This project could not have been completed without the cooperation of the staff of the Ninigret National Wildlife Refuge, and the field help of several volunteers, especially Jeffrey Hall, Jay Manning and William DeRagon. I also thank Drs. Keith L. Bildstein and Frank C. Golet for carefully reviewing this manuscript.

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Received 4 March 1983; Accepted 10 April 1984

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Raptor Collisions with Utility Lines — A Call for Information — The U.S. Bureau of Land Management, Sacramento, in cooperation with the Pacific Gas and Electric Company, is assembling all available published and unpublished information concerning collisions of raptors with power lines and other utility lines. Actual case histories — no matter how circumstantial or fragmentary — are needed. Please acknowledge that you have such information by writing to Dr. Richard R. (Butch) Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825 U.S.A. (Phone (916) 484-4541). A form on which to record your information will then be sent by return mail.

Kleptoparasitism by White-Tailed Hawk (*Buteo albicaudatus*) on Black-Shouldered Kite (*Elanus caeruleus leucurus*) In Southern Texas

BORJA HEREDIA AND WILLIAM S. CLARK

The White-tailed Hawk (*Buteo albicaudatus*) is a typical open and semi-open country raptor, inhabiting prairies and sparsely forested habitats from southern Texas to central Argentina. It feeds mainly on mammals [e.g. cottontail rabbits (*Sylvilagus floridanus*) and rodents], birds [largely Bobwhite Quail (*Colinus virginianus*) and meadowlarks (*Sturnella* sp.)], reptiles (mostly snakes but some lizards) and insects (e.g. grasshoppers and crickets) (Bent 1937, Cottam & Knappen 1939, Stevenson & Meitzen 1946). Its main hunting technique is to search the ground from a height of 15-50 m (Oberholser 1974) alternating between straight flapping flight, low angle glides and hovering. Its habit of congregating at prairie fires has been recorded on the Texas coast (Stevenson & Meitzen 1946). However, as far as we know, kleptoparasitism has not been recorded for this species.

We observed kleptoparasitism on 30 December 1982 on the King Ranch between Kingsville and Falfurrias, Texas. At about 1100 h we spotted a Black-shouldered Kite (*Elanus caeruleus*) flying level at a height of 20 m carrying prey, probably a small mammal. It was pursued by an immature White-tailed Hawk which was gaining on it. As the hawk neared the kite, the kite dropped its prey and began to harass the hawk. The kite stooped numerous times at the hawk, which turned over and presented its talons. Two additional immature White-tailed Hawks appeared and were also harassed by the kite. The kite finally left and the 3 hawks searched unsuccessfully for the dropped prey. After they left, we were also unable to find it.

White-tailed Hawks and Black-shouldered Kites are sympatric over much of their range in North America. Recent studies on a Mexican raptor community (Thiollay 1980) showed that there is an 85% overlap in their hunting habitats. Both select areas of tree cover ranging from < 10 to 40% and grass length between < 20 cm to 80 cm. Their hunting techniques also overlap by 90%, both species being typical searchers and aerial hunters. Both also hunt from perches (Warner & Rudd 1975). Although most of their hunting activity occurs late in the day, both may hunt at any time of day (Thiollay 1980).

Except for the habitual kleptoparasites such as the Crested Caracara (*Polyborus plancus*), typical kites (*Milvus* sp.), sea and fish eagles (*Haliaetus* sp.), and the Bateleur Eagle (*Terathopius ecaudatus*), Brown & Amadon (1968, p.73) state that piracy is rare among birds of prey. But piracy has been recorded for 23 other raptor species (Parmenter 1941, Jeserich 1957, Berger 1958, Meinertzhagen 1959, Temple 1969, Reese 1973, Bildstein and Ashby 1975, Hogg 1977, Brockmann & Barnard

1979, Dunne 1981), and especially for other species in the genus *Buteo*: Red-tailed Hawk (*Buteo jamaicensis*) on Peregrine Falcon (*Falco peregrinus*) (Beebe 1960); Rough-legged Hawk (*B. lagopus*) on Northern Harrier (*Circus cyaneus*) (Kirby 1958); Red-shouldered Hawk (*B. lineatus*) on Common Crows (*Corvus brachyrhynchos*) (Kilham 1982); and Common Buzzard (*Buteo buteo*) on Merlin (*Falco columbarius*) and Sparrowhawk (*Accipiter nisus*) (Cramp & Simmons 1979, p. 182). In addition, Clark has observed piracy of a Red-tailed Hawk on Prairie Falcon (*Falco mexicanus*). The Black-shouldered Kite has previously been recorded as the victim of piracy, being robbed by the Lanner Falcon (*Falco biarmicus*) (Reynolds 1974) and by the Peregrine Falcon (*Falco peregrinus*) (Longrigg 1981).

Brockmann & Barnard (1979) pointed out that regular association with other raptor species on or near feeding areas is an ecological factor that appears to promote piracy. Thus the overlap of hunting habitat between the White-tailed Hawk and the Black-shouldered Kite makes this interspecific interaction likely. It would be interesting to know not only how often these encounters occur, but if they are the regular situation.

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Received 26 December 1983; Accepted 30 May 1984

OBSERVATIONS OF NESTING PRAIRIE FALCONS IN THE LOS PADRES NATIONAL FOREST

WADE L. EAKLE

PRAIRIE FALCON (*Falco mexicanus*) nesting surveys were conducted by the U.S. Forest Service and California Department of Fish and Game on the Mt. Pinos (MPRD) and Santa Lucia (SLRD) Ranger Districts, Los Padres National Forest during April, May and June, 1981. Nine historical nesting territories were surveyed on the MPRD, of which 4 were active, and 14 historical territories were surveyed on the SLRD, of which 9 were active. An average of 3.3 young hatched per eyrie (N=3). Nine nestlings successfully fledged from these eyries ($X=3.0$ young per eyrie).

The goal of this study was to survey 2 Ranger Districts on the Los Padres National Forest in southwestern California and determine activity at each eyrie and productivity at 3 eyries. Productivity parameters provide a measure of reproductive success and allow comparisons with earlier determinations for the same populations (Johnson, 1978).

The survey area encompasses prairie falcon nesting territories in Santa Barbara, Ventura, San Luis Obispo and Kern counties, California.

Prairie falcon eyries were located and plotted on topographical maps during 1979 (Alten and Keasler, 1979). Observation points for viewing the eyries were chosen that provided viewing directly into nest cavities at distances ranging from 30 m up to 1 km. Disturbances were minimized by not climbing to eyries. Observation periods were restricted to 2 h in length. Observations were made

with Bushnell 10x50 Explorer binoculars and a Bushnell 20-45x Zoom Spacemaster spotting scope.

Prey remains and regurgitated pellets were collected from 2 eyries. Adult Prairie Falcons at BC-1 were observed bringing 1 horned lizard (*Phrynosoma* sp.), 4 ground squirrels (*Spermophilus* sp.) and 1 unknown prey item to the eyrie. At VV-8, adult falcons delivered 3 ground squirrels and 1 western meadowlark (*Sturnella neglecta*) to the eyrie.

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Reuse of Nesting Territories and Eyries. — Three of the 22 known nesting territories have remained active since 1977. Two have remained occupied for 4 of the 5 years that surveys have been completed. The remaining

Table 1: Summary of Prairie Falcon Nesting Activity. Mt. Pinos and Santa Lucia Ranger Districts, Los Padres National Forest. 1977-81.

Eyrie	1977	1978	1979	1980	1981
BC-1	NC	NC	A	A	A
HV-2	NC	NC	A	NC	NA
JW-3	NC	NC	A	NC	A
CR-4	NC	NC	A	NA	NA
SB-5	NC	NC	A	NA	NA
DC-6	NC	NC	A	NA	NA
CC-7	NC	NC	NC	NC	NC
VV-8	NC	NC	A	A	A
LC-9	NC	NC	NC	NC	A
BR-2	A	A	A	A	A
HM-11	A	NA	NA	NA	A
BC-38	A	NC	A	A	A
GM-39	A	A	A	A	A
BT-40	NC	NC	A	A	NC
MM-41	NC	NC	A	A	NC
BR-43	A	NC	NC	NC	NC
BS-45	A	NC	NC	NC	NC
HM-46	A	A	NA	A	A
TC-55	A	A	A	A	A
CC-56	NC	NC	NA	A	A
AC-57	NC	NC	A	A	A
TR-58	NC	NC	NC	NC	A

A - Active; NA - Not Active; NC - Not Counted.

17 were active for 3 years or less (Table 1).

1981 Breeding Season, MPRD. — When surveyed between March 11-18, 5 eyries were active with adult Prairie Falcons in the nest territory. Eight historical eyries were resurveyed in late April and early May. Only 3 eyries, however, remained active. Young hatched at these 3 eyries during the week of May 3-9. Nestlings fledged between June 8 and 19.

Productivity. — Clutch size was not determined. Assuming a minimum clutch size, however, from the brood size of active eyries ($N=3$), a minimum mean clutch size of 3.7 eggs/nest can be inferred. Brood sizes and fledging success in 1979 and 1981 are summarized in Table 2. For both years the average fledging success is above the 2.56 needed to maintain a stationary population (Garrett and Mitchell, 1973).

Mortality. — Two cases of egg loss or prefledging mortality were observed. When VV-8 was observed on May 17, 1 unhatched egg was present in the nest with 3 nestlings. When observed again on May 31, the egg was no longer present. A 1-2 day old nestling was found directly below the JW-3 eyrie in an emaciated condition.

Nesting Activity. — During 1977, both activity and productivity at prairie falcon eyries on the SLRD was high. Activity and productivity dropped in 1978 for some reason. In 1979 the level of activity at the eyries was lower, but the productivity was higher than the previous year. Activity during 1980 and 1981 appeared to be fairly high and when young were seen at the eyries, they were seen in numbers above the 2.56 fledglings per nest needed to maintain a stable population (Schlorff, 1979).

Productivity and activity at the prairie falcon eyries on the MPRD during 1979 was high. A complete survey was not conducted in 1980, so many eyries that may have been active were determined to be inactive or not counted. Activity at the eyries located in 1979 was down in 1981. Productivity at these active eyries was also lower than the 1979 level.

It is difficult to say why the number of active eyries observed in 1979 was not seen in 1981 on the MPRD. Perhaps the falcons are nesting in alternate areas unknown to the surveyors. Prey did not appear to be limiting. Garrett and Mitchell (1973) stated that the observed rates of prairie falcon production in California during 1971 and

Table 2: Summary of Prairie Falcon Nestling Production. Mt. Pinos Ranger District, Los Padres National Forest. 1979 and 1981.

Eyrie	1979		1981	
	Brood Size	Fledging Success	Brood Size	Fledging Success
BC-1	4	4	4	4
HV-2	4	4		
JW-3	2*	2*	3	2
CR-4	5	0		
SB-5	5	5		
DC-6	3*	U		
CC-7	U	U		
VV-8	5	5	3	3
TOTAL	28	20	10	9
Mean	4**	3.3***	3.3	3

* - Number may have been greater, but a complete count was not possible.

** - Mean excluding CC-7.

*** - Mean excluding DC-6 and CC-7.

U - Undetermined.

1972 was below expectation and indicated a declining population. However, in the Central region of their study, which includes the area of this study, a production rate in excess of 2.56 fledglings/total pairs was observed. Statewide, they determined an average production rate of 1.59 fledglings/pairs studied. They also observed an extensive shifting of production between eyrie locations in 1970 and 1971, with few of the nesting territories supporting productive pairs in both years. This may be the case on the MPRD.

Sincere appreciation is extended to Cliff Fox and Gary Smith, U.S. Forest Service, and Jim Davis, California Department of Fish and Game, for advice and assistance and to Dr. Stanley W. Harris, Humboldt State University, for directing the field problem.

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Received 2 November 1981; Accepted 1 March 1984.

Barred Owls and Nest Boxes

DAVID H. JOHNSON AND DON G. FOLLEN, SR.

The use of artificial nesting structures by the Barred Owl (*Strix varia*) has long been assumed. This is due in part to the use of man-made structures by a closely related species, the Tawny Owl (*Strix aluco*) in Europe (Davey 1969). Hamerstrom (1972) gave recommended but untested Barred Owl box dimensions. A literature search reveals 3 published accounts (Johnson 1980, Follen 1982, Synder and Drazkowski 1981) of Barred Owls using artificial structures for nesting. We briefly discuss Barred Owl use of various types of semi-natural and artificial nesting structures in Minnesota, Wisconsin, and Michigan.

Minnesota: Table 1 shows use of artificial and natural cavity nest sites by Barred Owls in north-central Minnesota (Hubbard, Wadena, and Crow Wing counties) during the breeding seasons of 1980, 1981, and 1982. All nesting attempts were successful in fledging from 1 to 4 young. A "# nesting attempts" column is shown as some nests were used in 2 and 3 consecutive years. Average production from 12 nesting attempts in artificial structures was 2.75 young fledged/nesting attempt. Average production in 4 natural cavity nests was 2.00 young fledged/nesting attempt. This difference in production is likely related to the prey abundance/availability within the owls' territory than to a function of nest site quality. However, larger sample sizes are needed to better assess this evaluation. Figure 1 shows the design of the Barred Owl nest box currently being used by the first author. This box is a slightly enlarged Wood Duck (*Aix sponsa*) box with a

17.8 cm diameter entrance hole. Thirty-five of these are currently being field tested in various forest habitats in north-central Minnesota. Heights of nest boxes and topless Wood Duck boxes used by owls have ranged from 3.73-6.70 m (measured from bottom of entrance hole to ground level). Both back-mounted and side-mounted nest boxes (see Fig. 1) have been used by owls (N=2 and N = 5 respectively, based on number of nesting attempts).

Table 1. Minnesota Records.

Type of nest	# nests used	# nesting attempts	young fledged
Barred Owl nest box	5	7	18
Topless Wood Duck box	2	4	12
Wood Duck box (with top)	1	1	3
Natural cavity	4	6	12

Wisconsin: In 1966, 3 young Barred Owls were fledged from a topless Wood Duck box, located on Goose Island, La Crosse County. In 1967, this same box contained 2 young. Additional boxes of this type were successful in subsequent years, but unfortunately the particular nesting data were not recorded (J. Rosso pers. comm., F. Lesher pers. Comm.).

A large Barred Owl nest box was established in 1979 by Bill Drazkowski along the Mississippi River backwaters in

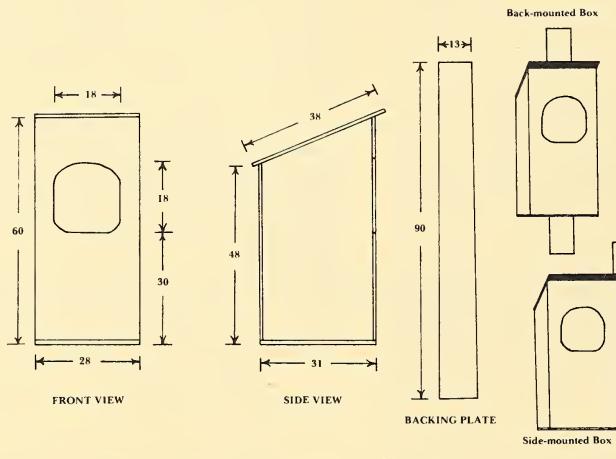


Figure 1. Barred Owl nest box made of wood (1.3 cm thick). All dimensions are in cm.

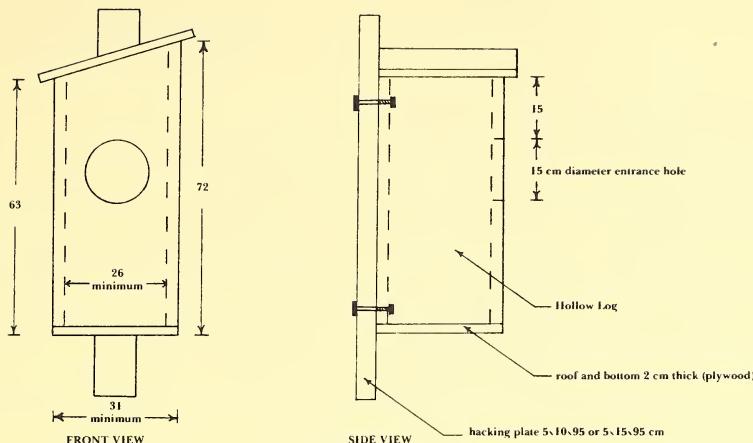


Figure 2. Semi-natural (hollow log) Barred Owl nest cavity. All dimensions are in cm.

Trempealeau County. In 1980 this box contained 2 young, and 3 in 1981. The dimensions of this box were: entrance hole 22.2 x 21.0 cm, bottom of entrance hole to floor of box 33.0 cm, inside floor 33.6 x 36.2 cm. Mr. Drazkowski found the birds to be nesting in the corner of the box, indicating that perhaps such a large box was not required.

In 1981, owls fledged 3 young from a semi-natural nest structure established by Follen in Wood County (Follen 1982). This structure (Fig. 2) consists of a section of a hollow log, with top, bottom and backing plate added. In this structure a 15.2 cm diameter entrance hole was used.

Michigan: In 1977 and 1978 Barred Owls nested in a Red-shouldered Hawk (*Buteo lineatus*) nest in Alpena County. It was unsuccessful, as eggshells and dead young were found beneath the nest. Lewis Scheller (pers. comm.) then established a reconditioned topless Wood Duck box in the area on 2 March 1979. It was used in 1979 and young owls successfully fledged. In 1980 owls again used it, as evidenced by a single infertile egg. In 1981 owls fledged 2 young from 2 eggs, and 3 young from 3 eggs in 1982. This box is approximately 57 cm deep with a bottom of about 31 x 31 cm. Scheller has also established 5 other slightly larger nest boxes, all with open tops. At the time of this writing, none of these have been used by owls.

The availability of suitable nest sites is reported to be a limiting factor for cavity nesting species (Thomas et al. 1979). With current forest management directives of short rotations, intensive culture, etc., this situation is becoming more severe. Although Barred Owls have nested in old hawk or squirrel nests in northeastern US (Bent 1938:183) and in Michigan (L. Scheller per. comm.), in Minnesota they have been recorded only as a cavity nester (Johnson 1982). Beginning in 1980, a five year project was initiated in north-central Minnesota to address the question of artificial nest structures (design, placement, and suitability) for Barred Owls. A project of a

similar nature has also been started in Wisconsin. Our findings thus far indicate that Barred Owls do successfully nest in various types of man-made and semi-natural nest cavities in Minnesota, Wisconsin, and Michigan. A nest box project has also been started in New Jersey by Leonard J. Soucy, Jr.

We thank Catherine M. Fouchi, Douglas Keran, Conrad Schmidt, Jon Carter, Fred Lesher, Dennis Seavers, Bill Drazkowski, Lewis Scheller, Jerry R. Rosso, and Leonard J. Soucy Jr. for their field assistance or other input into this project.

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Received 1 January 1983; Accepted 1 March 1984.

Ground-Nesting by Barn Owls

MICHAEL E. TEWES

While trapping small mammals on the Aransas National Wildlife Refuge in south Texas, I flushed some Common Barn-Owls (*Tyto alba*) from the ground in a dense stand of gulf cordgrass (*Spartina spartinae*). There were 3 separate tunnel-like pathways through the cordgrass which were apparently being used for roosting. Each cordgrass tunnel was about 1 m long, terminating in a small chamber beneath the grass. The floor of each chamber was littered with owl pellets and skulls of rodents and shrews.

Between November 1980 and January 1981, owls were regularly observed using these cordgrass tunnels for roosting, and in January an abandoned clutch of 4 eggs was found in 1 concealed compartment. I suspected the nest was abandoned after having been flooded during a rainstorm (gulf cordgrass communities normally occur on areas that are periodically flooded). I could not find additional nests or roosts. The grass community had a dominant *Baccharis* shrub influence except for a small 3 ha shrub-free area in which the owl tunnels were located.

These observations are of interest because they provide additional evidence that Common Barn-Owls will nest and roost on the ground. Quigley (Condor 56:315, 1954) found young barn owls in a box with an open top, sunk flush with the surface of the ground in a marsh. It is possible, however, that owls resort to such areas for nesting and roosting only if there is no alternative. The nearest tree or man-made construction that could serve as a nest or roost site was located over 4 km away.

Raptor management has received increased attention in recent years. If particular management objectives for an area include enhancing the raptor populations, then attempts should be made to preserve roost and nest sites by not altering selected mature cordgrass stands. Erection of nest boxes (Marti et al., Wildl. Soc. Bull. 7:145-148, 1979) over cordgrass meadows may attract barn owls and support more successful nesting attempts than ground nests. Otteni et al. (Wilson Bull. 84:434-448, 1972) and Delnicki and Bolen (Southwest. Natural. 22:275-277, 1977) provide additional instances of Common Barn-Owl use of nest boxes in marsh areas.

I acknowledge Ray Anderson and his students, University of Wisconsin at Stevens Point, for assistance. James G. Teer and Bruce C. Thompson critically reviewed the manuscript. Support for this research was provided by the Edwards H. and Winnie H. Smith Fellowship and the Rob and Bessie Welder Wildlife Foundation.

Welder Wildlife Foundation Contribution No. 155. Rob and Bessie Welder Wildlife Foundation, P.O. Drawer 1400, Sinton, TX 78387. Present address: Caesar Kleberg Wildlife Research Institute, Box 218, Texas A&I University, Kingsville, TX 78363.

Received 20 January 1983; Accepted 2 May 1984.

Unusually Low Nesting Site For American Kestrels (*Falco sparverius*)

Clark S. Monson

Two American Kestrel (*Falco sparverius*) nests found in extreme northern Utah were located in small pine stumps on a steep canyon hillside. The nests were less than 45 m apart and both nest holes were only 64 cm above the ground. Higher and seemingly more suitable holes were common in nearby trees but were not occupied by nesting kestrels.

The low nest holes that were occupied did not appear to make the birds more sensitive to human disturbance. On one occasion, I was able to walk directly up to one of the nests and temporarily remove the incubating female before she made an attempt to fly.

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Received 15 May 1983; Accepted 15 May 1984.

Monitoring Bald Eagle Nesting in Baja California, Mexico

BRUCE CONANT, ALBERT N. NOVARA AND CHARLES J. HENNY

Henney et al. (Auk 95:424, 1978) discussed Bald Eagle (*Haliaeetus leucocephalus*) sightings and nesting activity in the vicinity of Bahia Magdalena in Baja California. They confirmed 2 nesting pairs in 1977, apparently the first published record of Bald Eagle nesting in Baja California during the last 50 years.

During an aerial survey of wintering waterfowl on 18 January 1983, the first and second authors found 3 nests (2 occupied) on Isla Creciente. Two were close together (one occupied) at the location (24°22'N, 111°39'W; hereafter abbreviated as 2422-11139) reported by Henney et al. (op.cit.) and an additional one occupied at 2422-11133 also on Isla Creciente. At the latter nest there was an adult eagle incubating 2 eggs with another adult perched nearby. One of the other 2 nests had an incubating adult, but we were unable to flush it off the nest. Assuming an incubation period of 35 days, the eggs seen would not have been laid before mid-December. All nests were made of sticks and located in the crowns of mangrove, but were readily visible from the air. The location of the other nesting pair found by Henney et al. (op.cit.) in 1977 (near San Jorge 2534-11206) was not checked in detail in 1983.

The west coast winter waterfowl survey was conducted by the U.S. Fish and Wildlife Service in cooperation with the Dirección General de la Fauna Silvestre of Mexico as part of the U.S.-Mexico Joint Agreement. Bald Eagle observations were made incidental to the waterfowl survey. We expect to fly annual winter surveys in this area in the future and plan to monitor the status of Bald Eagle nests at both general locations.

ADDENDUM

The nests on Isla Creciente were checked again the following year on 16 January, 1984 during the 1984 Mexico winter waterfowl survey. An incubating adult was found in each of 2 nests (2422-11139 and 2422-11133) but we were unable to obtain an egg count. One flying adult was sighted near San Jorge (2534-11206) but the nest was not located.

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Received 30 June 1983; Accepted 8 March 1984.

THE SEASONAL ABUNDANCE, HABITAT USE AND FORAGING BEHAVIOR OF WINTERING BALD EAGLES *Haliaeetus leucocephalus*, IN WEST-CENTRAL ILLINOIS

The seasonal abundance, habitat use and foraging behavior of bald eagles wintering near Lock and Dam 19, Mississippi River, were investigated by regular census taking and intensive behavioral sampling during the winters 1978-79 and 1979-1980. The ultimate objectives of the study were to provide information necessary for an Environmental Impact Analysis of a proposed Mississippi River bridge and highway corridor on wintering bald eagles and to obtain information useful to management of winter bald eagle habitat.

The two study seasons contrasted greatly in weather severity. During the severe winter of 1978-79, 8263 eagles were recorded on 59 censuses. The peak count for this season was 454 eagles on January 18. During the mild winter of 1979-80, 4230 eagles were recorded on 97 censuses. The peak count this season was 127 eagles on February 18. Eagle abundance varied considerably each season; the greatest numbers were recorded during the coldest periods of each winter. The effects of weather severity on the eagle population of the study area are discussed. Overall, adult eagle outnumbered immatures by 2.28 to 1; however, age class composition varied over the course of each season. Immatures comprised a greater proportion of the eagle population during the early and late parts of the season.

The daily activities of eagles included foraging and eating, flying, loafing and night-roosting. Eagles typically used different portions of the study area for each of these activities, especially when the eagle population was large. Habitat use data were obtained from 10,710 locations of perched eagles plotted on census forms. Ice cover, wind exposure, human activity and local food concentrations were the most important factors determining the daily use of suitable perching habitat. Eagle dispersion was most clumped when ice cover on the river was at a maximum, and most uniform when the river was ice-free.

Eagles' use of foraging areas was greatest in the morning and diminished as the day progressed; however, when large numbers of eagles were present, eagles were observed foraging during all daylight hours. Use of loafing areas peaked in the middle of the day.

The prey base of eagles in the study area was dead or injured fish, primarily gizzard shad (*Dorosoma cepedianum*). Six behavior-

ally distinct foraging strategies were identified and are described. By far the most commonly used, and the most intensively studied of these was Strategy 1, an aerial search, swoop and capture of prey. Eagles fishing via this method were successful approximately 70% of the time and averaged less than 5 minutes of flight time per fish captured. Adults were significantly more successful in capturing fish and averaged shorter flight duration per fish captured than immatures. Approximately 70% of the fish captured were small (15 cm. or less) and the size of fish taken was similar for both age classes. Over 97% of small fish captured by eagles were successfully consumed. Most small fish (71.0%, N= 1181) were consumed in flight. Nearly 37% of large fish (greater than 15 cm) captured by eagles were lost (pirated or accidentally dropped) prior to being consumed. Most large fish (51.5%, N= 504) were eaten at tree perches.

Eagles readily attempted to steal prey from other fish predators, even though food was generally abundant. Eagles attempting interspecific piracy were relatively more successful (55.4%, N= 65) than eagles attempting intraspecific piracy (14.3%, N = 154). Eagles carrying large fish were more vulnerable to piracy, and were more likely to be attacked than were eagles carrying small fish. Intraspecific piracy increased in frequency as foraging eagles became more concentrated. Foraging eagles exhibited many behaviors designed to prevent the loss of procured prey to other eagles. These pirate avoidance and pirate defense strategies are discussed. — Fischer, David Lawrence. 1982. M.S. Thesis. Western Illinois University, Macomb.

ECOLOGY OF BALD EAGLES WINTERING IN SOUTHERN ILLINOIS

The population size, food habitats, distribution, and habitat of wintering Bald Eagles (*Haliaeetus leucocephalus*) were investigated in Illinois at Union County and Horseshoe Lake conservation areas during 1979-1981. Crab Orchard National Wildlife Refuge was examined also during 1980-1981.

Eagles arrived in southern Illinois during late October with estimated peak populations of 180-200 occurring, dependent upon weather conditions, in January and February; eagles departed by early March. Immature eagles predominated in wintering populations, but adult and immature subpopulations displayed similar patterns of fluctuations in numbers. Morning and evening roost counts provided an accurate estimate of total population size and automobile transect counts provided data on eagle distribution and habitat utilization patterns.

Diurnal perch sites near shallow water areas were utilized most during early winter. Occurrence of ice cover caused eagles to shift to areas of open water where waterfowl also concentrated. Canada Goose (*Branta canadensis*) carcasses appeared to be the principal food at this time, though unsuccessful eagle attacks were witnessed on injured or dying waterfowl. During late winter, eagles appeared less reliant on refuges for feeding. This may have been associated with spring migration.

Food availability was considered the major influence on the selection of diurnal perch sites. Protection from winds and insulation from human disturbance appeared to be of secondary importance. Communal roosts offered shelter from prevailing winds by surrounding vegetation and were associated with standing water. Most eagles left the roost by sunrise and returned by 20 min after sunset. Times of vocalization and movement were similar to those of entrance and departure. — Sabine, Neil. 1981. M.S. Thesis, Southern Illinois University, Carbondale.



"The Peregrine Falcon At Reelfoot Lake"

By Murrell Butler
Limited Edition Print of 2,500

A tree-nesting "Duck Hawk" populated the Mississippi and Ohio River areas in times past. A remnant nesting population was first documented during the 1930's at Tennessee's Reelfoot Lake by the late Albert F. Ganier. During the 1940's a new nest site was discovered on the west side of the lake by Dr. Walter R. Spofford, then Professor of Anatomy at Vanderbilt University. Dr. Spofford and a few carefully selected observers made yearly nesting observations until the early 1950's.

Mr. Thomas S. Butler was privileged to have been among those who spent many days recording the events of each year's breeding season beneath the enormous cypress tree that served as the falcons' nest site. During the late 1970's a happy circumstance led Tom to meet Murrell Butler, a distant cousin from Louisiana. Murrell was an accomplished wildlife artist and became enthralled by the tales of a Peregrine Falcon that once nested in the snag of the mammoth cypress tree. A subsequent trip to the nest site (the cypress still stands!), the relocation of old photographs and consultation with friends and fellow falconers culminated in this magnificent painting by Murrell Butler.

"The Peregrine Falcon at Reelfoot Lake" portrays the last known North American tree nest of the Peregrine. Available in a 16" by 20" limited edition print of 2500, the introductory price is \$65.00 for prints #1 - #500. The introductory price includes postage within the fifty states and a \$10.00 donation to The Raptor Research Foundation, Inc. The price will advance to \$125.00 per print for #2001 - 2500, according to the following schedule: #1 - 500, \$65.00; #501 - 1000, \$75.00; #1001 - 1500, \$85.00; #1501 - 2000, \$95.00; #2001 - 2500, \$125.00; Arkansas residents will need to add state, city and /or county sales tax). Prints may be ordered directly from Mr. Thomas S. Butler, Butler Galleries, 28 Fairmont Street, Eureka Springs, Arkansas 72632, USA. Payment may be made by check, money order, VISA or MASTERCARD.

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The editorial office of the Raptor Research Foundation, Inc., welcomes original reports, short communications and reviews pertaining to the ecology and management of both diurnal and nocturnal predatory birds for publication in *Raptor Research*. Publication in the journal is open to anyone, regardless of current membership in the Raptor Research Foundation, Inc. Contributions are welcomed from throughout the world but must be written in English. **Submit all contributions to the Editor, Clayton M. White, Department of Zoology, 161 WIDB, Brigham Young University, Provo, Utah, 84062, USA.** Referees and associate editors review each manuscript submitted for originality of data, ideas or interpretation, for accuracy, conciseness, and clarity. With the exception of abstracts, **manuscripts submitted for consideration must not have been published or concurrently be under consideration for publication elsewhere.**

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Submit a typewritten original and **two** copies of the text, tables, figure headings, and all other materials for use by the referees. Submit three copies of all illustrations. All typewritten material must be **double-spaced** on one side of $8\frac{1}{2} \times 11$ -inch ($21\frac{1}{2} \times 28$ cm), good quality, bond paper, with at least 1 inch ($2\frac{1}{2}$ cm) margins. Do not use erasable, mimeo, or light-weight bond paper. Copies may be Xerox or carbon reproductions of good, clear quality. Number pages through the Literature Cited section of the manuscript. Type the author's name in the upper right-hand corner of every page. Submit each table on a separate unnumbered page; combine legends for illustrations on one unnumbered page whenever possible. Material submitted in tables or illustrations should not be repeated in the text of the manuscript. Write mathematical formulas on one line whenever possible. Each manuscript should include a cover page containing a concise, informative, full title, a shortened version of the title (not to exceed 35 characters in length) to be used as a running head, and the name(s) of the author(s) as it should appear in print. Avoid footnotes and hyphenation.

Address for each author at the time the research was conducted should be listed at the end of the manuscript following the Literature Cited section. Present address of author(s), if different, should be listed, as well as name and full address to whom proof is to be sent. If you are no longer associated with the institution where the research was conducted, but you wish to credit that institution, it may be mentioned first.

Provide an abstract for each manuscript more than four double-spaced typewritten pages in length. Abstracts are submitted as a separate section from the main body of the manuscript and should not exceed 5% of the length of the manuscript. The abstract should recapitulate the overall findings of the research and should be suitable for use by abstracting services.

Authors should cite the scientific and (if any) common names of all species at first mention in **both** the abstract and the main text of the manuscript. Names for birds should follow those in the A. O. U. Check-list of North American Birds (sixth ed., 1983), or an appropriate equivalent. Subspecific identification should only be cited when pertinent to material presented in the manuscript. In all cases where the scientific and common names are cited together, the common name should be placed first.

Metric units should be cited for **all** measurements in accordance with Système International D'Unite (SI) notation and conventions. Abbreviations of statistical terminology and mensural units should conform with the Council of Biology Editors (CBE) Style Manual (fourth ed., 1978, American Institute of Biological Sciences, 1401 Wilson Blvd., Arlington, Virginia, 22209, USA). Use the 24-hour

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RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

VOLUME 18, NUMBER 2, SUMMER 1984
(ISSN 0099-9059)



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Published quarterly by The Raptor Research Foundation, Inc. Business Office: DR. GARY E. DUKE, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 18

SUMMER 1984

No. 2

HEPTACHLOR SEED TREATMENT CONTAMINATES HAWKS, OWLS, AND EAGLES OF COLUMBIA BASIN, OREGON

CHARLES J. HENNY, LAWRENCE J. BLUS AND T. EARL KAISER

ABSTRACT - We evaluated organochlorine residues in 12 species of hawks, owls, and eagles from the Columbia Basin of Oregon between 1978 and 1981. Companion studies showed that heptachlor epoxide (HE) induced adult mortality and reduced productivity of the Canada Goose (*Branta canadensis*) and American Kestrel (*Falco sparverius*). In this study, brain tissue from raptors found dead and sample eggs from 90 nests were analyzed for organochlorines. The primary concern was HE that entered raptor food chains through the ingestion of heptachlor-treated seed by their prey. HE residues were detected in eggs from 9 of 10 species and ranged as high as 4.75 ppm (wet wt), but no definite effects of HE on productivity were readily apparent from the limited series of nests. However, the hazard of heptachlor seed treatments to birds of prey was demonstrated by the occurrence of lethal residues of HE in brain tissue of 3 Golden Eagles (*Aquila chrysaetos*) and 1 Rough-legged Hawk (*Buteo lagopus*). Other organochlorine pesticides were present in the eggs and significant relationships were found between DDE and eggshell thickness for the Swainson's Hawk (*Buteo swainsoni*) and Western Screech-Owl (*Otus kennicotti*), although shell thinning (9.6% and 7.4%) was below the generally accepted range where reproductive problems have been known to occur.

The history of heptachlor as a wheat seed treatment to control wireworms in Umatilla and Morrow counties, Oregon, is poorly understood. Through 1970, it was listed in the *Pacific Northwest Insect Control Handbook* (Anon., various dates) after aldrin and dieldrin, with an application rate on seed of 1 oz/bu (about 1,000 ppm). It was not listed in 1971, 1972, and 1973. Then from 1974, heptachlor was listed at 2 oz/bu (about 2,000 ppm). In 1979, heptachlor seed treatments were banned in a 1700 km² area near the Umatilla National Wildlife Refuge (NWR), and by 1981, there appeared to be a nearly complete changeover from heptachlor to lindane as a seed treatment in our study area. As of September 1982, production of heptachlor for use as a seed treatment in the United States was prohibited; however, there was a provision for using up existing stocks.

In 1976 and 1977, die-offs of several species of birds occurred in Umatilla and Morrow counties, Oregon. Residues of HE that are considered lethal (Stickel et al. 1979) were found in brain tissue of the Ring-necked Pheasant (*Phasianus colchicus*), California Quail (*Callipepla californica*), Canada Goose, Black-billed Magpie (*Pica pica*), and Golden Eagle (Blus et al. 1979). This history of wildlife mortality associated with heptachlor seed treatment of wheat prompted a detailed study of Canada

Geese nesting at Umatilla NWR (Blus et al. 1979), and a study of American Kestrels nesting throughout the region (Henny et al. 1983). Both studies showed heptachlor-induced adult mortality. Furthermore, although HE did not thin eggshells, reduced nesting success was correlated with increased HE residues in eggs of both species. The kestrel was more sensitive to HE residues in eggs than was the Canada Goose (i.e., reduced productivity occurred at > 1.5 ppm [wet wt] in kestrel eggs vs. > 10 ppm in Canada Goose eggs).

We reasoned that Canada Geese were obtaining heptachlor directly from the ingestion of treated seeds; however, the diet of American Kestrels is mainly insects (especially grasshoppers) but includes mice, small birds and some lizards and amphibians (Fisher 1893). Therefore, the presence of HE in kestrel eggs indicated contamination of the food chain of at least one species of hawk.

This study was designed (1) to determine if HE entered food chains of other species of hawks and owls nesting in the region, and (2) to evaluate the success or failure of each nesting attempt in relationship to organochlorine residues in the sample egg collected. The egg data provides insight into residue concentrations that affect reproductive success of the various species although more information of this type is needed. Also, brain tissue of

birds of prey found dead were analyzed to determine if mortality was related to organochlorine contaminants.

METHODS

We collected a sample egg from 90 raptor nests located in Umatilla and Morrow counties, Oregon in 1978-81. The remainder of the eggs were monitored for hatchability and fledging rates. Since a sample egg was collected from each nest for organochlorine analysis, some productivity values were not directly comparable to other published studies. Nest boxes were placed in the region to attract American Kestrels, but Western Screech-Owls and the Northern Saw-whet Owl (*Aegolius acadicus*) also used them. The Burrowing Owl (*Athene cunicularia*) used artificial burrows (Henny and Blus 1981).

The sample eggs were refrigerated until opened. Contents were placed in a chemically cleaned jar and frozen for later analysis. Shell thickness (shell and shell membranes) was measured at 3 sites on each egg equator with a micrometer graduated in units of 0.01 mm. Historical eggshells (pre-1947) were measured at 3 museums in Oregon and Washington. One randomly selected egg from each clutch was measured.

Samples were homogenized and subsamples extracted by a Soxhlet apparatus and cleaned by Florisil-column chromatography. Polychlorinated biphenyls (PCB's) were separated from pesticides by silicic acid column chromatography (Cromartie et al. 1975 and Kaiser et al. 1980). All samples were analyzed for DDE, DDD, DDT, dieldrin, heptachlor epoxide, mirex, oxychlordane, *cis*-chlordane, *cis*-nonachlor, *trans*-nonachlor, endrin, toxaphene, hexachlorobenzene, and PCB's. Additionally, samples in 1978, 1980 and 1981 were analyzed for lindane, samples in 1978 and 1981 for β -BHC, and samples in 1978 for pentachloronitrobenzene (it was not detected).

Residues were quantitated by electron-capture gas-liquid chromatography using either a 1.5/1.95% OV-17/QF-1 or a 1.5/1.95% SP-2250/2401 column. Recoveries from fortified chicken eggs ranged from 83-104%. Residue levels were not corrected for recovery. A few samples from 1978 were analyzed at the Denver Wildlife Research Center (Peterson et al. 1976). Residues in 8% of the samples were confirmed on a Finnigan 4000 series gas chromatograph/mass spectrometer (Kaiser et al. 1980). The lower limit of residue quantification was 0.1 ppm for pesticides and 0.5 ppm for PCB's. For statistical purposes, the lower limit of quantification was divided in half and that value assigned to samples in which the contaminant was not detected. Statistical calculations were not performed unless 75% of the samples contained detectable residues. Contents of eggs were converted to an approximate fresh wet wt by use of egg volume (Stickel et al. 1973); residue concentrations were then expressed on an estimated fresh wet wt basis. A t-test was used to determine significant ($P \leq 0.05$) changes in eggshell thickness. The mean clutch size and mean number of young fledged was not calculated unless ≥ 6 nest records were available.

RESULTS AND DISCUSSION

The largest series of eggs was obtained from the Swainson's Hawk (25 nests) and Long-eared Owl (*Asio otus*) (21 nests), but because the preponderance of data pertain to either 1978 or 1979, a statis-

tical analysis of the residue changes over time was not advisable. A ban on heptachlor seed treatments near the Umatilla NWR in 1979 resulted in an immediate lowering of HE concentrations in kestrel eggs the following year (Henny et al. 1983).

Hawk Eggs. — Heptachlor epoxide was detected in the majority of eggs sampled among the buteos, i.e., Swainson's Hawk (21 of 25, 84%), Ferruginous Hawk (*Buteo regalis*) (9 of 10, 90%), and Red-tailed Hawk (*B. jamaicensis*) (5 of 6, 83%) (Table 1). DDE was detected at about the same frequency as HE in all 3 species: Swainson's Hawk (23 of 25, 92%), Ferruginous Hawk (8 of 10, 80%), and Red-tailed Hawk (5 of 6, 83%). Dieldrin was frequently detected in Swainson's Hawk eggs (13 of 25, 52%), but was virtually absent from the Ferruginous Hawk (0 of 10) and Red-tailed Hawk (1 of 6) eggs.

Residues in sample eggs were tabulated from the highest to the lowest to ascertain if residues influenced nesting success. Although sensitivity to contaminants varies from species to species, we know American Kestrel nesting success declined when HE egg residues increased above 1.5 ppm (Henny et al. 1983). With the Swainson's Hawk, 15 of 21 nests (71%) with < 1.5 ppm HE were successful with 26 young fledged (1.24 per nesting attempt) which was judged good to excellent. (Note: 1 egg was collected which reduced the number fledged). Only 4 nests contained ≥ 1.5 ppm HE (2 were successful and fledged 4 young or 1.00 per nesting attempt). Four of 5 Swainson's Hawk nests with the highest DDE residues (5 to 10 ppm) in eggs were successful and produced 10 young (2.00 young/nest). Two successful Swainson's Hawk nests in 1976 contained DDE residues of 4.35 and 7.13 ppm and produced 3 young and 1 young, respectively (Henny and Kaiser 1979). When the 10 nest records from 1976 were combined with 25 nests in this study, regression analysis indicated a significant logarithmic relationship between DDE and eggshell thickness ($Y = 0.393 - 0.022 \log_{10}X$, $r = -0.40$, $P < 0.02$). The same method showed no significant relationship between HE and eggshell thickness ($Y = 0.393 + 0.002 \log_{10}X$, $r = 0.04$, $P > 0.05$). Eggshell thickness ($\bar{x} \pm SE$) during this study was 0.387 ± 0.007 mm which was 9.6% thinner ($P < 0.01$) than the pre-DDT era (before 1947) mean of 0.428 ± 0.005 mm in the Pacific Northwest (Henny and Kaiser 1979). This amount of thinning was less than the generally accepted 18-22% range where reproductive problems occur (Lincer 1975).

Bechard (1981) collected a sample egg from 6 Swainson's Hawk nests in nearby southeastern Washington in 1977 and 1978. At least 1 young was fledged from each nest. Low DDE residues (ppm wet wt) were reported in 5 eggs (0.20, 0.68, 1.2, 1.4, 2.9) and low HE residues in 2 eggs (0.11, 0.35).

Neither the Ferruginous nor the Red-tailed Hawk eggs contained HE above 1.5 ppm (the effect zone observed for the American Kestrel), and DDE residues were generally low. Shell thickness for the Red-tailed Hawk was identical (0.420 ± 0.017 mm) to pre-1947 thickness from the northern prairies (Anderson and Hickey 1972); whereas, the small series of Ferruginous Hawk eggs showed a significant ($P < 0.01$) shell thickness increase

(0.485 ± 0.006 mm, $n = 10$ vs. 0.451 ± 0.008 mm, $n = 14$) in comparison to eggs collected in Oregon and Washington before 1947. Ferruginous Hawk eggs collected from 6 nests in southcentral Idaho in 1979 contained low residues (ppm wet wt) of DDT and its metabolites (highest value 0.65) and low residues of HE (highest value 0.10) (Thurow et al. 1980). HE residues in Swainson's and Ferruginous Hawk eggs from this study were higher than reported from eggs collected in adjacent states during the same time period.

Four Northern Harrier (*Circus cyaneus*) eggs and 2 Prairie Falcon (*Falco mexicanus*) eggs all contained HE and DDE (Table 1).

Owl Eggs. — Heptachlor epoxide was detected

Table 1. Clutch size, fledging success, eggshell thickness, and organochlorine residues (ppm wet wt) in eggs of hawks nesting in Umatilla and Morrow counties, Oregon, 1978-80.

Year	Clutch size ^a	Fledged	Shell Thickness (mm)	HE	OXY	DDE	Dieldrin	HCB	TRNO
Swainson's Hawk									
1979	4	1	0.480	2.95	0.31	0.76	0.49	0.19	0.10
1978 ^b	4	3	0.383	2.93		2.16			
1979	2	0	0.372	2.82	0.23	10.34			1.03
1979	3	0	0.360	2.52	0.28	1.15	0.52	2.62	0.58
1979	2	0	0.418	1.42		0.21			
1979	2	1	0.391	1.31	0.14	1.87			0.14
1979 ^c	4	3	0.365	1.20	0.11	10.41	0.11		
1979	4	3	0.430	0.93		0.66	0.14		
1979	3	0	0.417	0.67		0.21	0.45		
1980	?	1	0.429	0.64	0.13		0.10		
1979	3	0	0.353	0.50		0.45			
1979 ^c	4	3	0.335	0.36		8.74	1.34		
1979 ^d	3	0	0.378	0.35	0.13	1.28	0.33		
1979	3	0	0.398	0.26			0.10		
1980	2	0	0.351	0.25		0.28	0.17		
1979 ^e	4	3	0.370	0.23		7.50	0.10		
1979	3	1	0.359	0.23		1.41			
1979	3	1	0.388	0.19		2.66	0.15		
1979	4	2	0.377	0.14		2.96			
1979	3	1	0.430	0.13		0.56			
1978 ^b	?	1	0.371	0.10		0.15			
1978 ^b	3	1	0.346			5.00			
1979	4	2	0.381			1.56			
1979	3	1	0.404			1.32	0.13		
1979 ^f	4	2	0.397			0.23			
	3.22 ^g	1.20 ^g	0.387 ^g	0.38 ^h		0.98 ^h			

(Table 1 Continued)

(Table 1 Concluded)

Year	Clutch size ^a	Fledged	Shell Thickness (mm)	HE	OXY	DDE	Dieldrin	HCB	TRNO
Ferruginous Hawk									
1978 ^b	4	3	0.475	1.32		3.88			
1979	2	0	0.493	1.08	0.12	2.25			
1979	2	0	0.509	0.56	0.11				0.28
1978 ^b	2	1	0.457	0.49		1.05			
1979	4	2	0.455	0.40		0.65			
1979	4	2	0.512	0.38					
1978 ^b	4	3	0.497	0.17		0.29			
1978 ^b	4	0	0.477	0.14		0.10			
1978 ^b	5	0	0.496	0.10		0.32			
1980	4	2	0.475			1.31			0.30
	3.50 ^g	1.30 ^g	.485 ^g	0.31 ^h		0.42 ^h			
Red-tailed Hawk									
1979	4	0	0.353	1.44	0.17	0.20			
1980	?	2	0.477	1.34	0.14	0.15			
1978 ^b	3	?	0.417	1.22		3.58			
1979	3	2	0.441	0.87	0.22	0.24			0.43
1978 ^b	?	2	0.407	0.14		0.32			
1979	3	2	0.424						
				0.420 ^g	0.49 ^h		0.27 ^h		
Northern Harrier									
1979	6	0 ⁱ	0.315	1.90	0.18	3.61	0.22		
1978 ^b	?	0 ⁱ	0.317	1.06		5.24			
1978	?	0 ⁱ		0.55	0.14	4.15	0.13		
1979	?	0 ⁱ	0.289	0.25		0.61			
				0.307 ^g	0.73 ^h		2.63 ^h		
Prairie Falcon									
1979	5	3	0.372	4.75	0.33	0.86			0.21
1978 ^b	4	?	0.319	1.84		1.11			0.22
				0.346 ^g	2.96 ^h		0.98 ^h		

Note: HE = heptachlor epoxide, OXY = oxychlordane, HCB = hexachlorobenzene, and TRNO = *trans*-nonachlor.

^aBefore sample egg removed. ^bAnalyzed at Denver Wildlife Research Center. ^cAlso, 0.36 or 0.66 ppm toxaphene. ^dAlso, 0.13 ppm DDD. ^eAlso, 1.0 ppm PCB's. ^fRecycled after first nest abandoned. ^gArithmetic mean. ^hGeometric mean. ⁱNests destroyed by farm mowing operations.

less frequently in eggs of the 5 species of owls (Table 2) than in hawk eggs: Western Screech-Owl (5 of 7, 71%), Short-eared Owl (*Asio flammeus*) (3 of 5, 60%), Long-eared Owl (7 of 21, 33%), Burrowing Owl (2

of 6, 33%), and Northern Saw-whet Owl (0 of 4). Our criteria for calculating geometric means (75% of samples with detectable amounts) was not met for HE in any of the owl species. DDE occurred in

eggs at greater frequencies than HE: Western Screech-Owl (6 of 7, 86%), Burrowing Owl (5 of 6, 83%), Long-eared Owl (17 of 21, 81%), Short-eared Owl (4 of 5, 80%), and Northern Saw-whet Owl (1 of 4, 25%). However, the DDE concentrations in owls were low.

Long-eared Owls experienced excellent reproductive success; 16 of 19 nests (84%) were successful. The 3 nests that failed did not contain higher residue concentrations than the successful nests. A test for the logarithmic relationship between DDE and eggshell thickness was not statistically significant ($P > 0.05$). The mean eggshell thickness (0.237 ± 0.003 mm, $n = 21$) was similar to the pre-1947 mean (0.238 ± 0.002 mm, $n = 11$) from Oregon and Washington.

Western Screech-Owl eggs contained some of the higher DDE residues among the owls (Table 2). Although only 7 Western Screech-Owl eggs were collected, a highly significant logarithmic relationship existed between DDE and eggshell thickness ($Y = 0.211 - 0.025 \log_{10}X$, $r = -0.92$, $P < 0.01$). There was no significant relationship ($P > 0.05$) between HE and eggshell thickness. Mean Western Screech-Owl eggshell thickness of 0.212 ± 0.007 mm was 7.4% thinner ($P < 0.01$) than the pre-1947 mean (0.229 ± 0.004 mm, $n = 11$) from Oregon and Washington. Laboratory studies showed that 2.8 ppm (wet wt) of DDE in the diet reduced Eastern Screech-Owl (*Otus asio*) eggshell thickness by an average of 12% (McLane and Hall 1972). Residues of DDE in Eastern Screech-Owl eggs from Ohio in

Table 2. Clutch size, fledging success, eggshell thickness, and organochlorine residues (ppm wet wt) in eggs of owls nesting in Umatilla and Morrow counties, Oregon, 1978-81.

Year	Clutch size ^a	Fledged	Shell Thickness (mm)	HE	OXY	DDE	Dieldrin	HCB	PCB's
Long-eared Owl									
1979	5	4	0.237	1.92	0.25	0.14		0.10	
1979	5	3	0.250	0.65	0.11	0.16			
1979	6	5	0.236	0.61		0.45		1.49	
1979	6	5	0.242	0.49		0.15			
1980	5	?	0.243	0.45	0.19	1.04		0.22	
1980	5	4	0.240	0.15		0.16		0.39	
1978	5	0	0.265	0.14					
1980	5	4	0.218			3.32			
1979	7	5	0.221			1.58			
1979	8	0	0.228			0.90			
1980	5	3	0.250			0.56		0.18	
1980	6	4	0.218			0.44			
1978 ^b	7	2+	0.247			0.42			0.78
1980	5	?	0.236			0.26		0.48	
1980	6	0	0.234			0.25			
1979	6	5	0.208			0.16			
1980	4	3	0.264			0.12			
1980	7	6	0.254			0.10			
1980	5	4	0.231						
1980	5	4	0.231						
1980	5	4	0.218						
	5.62 ^c	3.42 ^c	0.237 ^c			0.24 ^d			

(Table 2 Continued)

(Table 2 Concluded)

Year	Clutch size ^a	Fledged	Shell Thickness (mm)	HE	OXY	DDE	Dieldrin	HCB	PCB's
Western Screech-Owl									
1979	5	4	0.225	3.15	0.39	0.55		0.39	2.76
1979	1 ^e	X	0.189	2.57	0.73	3.94	0.15	0.11	1.01
1980	4	0	0.204	1.03	0.13	0.60			
1978 ^b	?	2	0.206	0.46		1.98			
1979 ^f	3	0	0.201	0.30	0.28	3.43	0.50	0.10	
1980	5	4	0.215			1.06			
1981	4	3	0.243						
	4.20 ^c	2.17 ^c	0.212 ^c			0.90 ^d			
Burrowing Owl									
1981	6	0	0.178	0.19		0.66			
1981	5	0 ^g	0.182	0.16		0.24			
1979	10	7	0.172			0.18			
1980	8	7	0.174			0.14			
1980	10	?	0.180			0.11			
1980	12	10	0.192						
	8.50 ^c		0.180 ^c			0.17 ^d			
Short-eared Owl									
1979	6+	3	0.246	1.70	0.33	0.20		0.51	
1980	4	?	0.277	0.99	0.35	0.29	0.24		
1978 ^b	?	0 ^h	0.216	0.61		1.08			
1979	8	5+	0.235			0.74		0.26	
1979	9	3+	0.258				0.85		
			0.246 ^c			0.30 ^d			
Northern Saw-whet Owl									
1978	5+	3	0.185			0.11			
1979	6	5	0.197						
1981	7	3	0.192						
1981	6	2	0.191						
			0.191 ^c						

Note: HE = heptachlor epoxide, OXY = oxychlordane, HCB = hexachlorobenzene, PCB's = polychlorinated biphenyls.

^aBefore sample egg removed. ^bAnalyzed at Denver Wildlife Research Center. ^cArithmetic mean. ^dGeometric mean. ^eLone egg found in nest box. ^fAlso, 0.96 ppm cis-chlordane. ^gFour hatched but depredated by a Badger (*Taxidea taxus*). ^hNest destroyed by farm mowing operation.

1973 were generally low (arithmetic \bar{x} 1.29 ppm wet wt, range 0.33-2.8) and no relationship was found between hatching failure and presence of organochlorine residues (Klaas and Swineford 1976). For comparison, the arithmetic mean for DDE in this study was 1.65 ppm.

The shell thickness of 6 Burrowing Owl eggs averaged 0.180 ± 0.003 mm which was not significantly different from 6 eggs collected in Oregon and Washington before 1947 (0.191 ± 0.009 mm). Short-eared Owl eggs showed a mean shell thickness of 0.246 ± 0.010 mm which was nearly identical to the 0.245 ± 0.006 mm from 3 eggs collected in Oregon and Washington prior to 1947. Northern Saw-whet Owl eggs had a mean shell thickness of 0.191 ± 0.003 mm; however, no historical eggs were available from the region for comparison. DDE residues were generally < 1 ppm in eggs of these 3 species of owls.

Eagles and Hawks Found Dead. — Although eggs from Golden Eagle nests in the region were not collected, 8 eagles found dead were analyzed (Table 3). Residues of HE in brain tissue of 3 Golden Eagles (7.9, 10, and 13 ppm) were diagnostic of HE poisoning (i.e., > 8 ppm established for experimental birds [Stickel et al. 1979]). The eagle with 4.7 ppm HE died under suspicious cir-

cumstances; it was observed gliding and then fatally diving straight into the ground! Rough-legged Hawks nest in the Arctic and winter in the region, but 1 bird accumulated lethal residues of HE. A nesting American Kestrel died in its nest box with 28 ppm HE in her brain; an egg she laid contained the highest HE concentration among the 261 kestrel eggs collected during a 4-year study (Henny et al. 1983). The birds with lethal HE residues died in March, April, May, and June which is considerably after the fall planting time for heptachlor-treated wheat seeds.

ACKNOWLEDGMENTS

Biological technicians collecting field data for this study included E.G. Huff, R.R. Sheehy, G.A. Green, B.E. Forman, K.D. Hansen, and R.A. Grove. J.E. Kurtz and G.M. Constantino, refuge managers at Umatilla NWR, kindly allowed use of refuge facilities as our field operations center. S.A. Rohwer, Thomas Burke Memorial Museum, Seattle; G.D. Alcorn, University of Puget Sound Museum, Tacoma; and the staff of the University of Oregon Museum, Eugene, assisted in obtaining measurements from pre-DDT era eggs housed at their facilities. E.F. Hill and D.H. White of the Patuxent Wildlife Research Center and G.A. Fox of the Canadian Wildlife Service improved the manuscript with their thoughtful reviews. We thank all who assisted in this effort.

ADDENDA

A Barn Owl (*Tyto alba*) found dead in the study area on 1 January 1984 had the following residues (ppm wet wt) in its

Table 3. Organochlorine residues (ppm wet wt) in brain tissue of eagles and hawks found dead in Umatilla and Morrow counties, Oregon, 1977-80.

Species	Wt (g)	Age	Sex	Date	HE	OXY	DDE	Dieldrin	TRNO	HCB	PCB's
Golden Eagle ^a	2640	Adult	M	30 April 1977	10	0.62	1.1	0.75	0.40	0.29	0.61
Golden Eagle ^b	3600	Adult	M	May-June 1978	13	0.69	0.49		0.43	0.21	
Golden Eagle	4825	Adult	F	Winter 78-79							
Golden Eagle	4500	S Ad	F	Winter 78-79				0.11			
Golden Eagle	3350	S Ad	M	Winter 78-79	0.10						
Golden Eagle	3225	Adult	M	Early 1979	1.5	0.12					
Golden Eagle	4025	Adult	F	3 May 1980	4.7	0.30	1.8		0.12		0.89
Golden Eagle	2900	S Ad	M	17 June 1980	7.9	0.67	1.5	0.26	0.31		1.6
Red-tailed Hawk	1050	Juv	M	10 Feb 1980							
Rough-legged Hawk	728	Juv	F	20 March 1980	20	2.4	0.42		0.34	7.4	
American Kestrel ^c		Adult	F	11 June 1979	28	2.5	0.35		0.95	0.21	

Note: SAd = subadult (has white on tail or wings; see Steenhof et al. 1983), Juv (in second calendar year of life; juvenal plumage); HE = heptachlor epoxide, OXY = oxychlordane, TRNO = *trans*-nonachlor, HCB = hexachlorobenzene, PCB's = polychlorinated biphenyls.

^aFell from sky, hit ground and began convulsing. ^bFound alive; no coordination and some muscle twitching. ^cSee Henny et al. (1983) for details.

brain: heptachlor epoxide 1.1, oxychlordane 0.31, *trans*-nonachlor 0.10, and DDE 0.18. Thus, another raptor species in the area accumulated residues of heptachlor epoxide.

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Received 10 March 1984; Accepted 9 May 1984.

BREEDING ECOLOGY OF BARRED OWLS IN THE CENTRAL APPALACHIANS

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ABSTRACT - Eight pairs of breeding Barred Owls (*Strix varia*) in western Maryland were studied. Nest site habitat was sampled and quantified using a modification of the James and Shugart (1970) technique (see Titus and Mosher 1981). Statistical comparison to 76 random habitat plots showed nest sites were in more mature forest stands and closer to forest openings. There was no apparent association of nest sites with water. Cavity dimensions were compared statistically with 41 randomly selected cavities. Except for cavity height, there were no statistically significant differences between them.

Small mammals comprised 65.9% of the total number of prey items recorded, of which 81.5% were members of the families Cricetidae and Soricidae. Birds accounted for 14.6% of the prey items and crayfish and insects 19.5%. We also recorded an apparent instance of juvenile cannibalism.

Thirteen nestlings were produced in 7 nests, averaging 1.9 young per nest. Only 2 of 5 nests, where the outcome was known, fledged young.

The Barred Owl (*Strix varia*) is a common nocturnal raptor in forests of the eastern United States, though few detailed studies of it have been published. Most reports are of single nesting occurrences and general observations (Bolles 1890; Carter 1925; Henderson 1933; Robertson 1959; Brown 1962; Caldwell 1972; Hamerstrom 1973; Applegate 1975; Soucy 1976; Bird and Wright 1977; Leder and Walters 1980). Habitat was described qualitatively by Nicholls and Warner (1972) and Fuller (1979). Barred Owl food habits were reported by Cahn and Kemp (1930), Errington (1932), Errington and McDonald (1937), Wilson (1938), Mendall (1944), Hamerstrom and Hamerstrom (1951), Blakemore (1960) LeDuc (1970), and Korschgen and Stuart (1972). The food habits studied, however, were all from midwestern states, except Mendall's (1944) study from Maine. Dunstan and Sample (1972) reported the number of fledglings from 1 cavity each year for 5 years, but provided no other productivity information. Clutch sizes in various geographic regions can be found in Bent (1961) and Murray (1976).

This study was conducted in an area where 4 diurnal raptor species, the Red-shouldered Hawk (*Buteo lineatus*), Broad-winged Hawk (*B. platypterus*), Red-tailed Hawk (*B. jamaicensis*) and Cooper's Hawk (*Accipiter cooperi*), were also under study (see Titus and Mosher 1981, Janik and Mosher 1982). Our objectives were to quantitatively describe vegetation structure at Barred Owl nest sites and compare it with surrounding habitat, measure and compare dimensions of cavities used by them with those from randomly selected cavities, describe their food habits for this geographic region, and determine their breeding chronology and productivity.

STUDY AREA AND METHODS

The study was conducted in Green Ridge State Forest (GRSF), Allegany County, Maryland. It is within the Ridge and Valley physiographic region (Stone and Matthews 1977), characterized by narrow mountain ridges oriented northeast to southwest separated by steep narrow valleys (see Titus 1980).

About 74% of the county and nearly all of GRSF is forested. Major forest types were described by Brush et al. (1980). Predominant tree species include white oak (*Quercus alba*), red oak (*Q. rubra*), chestnut oak (*Q. prinus*), scarlet oak (*Q. coccinea*), red maple (*Acer rubrum*), and pignut and mockernut hickories (*Carya glabra* and *C. tomentosa*). Predominant understory species include flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), serviceberry (*Amelanchier* spp.), and saplings of the dominant trees.

The study area was systematically searched for active nests from late February through May in 1981 and 1982. During 1982, tape recorded Barred Owl calls were broadcast in order to elicit responses and help localize nesting pairs.

Nest sites were plotted on 7.5 min USGS topographic maps and County Soil Conservation Service maps. A nest site was defined as a 0.4 ha plot (11.3 m radius) centered on the nest tree. This size plot was considered more time and field efficient than either smaller or larger size plots when making quantitative estimates of the vegetation (Lindsey et al. 1958, James and Shugart 1970).

Nests were checked periodically each season to obtain nesting chronology and productivity information. At the same time, regurgitated pellets found in the cavities were collected and any prey remains were noted.

At the end of the nesting season, vegetation at each active nest site was sampled using a modification of the James and Shugart technique (1970), as described by Titus and Mosher (1981). Thirty-four variables were measured or derived at each site (Table 1). The type of cavity in which a pair nested (hollow tree stub, hole from disease, excavated hole, or hole from broken limb) and successional stage of the cavity tree (Fig. 1) were recorded.

Height to cavity entrance was measured with a meter tape for trees climbed, otherwise height measurements and percent slope were measured with a Haga altimeter. Percent canopy, understory and ground covers were based on 40 ocular tube readings, 10 along each of 4 transects starting at the nest tree and extending in each of the cardinal compass directions.

We compared nest site data with random habitat samples collected by Titus and Mosher (1981) to determine if vegetation structure around nest trees differed from surrounding habitat. Variables measured at random plots are listed in Table 1 except

Table 1. Quantitative habitat variables and cavity characteristics used in analysis of Barred Owl nest site habitat

1. ALTITUDE	Altitude of plot in meters; taken from U.S.G.S. 7.5-min. quadrangles
2. SOIL	Soil-woods suitability; measures suitability for tree productivity; class 1 indicates high productivity and class 6 indicates low productivity (Stone and Matthews 1977)
3. SITindx	Site index; based on SOIL and the tree species present in the plot (Stone and Matthews 1977)
4. WATER	Distance to water in meters
5. DISFOROP	Distance to the nearest forest opening in meters; measured to the nearest break in forest continuity, such as created by trail, road, field, etc.
6. PERSLOP	Percent slope of plot
7. CANHT	Canopy height of the plot in meters; the mean of 5 measurements taken to the top of the canopy
8. CANEVER	Percentage evergreen canopy cover
9. CANTOT	Percentage total canopy cover
10. UNDEVER	Percentage evergreen understory cover
11. UNDTOT	Percentage total understory cover
12. GRNDEVER	Percentage evergreen ground cover
13. GRNDTOT	Percentage total ground cover
14. SHRUBDEN	Shrub density (James and Shugart 1970, James 1978)
15. SHRUBIND	Shrub index (Titus 1980)
16. NOSPTREE	Number of species of overstory trees in the plot
17. NOSPSHRB	Number of species of shrubs and saplings in the plot
18. NOTREES	Number of overstory trees in the plot
19. UND14	Number of understory stems 1-4 cm diameter in the plot
20. UND58	Number of understory stems 5-8 cm diameter in the plot
21. UNDGT8	Number of understory stems greater than 8 cm diameter in the plot
22. DBHLT26	Number of overstory trees less than 26 cm dbh in the plot
23. DBH2650	Number of overstory trees 26-50 cm dbh in the plot
24. DBHGT50	Number of overstory trees greater than 50 cm dbh in the plot
25. BASAL	Basal area in m ² /ha for overstory trees
26. DBH*	Diameter at breast height of nest tree
27. TREEHT*	Height of cavity tree in meters
28. CAVHT*	Height to lowest point of cavity entrance in meters
29. %CAVHT*	Percentage cavity height; calculated as: (CAVHT/CANHT) (100) = %CAVHT
30. TREEDIAM*	Diameter of cavity tree at cavity height
31. HORIZONT*	Horizontal length of cavity opening in cm
32. VERTICAL*	Vertical length of cavity opening in cm

(Table 1 continued)

(Table 1 concluded)

33. CAVDIAM* Inside diameter of cavity in cm; measured from inside of entrance to back wall; for hollow tree stubs, the largest diameter is recorded
34. CAVDEPTH* Cavity depth in cm; measured from lowest point of cavity entrance to base of cavity.

(* = variables unique to cavities and cavity trees).

for the cavity and cavity tree specific variables.

Dimensions of 41 randomly selected, unoccupied cavities were measured and compared with nest cavities to provide a measure of cavity sizes available to Barred Owls and assess cavity selection. The random sampling of cavities was stratified. Transects, approximately 100 m apart, 1.6 km long extending on both sides of a road running the length of the study area, were randomly chosen. A coin flip determined which side of the road the transect was walked. Every third cavity encountered was measured but no more than 3/transect to avoid measuring too many within a single habitat type. The criteria for accepting a random cavity was that it be at least 2 m from the ground and have at least a 15 cm diameter opening, or, for a hollow tree stub, a 25 cm dbh.

Minimum sample sizes were calculated for each variable to determine if random sampling was adequate. Sample sizes were considered adequate if they met the criteria of remaining within 20% of the mean for 95% of the samples. Twenty of 25 variables pertaining to habitat structure met this criteria with < 76 samples. Seven of 9 cavity and cavity tree variables met this criteria with sample sizes of < 41.

Habitat data were subjected to nonparametric statistical analyses conducted on the Statistical Package for the Social Sciences (SPSS) computer program (Nie et al. 1975, Hull and Nie 1981). Two sets of Kruskall-Wallis one-way analysis of variance

(Siegal 1956) tested for similarity between nest site habitat and random habitat plots, and nest site cavity and random cavity dimensions. Spearman rank correlation coefficients (Siegal 1956) were calculated to determine the extent of correlation among structural features of habitat and among cavity characteristics. χ^2 goodness-of-fit tests were used on pooled samples of nest site and random cavities to determine if differences existed among the number of each cavity type found and number of cavity trees in each successional stage. Test results were considered significant if $P < 0.05$.

RESULTS AND DISCUSSION

Habitat. — Eight-Barred Owl nests were located. The 4 found in 1981 were not reused in 1982. Nest site habitat and random habitat plots were significantly different between groups for 7 of 25 variables (Table 2). Nest sites were found significantly closer to forest openings than random sites, in habitats with well developed understories. Percent under-story cover and the number of stems greater than 8 cm diameter, both positively correlated with each

Table 2. Means \pm standard deviations and ranges of habitat variables at Barred Owl nest sites and random habitat plots, and results from Kruskal-Wallis one-way ANOVA (chi-square statistic) testing for significant differences between groups.

Habitat variable ^a	Barred owl nest sites (N = 8)	Random sites (N = 76)	Kruskal-Wallis χ^2 value
ALTITUDE	1239 \pm 517 (820 – 2420)	1356 \pm 613 (560 – 2860)	0.084
SOIL	3.6 \pm 1.4 (1 – 6)	3.9 \pm 1.3 (1 – 6)	0.093
SITINDX	65 \pm 11.7 (45 – 85)	61.4 \pm 12.5 (40 – 90)	0.410
WATER	218 \pm 222 (15 – 675)	320 \pm 243 (35 – 1050)	1.860

(Table 2 continued)

(Continuation of Table 2)

Habitat variable ^a	Barred owl nest sites (N = 8)	Random sites (N = 76)	Kruskal-Wallis X ² value
DISFOROP	85 ± 116 (4 - 350)	221 ± 209 (8 - 1110)	7.481**
PERSLOP	9.4 ± 12.9 (0 - 40)	21.6 ± 13.3 (3 - 80)	0.107
CANHT	23.5 ± 3.3 (19 - 28)	20.6 ± 4.5 (10 - 31)	2.991
CANEVER	7 ± 13 (0 - 32)	6 ± 14 (0 - 53)	0.019
CANTOT	68 ± 21 (30 - 98)	75 ± 9 (43 - 90)	0.230
UNDEVER	0	2 ± 7 (0 - 37)	0.535
UNDTOT	67 ± 14 (50 - 90)	53 ± 14 (17 - 80)	5.120*
GRNDEVER	0	.5 ± 3 (0 - 30)	0.059
GRNDTOT	43 ± 13 (23 - 68)	38 ± 16 (10 - 75)	0.893
SHRUBDEN	23 ± 19 (5 - 68)	24 ± 11 (3 - 64)	1.074
SHRUBIND	42 ± 23 (10 - 83)	50 ± 21 (14 - 115)	1.220
NOSP TREE	4.5 ± 1.7 (3 - 7)	4.6 ± 1.8 (1 - 10)	0.046
NOSPSHRB	11.4 ± 2.8 (8 - 16)	10.1 ± 2.9 (5 - 17)	1.395
NOTREES	10.9 ± 3.6 (4 - 17)	19.5 ± 10) (7 - 48)	7.315**
UND14	69.8 ± 34.9 (28 - 131)	74.3 ± 33.3 (9 - 154)	0.245
UND58	17.5 ± 8.8 (3 - 33)	12.7 ± 8.7 (1 - 45)	2.874

(Table 2 continued)

(Table 2 concluded)

Habitat variable ^a	Barred owl nest sites (N = 8)	Random sites (N = 76)	Kruskal-Wallis X^2 value
UNDGT8	9.5 ± 3.7 (4 - 16)	5.9 ± 3.6 (0 - 14)	5.870*
DBHLT26	5.1 ± 3.2 (0 - 10)	14.7 ± 11.6 (0 - 48)	6.554**
DBH2650	3.9 ± 2.2 (2 - 8)	4.6 ± 2.8 (0 - 12)	0.665
DBHGT50	1.8 ± 1.2 (0 - 4)	0.2 ± 0.6 (0 - 3)	12.714***
BASAL	28.4 ± 5.8 (21.7 * 40.1)	20 ± 5.5 (3.9 - 34.2)	11.755***

^aMnemonic names defined in Table 1.

(* = P < 0.05; ** = P < 0.01; *** = P < 0.001).

other ($r = 0.24$, $P = 0.03$, $N = 84$), were significantly higher at nest sites. There were fewer over-story trees, because of fewer trees in the < 26 cm dbh size class. There were significantly more trees > 50 cm dbh at nest sites (45/ha vs 5/ha at random sites), and greater basal area.

These results are in general agreement with the qualitative habitat descriptions provided by previous authors (i.e., Barred Owls utilize forest stands mature enough to provide suitable nesting cavities). Craighead and Craighead (1969) suggested one of the reasons Barred Owls were absent from part of their study area was a lack of mature basswoods (*Tilia* sp.) and a lack of heart rot fungus in woodlots that had mature trees. However, owls are known to nest in old hawk or squirrel nests, as did 1 pair in this study, and 23 of 38 pairs reported by Bent (1938). Bent suggested that they choose alternative nests because of lack of cavities. Hilden (1965) and Temple (1977) indicated that birds may shift from their traditional nesting sites by imprinting on the type of nests from which they fledge. If this occurs in Barred Owls, those raised in old hawk or squirrel nests may subsequently use these nest types regardless of cavity availability.

Much literature on Barred Owls indicates an apparent association with wet areas (Carter 1925, Erington and McDonald 1937, Bent 1938, Applegate

1975, Soucy 1976), perhaps because such areas are often inaccessible or too wet to be logged, thereby providing old growth timber and abundant nesting cavities. We found no difference in the proximity to water between nest sites and random habitat plots. The average distance to water was 218 m with only 1 nest located on a stream "floodplain". Furthermore, Nicholls and Warner (1972) and Fuller (1979), both radiotelemetry studies, reported that Barred Owls utilized oak-upland habitat more frequently and consistently than any other habitat type including white cedar (*Thuja occidentalis*) swamps, alder (*Alnus* spp.) swamps, and marshes. Nicholls and Warner (1972) suggested that owls used upland sites because of more suitable nest sites, abundance of hunting perches, open understory for hunting, and the opportunity to hear prey better in dry areas.

Bent (1938) reported that distribution of Barred Owls in southern New England coincides with Red-shouldered Hawks and noted they are often found in the same woodlot. In this study, forest structure around Barred Owl nest sites was similar to that of sympatric Red-shouldered Hawks, both species utilizing old growth timber for nesting. Six of the 7 significant variables listed in Table 2 were also significant for the Red-shouldered Hawk (Titus and Mosher 1981). Apparent differences

between them were that Red-shouldered Hawk nests were no closer to forest openings than random habitat plots, but were significantly closer to water, and there was a higher shrub density at Red-shoulder occupied sites.

Cavities. — Six Barred Owl nests were in the top of hollow tree stubs, 1 in a cavity created by disease and 1 in an old stick nest. The high incidence of hollow tree stubs as nest sites is probably a reflection of cavity type availability in this area. Sixty-nine percent of the total number of cavities measured were hollow tree stubs, significantly more than the

other 3 types ($X^2 = 54.17$, 3 df, $P < 0.05$). Twenty-three percent were holes, resulting from broken limbs and 8% were holes created by disease. No excavated holes were found that met the criteria to be included in the random cavity sample. Four of the 7 nesting cavities were in trees in the second successional stage (see Fig. 1) and 1 each in the third, fourth and fifth stages. There was no statistical difference in the total number of cavity trees in each of the 5 successional tree stages ($X^2 = 9.29$, 4 df, $P < 0.05$).

There was a significant difference between ran-

Table 3. Means \pm standard deviation and ranges of cavity and cavity tree dimensions for Barred Owl nest site cavities and random cavities, and results from Kruskal-Wallis one-way Anova (chi-square statistics) testing for similarity between groups.

Cavity variable ^a	Nest site cavities	N	Random cavities	N	Kruskal-Wallis X^2 square value
DBH	61 \pm 15 (42 – 88)	7	53 \pm 13 (26 – 90)	41	1.652
TREEHT	15.4 \pm 5.8 (10 – 25)	7	12.9 \pm 7.1 (3 – 24)	41	1.137
CAVHT	9.1 \pm 2.9 (4 – 14)	7	6.3 \pm 3.1 (2 – 17)	41	5.5999*
%CAVHT	39 \pm 11 (17 – 50)	7	30 \pm 14 (10 – 71)	41	2.724
TREEDIAM	46 \pm 8 (36 – 54)	4	48 \pm 11 (25 – 69)	33	0.048
HORIZONTAL	15 \pm 0	1	21 \pm 8 (12 – 40)	12	2.571
VERTICAL	45 \pm 0	1	49 \pm 35 (20 – 140)	12	2.571
CAVDIAM	33 \pm 8 (22 – 41)	6	30 \pm 10 (11 – 60)	33	0.985
CAVDEPTH	54 \pm 44 (3 – 130)	6	167 \pm 203 (0 – 800)	33	0.767

^aMnemonic names defined in Table 1.

(* = $P < 0.05$).

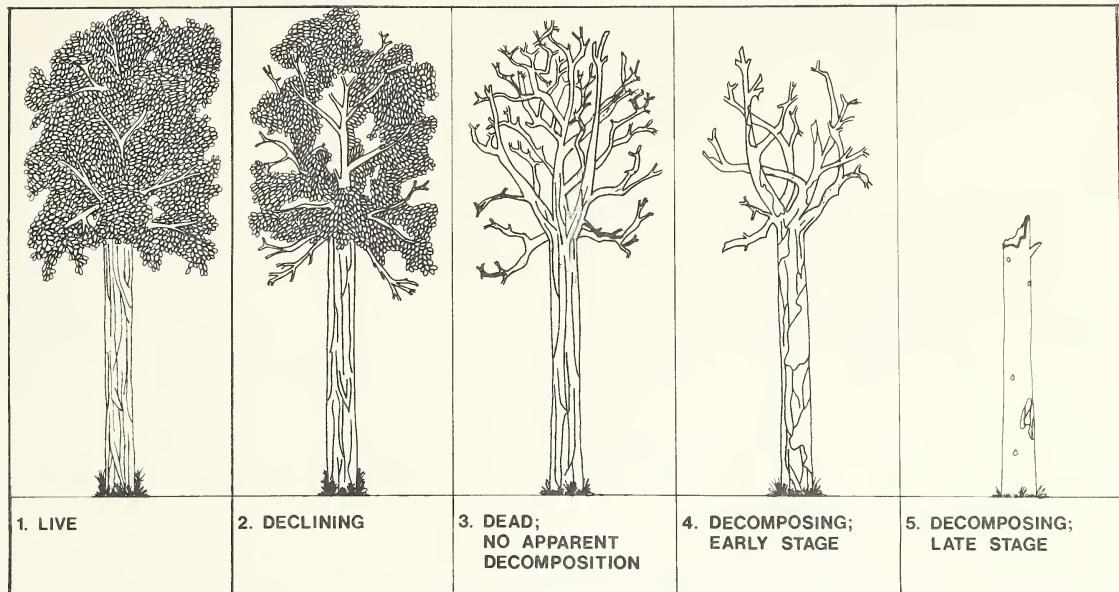


Figure 1. Successional stages for describing Barred Owl cavity trees: 1. LIVE - tree is apparently healthy except for cavity; 2. DECLINING - tree is obviously declining; losing leaves; some dead branches; 3. DEAD; NO APPARENT DECOMPOSITION - no leaves; tree still has all or most of bark; some branches may be broken; no apparent rotting of wood; 4. DECOMPOSING; EARLY STAGE - many broken branches; bark falling off; wood becoming soft in spots; 5. DECOMPOSING; LATE STAGE - little or no bark on tree; very soft wood; broken tree stub is often all that remains

dom and nest site cavity dimensions for only 1 of 9 variables (Table 3). Cavities used by owls averaged 3 m higher than random cavities. Cavity depth of nest site cavities was highly variable, ranging from 3 - 130 cm. Bent (1938) recorded a depth for 1 Barred Owl cavity of 244 cm.

The cavity data suggest that most cavities, given certain minimum dimensions, may be suitable for nesting. Nest trees generally have at least a 25 cm dbh and those with cavities 9 m or more above ground may be preferred. Most reported dimensions (Bent 1938; Allin 1944; LeDuc 1970; Dunstan and Sample 1972; Soucy 1976 Leder and Walters 1980) are less than the maximum cavity dimensions we found. Few data exist on the length and/or width of cavity openings. Hamerstrom (1972) recommended a 20 cm dia opening when constructing a nest box for this species but did not indicate the basis for this measurement. Forsman (1975) reported a range of cavity entrance widths of 15.2 - 55.9 cm for 10 cavities used by the closely related Spotted Owl (*Strix occidentalis*).

Food Habits. — Barred Owl food habits in the GRSF region are summarized in Table 4. The per-

cent occurrence of mammals and birds is fairly typical of what has been reported in the literature. Fish, reptiles, amphibians, and arthropods have also been recorded as prey items but are probably more important to individual owl pairs than to a regional population. The majority of crayfish recorded as prey in this study, for example, were from 2 nests.

Jaksic (1982) hypothesized that temporal segregations of falconiform and strigiform raptors may not reduce competition for food between groups. However, his data for Barred Owls revealed little dietary overlap with falconiform species, except with the American Kestrel (*Falco sparverius*). We also observed little overlap. Sciuridae mammals were clearly the major prey for the 4 hawk species on the study area (Janik and Mosher 1982), while Cricetidae and Soricidae species, which accounted for 81.5% of the mammals and 53.7% of the total number of prey items, were the predominant prey for owls. Furthermore, Flying Squirrels and Crayfish, both nocturnal and not recorded as prey items for the hawks, comprised 8.5% and 12.2% of the total number of prey items recorded, respectively.

Table 4. Food habits of Barred Owls in the Central Appalachians^a.

Prey Species	Occurrence	%
Mammals		
Southern Flying Squirrel (<i>Glaucomys volans</i>)	7	
Shorttail Shrew (<i>Blarina brevicauda</i>)	7	
<i>Peromyscus</i> spp.	5	
Meadow Vole (<i>Microtus pennsylvanicus</i>)	4	
Eastern Chipmunk (<i>Tamias striatus</i>)	2	
Red Squirrel (<i>Tamiasciurus hudsonicus</i>)	1	
Unidentified <i>Cricetidae</i> sp.	16	
Unidentified <i>Soricidae</i> sp.	12	
Total	54	65.9
Birds		
Scarlet Tanager (<i>Piranga olivacea</i>)	3	
Eastern Phoebe (<i>Sayornis phoebe</i>)	2	
Blue Jay (<i>Cyanocitta cristata</i>)	1	
Unidentified	6	
Total	12	14.6
Arthropods		
Crayfish (<i>Cambarus</i> sp.)	10	
Unidentified insects	6	
Total	16	19.5
Total Items	82	100.0

^aBased on prey remains and analysis of pellets from seven nests.

One nestling, about 28 d old, was cannibalized by its sibling. Most of its body was eaten; legs, and skin and feathers of the back were all that remained. Based on growth measurements being taken every 3 to 4 d, both nestlings appeared healthy and were of relatively equal size at 27 d old. The cause of death was unknown but fratricide in raptors usually occurs shortly after the second young hatches (Stinson 1979) and among nestlings of considerable size difference (Ingram 1959), neither of which were the case in this incident. Juvenile cannibalism is not an uncommon occurrence among raptors, but to our knowledge has not previously been documented for Barred Owls.

Nesting Chronology and Productivity.—Nesting chronology and productivity parameters are summarized in Table 5. Hatch dates were fairly consistent among nests, 5 out of 6 hatching within 7 d of each other. Mean egg dates indicate Barred Owls

begin nesting about 1 wk before Red-tails (Janik 1980), the earliest nester of the hawk species for this area.

Average clutch size/nest was 2.3, slightly higher than the 2.0 reported by Murray (1976) for Barred Owls in this region and latitude. A total of 13 nestlings were produced in 7 nests, averaging 1.9 young/active nest. The outcome of 5 nests was known. Of these, only 2 fledged young. The eggs rolled out of 1 nest and the nestlings in the other 2 were preyed upon, perhaps as a result of human activity at the nest sites.

The 2 young in successful nests emerged from their cavities when 31 ± 1 d and 30 ± 1 d old, respectively. At this age, Barred Owls are essentially flightless. Primary remiges and rectrices of these 2 owls were only 50 and 12% of adult size, respectively, within 2 d of fledging. Bent (1938) also reported nestling Barred Owls climbing out of their cavities

Table 5. Nesting chronology and productivity of Barred Owls in the central Appalachians, 1981-1982 (# of nests in parentheses).

Mean egg date ^a (6)	20 March
Mean hatch date (6)	10 April
Mean nest departure date (2)	24 May
Mean clutch size (7)	2.3
Total eggs produced ^b (8)	19.0
% hatching success (8)	68.4
# of nestlings per active nest (7)	1.9
Total number fledged (5)	2.0
# fledged/successful nest attempt (2)	1.0
% nesting attempts successful (2/5)	40.0

^aEgg dates based on back dating from hatch dates using a 28-day incubation period (Bent 1938)

^bMinimal number of eggs produced based on # of hatchlings and/or eggs found in nests

at 28-35 d old. Forsman (1975) reported Spotted Owls leaving their cavities at 34-36 d old. Dunstan and Sample (1972) and Soucy (1976), however, reported Barred Owls not leaving nests until about 49 d old. The age at which owls emerge may be a factor of cavity size. Those in small, cramped cavities, unable to spread and exercise their wings, may emerge at an earlier age.

Leaving the nest early is a disadvantage from a development standpoint because additional energy is required to compensate for that lost to environmental stress and increased activity. This was suggested by measurements of 1 of the owls that weighed the same 2 d after leaving the nest as 2 d before leaving. However, mobility vs sitting in the nest may be advantageous in terms of predator avoidance. Birds in cavities are especially vulnerable to predation because there is usually only 1 escape route. Young Barred Owls that do leave nests at a preflight stage are not totally helpless. Adult Barred Owls will continue to feed and defend their young throughout the summer, even after they can fly (Henderson 1933, Bent 1938, Dunstan and Sample 1975, Bird and Wright 1977). Also, young Barred Owls have the ability to climb trees using their beaks and talons (Dunstan and Sample 1972). Thus, they are able to move about, first by gliding or fluttering to the ground, then climbing a nearby tree. Tree climbing has also been reported for Great-horned Owl (*Bubo virginianus*), Screech Owl (*Otus asio*) (Dunstan and Sample 1972) and Spotted Owl (Forsman 1975).

CONCLUSIONS

Secondary cavity nesting birds, including the Barred Owl, cannot choose a location within a habitat to "place" their nests. They are limited to what is already available. The data indicate that differences exist between Barred Owl nest site habitat and surrounding habitat, but do not indicate whether cavities are selected based on those differences. Further study is needed to answer this question.

ACKNOWLEDGEMENTS

We thank J. Coleman, L. Garrett, M. Kopeny, D. Lyons, F. Presley, R. Whetstone and K. Titus for their time and assistance. We also thank S. Postupalsky for comments on an earlier version of the manuscript. This study was supported, in part, by grants from Sigma Xi, the Maryland Ornithological Society, and the U.S. Fish and Wildlife Service (FWS 14-16-0009-80-007). This is Scientific Series No. 1549-AEL of the Appalachian Environmental Laboratory and Technical Report-10 of the Central Appalachian Raptor Ecology Program.

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Received 8 March 1983; Accepted 10 May 1984.

TELEMETRY OF HEART RATES IN LARGE RAPTORS: A METHOD OF TRANSMITTER AND ELECTRODE PLACEMENT

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ABSTRACT - Heart rates of the Red-tailed Hawk (*Buteo jamaicensis*) and Barred Owl (*Strix varia*) were monitored telemetrically. The most acceptable data were received from devices whose electrodes were anchored within the thoracoabdominal space near the apex of the heart (primary lead) and dorsum (reference lead). Easily assembled plastic backpacks and leather harnesses were designed to be comfortable to birds and also to be resistant to damage from beaks and talons.

Previously developed methods for monitoring heart rate telemetrically (Sawby et al. 1974; Busch et al. 1978; Kanwisher et al. 1978) proved unsuccessful for large raptors for several reasons. First, unsuitable arrangement of electrode leads gave unreliable results (Sawby et al. 1974) and were too difficult and time-consuming to place to be of practical value (Busch et al. 1978). Secondly, an easy, reliable method of attaching the transmitting devices to the dorsum of each bird has been lacking. In addition, Kanwisher, et al. (1978) described a method which was vague on electrode placement and included an unprotected backpack. Our objectives were, therefore, to develop a more satisfactory placement of electrodes and a safe, economical backpack and harness for transmitter attachment.

MATERIALS AND METHODS

Electronics. — Two electrodes, 1 acting as primary lead and the other as reference lead, were surgically implanted. The primary lead consisted of a 34 cm strand of Teflon-E insulated 7 x 40 cm silver coated copper wire (Beldon Electronics, Geneva, IL 60134) terminating at 1 end with a 1 mm round pin (Vector Electronic Co., Inc., Sylmar, CA 91342) and a No-Knot Eyelet fish hook (Wilson-Allen Corp., Windsor, MO) at the other end (Sawby et al. 1974), constituting a barbed-needle electrode (Fig. 1). The reference lead was constructed with the same material except that the No-Knot Eyelet was replaced with a 0.5 cm loop of uninsulated wire, constituting a circle electrode (Fig. 1). These electrodes detected action potential of high amplitude S-waves of the electrocardiogram of the raptor and the attached transmitter module converted information into short RF pulses which were transmitted in the range of 148-149 MHz (J. Stuart Enterprises, Grass Valley, CA 95945). The transmitter had a mass of 20 g and measured 2.0 x 1.5 x 8.5 cm (Fig. 1).

Surgical Procedure. — Subjects were anesthetized with an intramuscular injection of Ketamine Hydrochloride (Fowler 1978) and Acepromazine Maleate into the muscles of the leg. The Acepromazine Maleate reduces the muscle spasms resulting from the use of Ketamine Hydrochloride as the principal anesthetic (Fowler 1978). Satisfactory dosages were 15-25 mg/kg of a 10:1 Ketamine/Acepromazine solution.

A 1 cm incision was made along the abdominal midline 0.5 cm posterior to the sternum, roughly following the method proposed by Sawby et al. (1974). Using a curved hemostat, the barbed-needle electrode of the primary lead was inserted cranially through the incision into the abdominal cavity (Fig. 2) and ad-

vanced along the peritoneal surface of the keel, to a position as close as possible to the apex of the heart, then imbedded into the sternum. The remainder of the lead was passed laterally from the incision subcutaneously to a point just posterior to the left wing. It was usually necessary to open this track with a blunt probe before pushing the lead through. A 0.5 cm incision was made to allow the lead to exit. This lead was similarly tunneled from the point of lateral incision to a point on the median of the dorsum. Another incision was made to allow exit of the lead and removal of the slack. All incisions were closed with 3-0 gut suture.

The circle electrode on the reference lead was anchored subcutaneously with 3-0 gut suture to muscle tissue at the point of the dorsal incision (Fig. 2). This incision was then closed with 3-0 gut suture, leaving both leads protruding out of the skin. The procedure usually lasted about 20 min.

Salvaged raptor carcasses were dissected prior to this study to practice locating heart and surrounding structures before beginning on a live bird. Also, domestic fowl (*Gallus* sp.) were implanted with electrodes to perfect surgical technique and electrode placements.

Backpack and Harness. — A backpack was constructed of 10 cm of 2.6 cm (i.d.) clear plastic tubing (Kirkill, Inc., Downy, CA 90241) and end-caps consisting of plastic 35 mm film canisters. A leather harness was made by riveting 2 strips of leather (each 1.5 cm wide) to the dorsal wall of the backpack (Fig. 3). The contact pins of both leads were passed through a hole in the ventral wall of the plastic tubing and connected to the transmitter inside of the tubing. Leather straps were passed around the wings of the bird to the ventrum and riveted together (Fig. 2).

Data Collection. — Signals were received by a portable unit consisting of 3 components: a hand-held antenna, a radio receiver, and a strip-chart recorder (J. Stuart Enterprises, Grass Valley, CA 95945). The receiver was a Telonics Model TR-2 direct-frequency reading, synthesized triple heterodyne, AC/DC receiver which measured 11.5 x 5.1 x 18.0 cm. The recorder was a Gulton Model 288 DC recorder which utilized pressure sensitive strip-chart paper to record an instantaneous average of heart rate in beats/min at 2-sec intervals. This unit measured 15.3 x 22.9 x 19.1. The normal DC mode of the recorder was converted to AC by the use of a current transformer. A programmable household timer (Radio Shack/Tandy, Ft. Worth, TX 76113) was used to turn on the recorder at previously determined intervals. The graphs produced resembled that in Fig. 4.

Two Red-tailed Hawks, 1 Great Horned Owl (*Bubo virginianus*) and 1 Barred Owl were affixed with transmitters. All were victims of crippling injuries to 1 wing and thus incapable of flight and had been received from the rehabilitation unit of the Raptor Rehabilitation and Propagation Project, Inc. Each bird was housed in an outdoor enclosure (2.5 x 5.0 x 2.5 m) after implantation and recovery.

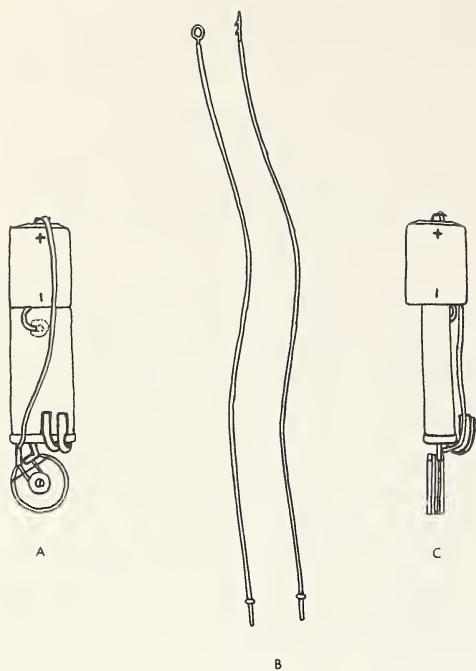


Figure 1. A and C: Bottom and side views of transmitting device; B: Primary lead and reference lead.

RESULTS AND DISCUSSION

Signals from the heart rate transmitter were received up to a distance of 1 km. Lithium batteries in each of the 3 units used were in continuous operation for over 1 yr, with no apparent reduction in performance. The backpacks and leads, when properly placed, remained functional for at least 1 mo. The backpacks and leads were checked daily for damage. We believe that the method of recording was less complex to operate and more easily monitored than day-to-day methods previously reported (Sawby et al. 1974, Busch et al. 1978, Kanwisher et al. 1978).

Difficulty in implanting the barbed-needle electrode of the primary lead was encountered with older birds whose skeletons had undergone more ossification. Implanting the electrode in the lateral edge of the sternum may prove adequate if normal implantation is not possible.

Placement of the leads proved critical. The primary lead did not respond satisfactorily if placed outside the abdominal cavity or if placed loosely inside the abdominal cavity. The barbed-needle electrode on the primary lead provided a secure long-lasting anchor inside the body cavity in proximity to the apex of the heart. Care was taken during the implantation to prevent accidental injury to internal structures, especially pericardium.

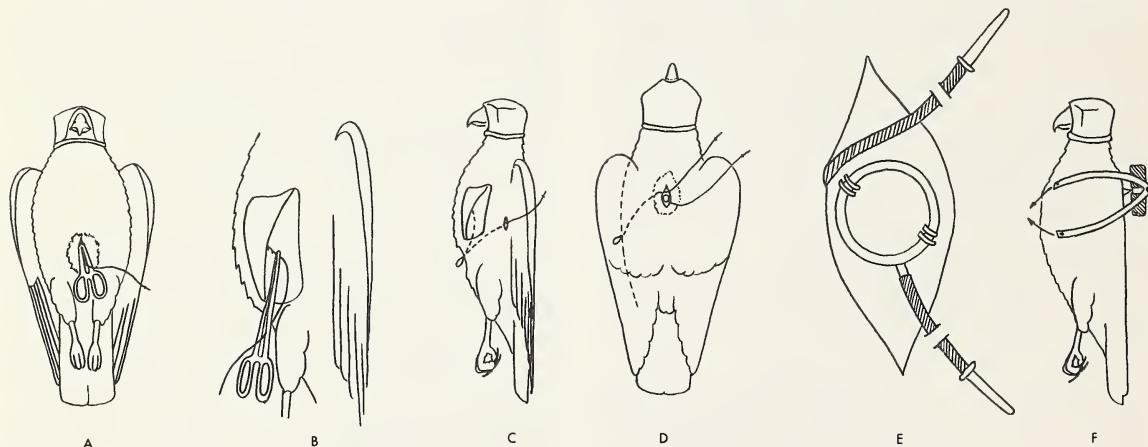


Figure 2. A: Ventral insertion of internal (primary) lead near end of keel; B: Side view of barbed-needle electrode of internal lead being pushed into dorsal side of keel through ventral incision; C: Subdermal insertion of internal lead toward dorsal exit point; D: Dorsal view showing exit of internal lead and surgical implantation of external (reference) lead; E: Enlarged view of subdermal attachment of reference lead and exit of primary lead; F: Attachment of harness containing transmitter.

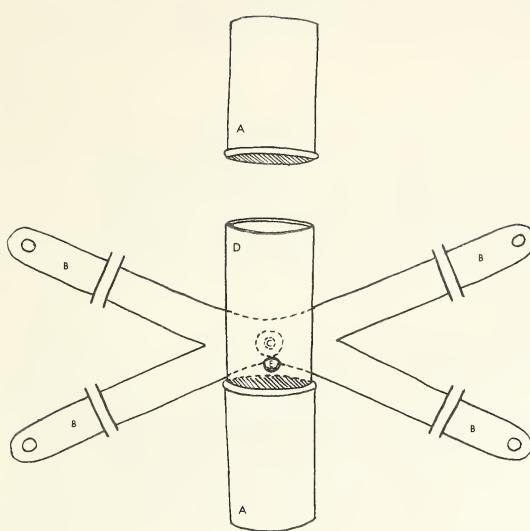


Figure 3. Construction of Backpack and Harness; A: Plastic film canisters; B: Leather straps; C: Metal rivet; D: Clear plastic tubing; E: Hole for exit of leads.

The reference lead, if anchored in any area but the surface of dorsal muscles, did not provide adequate grounding for a proper response of the system. Interference by the electromyogram of the pectoral muscle tissue was assumed to have prevented satisfactory ventral placement of this lead, since difficulty was encountered only when that muscle was contracting. Obviously, this would be unacceptable in applications involving birds in flight. The method described might possibly be used to monitor the heart rate of birds in flight, however, given the lack of electromyogram interference and range of signal transmission.

Construction of the backpack/harness assembly was very simple and economical. Total cost was under \$1 US. The plastic materials utilized endured the efforts of the birds to remove or dismantle them with beak or talon without contributing excessive mass. A very snug fit is required to prevent the bird from gaining access to the leads where they exit the dorsal incision and enter the backpack.

ACKNOWLEDGEMENTS

Artwork was done by David Huth. Equipment was funded through a cooperative aid agreement with the North Central Forest Experiment Station, USDA Forest Service. Dr. Gary Duke kindly provided constructive criticism of our preliminary drafts.

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Figure 4. Heartrate data (heartbeats/min) obtained from a captive Red-tailed Hawk (*Buteo jamaicensis*) at a distance of 15 m.

Raptor Rehabilitation and Propagation Project, Inc., Tyson Research Center, Eureka, MO 63025.

Received 25 August 1983; Accepted 27 April 1984.

ELECTRORETINOGRAMS AND RETINAL STRUCTURE OF THE EASTERN SCREECH OWL (*Otus asio*) AND GREAT HORNED OWL (*Bubo virginianus*)

STEVEN J. AULT

ABSTRACT — Electroretinograms (ERGs) were recorded from 2 species of owls: Eastern Screech Owl (*Otus asio*) and Great Horned Owl (*Bubo virginianus*). Dark adaptation and flicker stimuli were used to determine retinal activity and to infer retinal structure. The dark adaptation results showed typical patterns associated with retinas composed primarily of rods. This was indicated by the late regeneration of the scotopic b-wave. Flicker ERGs, however, also indicated a residual cone component. This was indicated by the one-to-one response at high luminance levels and high flicker frequencies. The ERG data confirm existing histological observations of high rod numbers and few cones in the retinas of nocturnal owls.

Owl retinas have been examined histologically by a number of investigators (Bornschein and Tansley 1961; Hocking and Mitchell 1961; Oehme 1961; Fite 1973; Yew et al. 1977; Bowmaker and Martin 1978). All reported retinas with high concentrations of rods, as would be expected for basically nocturnal animals. However, Fite (1973) and Oehme (1961) point out that owl retinas do possess very small concentrations of cones, even in the most nocturnal species.

Few electroretinographic studies have been performed on owls. Bornshein and Tansley (1961) obtained ERGs from Short-eared Owl (*Asio flammeus*) and compared response of the retina to that of the pigeon. These authors also correlated the ERG results with histological preparations of the owl and pigeon retinas. The ERGs and the histological examination revealed a retina composed predominantly of rods in the Short-eared Owl. Martin and Gordon (1975) recorded ERGs from the nocturnal Tawny Owl (*Strix aluco*) to determine its retinal spectral sensitivity. The ERG data supported earlier findings (Martin 1974; Martin and Gordon 1974) that the Tawny Owl possesses a retina with cone receptors that are present in large enough numbers to contribute to the visual response.

The purpose of this investigation was to record electroretinographic activity of the Eastern Screech Owl and Great Horned Owl, two species not previously investigated. Correlation of the ERG data with retinal structure of these species was made in an attempt to better define the relative role of the rods and cones in the visual process of these owls.

MATERIALS AND METHODS

Subjects and Anesthesia. — One Eastern Screech Owl and one Great Horned Owl were used for electroretinography. Both were anesthetized with an anesthetic mixture containing Ketamine (10

mg/ml), Acepromazine (0.1 mg/ml), and Xylazine (1.0 mg/ml). Dosage was 1 ml/kg body weight, administered IM. Average duration of anesthesia was approximately 1 h.

Each subject was placed into a light-tight, electrically grounded box, and a corneal electrode was placed on the eye. Space between the cornea and electrode was flooded with a saline (0.9% NaCl) conducting solution. A reference electrode was placed in the skin of the ear flap or in the skin of the ear canal. A ground electrode was inserted in the wing skin. A fiber optic light guide was placed a few mm from the cornea.

Electroretinograph. — The light source was a 300 watt tungsten-halogen lamp that could deliver steady, single-flash, or flickering stimuli. Flicker stimuli were produced by a motor-driven disc that interrupted the light to give equal time on and off. The light beam was focused upon a fiber optic light guide which delivered light to the subject's eye in Maxwellian view (Armington 1974). The light beam wavelength and intensity were adjusted by the use of various color and neutral density filters. Unfiltered light intensity from this apparatus was approximately 1.076×10^4 mililamberts (mL) (1 mL = 0.001 lumens/cm²).

The recording electrodes used were silver pedestal corneal contact lens systems. Reference and ground electrodes were silver skin needle probes. Signals from the electrodes were channeled through a Tektronix TM 504 pre-amplifier. The signal was amplified and displayed on a Tektronix 5103N dual-trace storage oscilloscope. Traces were permanently recorded by Polaroid photography.

Procedure. — Two tests commonly used in electroretinography, dark adaptation and flicker stimuli, were used. Dark adaptation tests were used to observe changes in the ERG as the retina adjusted to darkness. The eye was first pre-adapted to light for 5 min to insure bleaching of the photopigments. Pre-adaptation retinal illuminance was approximately 1.076×10^3 mL for the Eastern Screech Owl and 1.076×10^4 mL for the Great Horned Owl. Different intensities were used for both owls to assess the effectiveness of such intensities for pre-adaptation, single-flash (20 msec duration) stimuli attenuated with a Kodak #2 neutral density filter and a Kodak #26 gel film red filter, were delivered at widely spaced intervals (see Figs. 1-3) to the eye to observe the retina's increasing sensitivity to darkness. After 20-30 min, full-intensity single-flash stimuli of red (Kodak #26 gel film), blue (Kodak #47, 47A, 47B gel film) and white (no filters) were given successively to assess the degree of photopic (cone) and scotopic (rod) recovery.

The second test utilized flickering stimuli of various intensities and flicker frequencies. Various neutral density filters, but no color filters, were used.

Histology. — The retinas of a Great Horned and Eastern

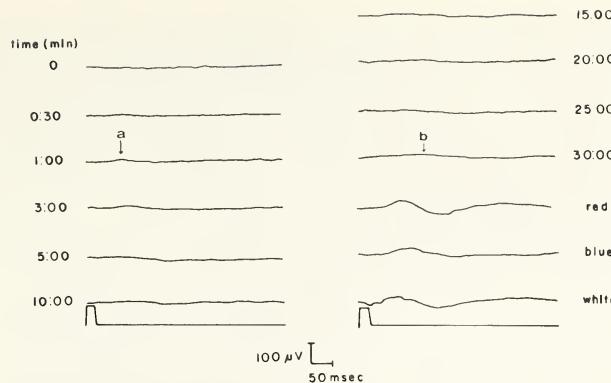


Figure 1. ERGs during dark adaptation in the Eastern Screech Owl. Time indicates minutes into dark adaptation. Stimulus: 1.076×10^4 mL attenuated with #2 neutral density filter and #26 red filter; 20msec duration. a) Slight regeneration of photopic b-wave after 1 minute into dark adaptation. b) Slight regeneration of scotopic b-wave after 30 minutes into dark adaptation.

Screech Owl were examined histologically. The Great Horned was the same animal used in the ERG study. The subjects were euthanized with lethal injection of Ketamine and enucleated. The posterior portion of the eye was cut away and fixed in Bouin's solution. The tissue was dehydrated in a graded ethanol series and cleared in cedarwood oil. Portions of peripheral retina were embedded in paraffin, sectioned meridionally at 5 μ m on a rotary microtome and stained with Hematoxylin and Eosin.

RESULTS

Dark Adaptation. — The ERGs from dark adaptation tests for both subjects showed very early low-amplitude responses which peaked at around 1-2 min into dark adaptation (Figs. 1a, 2a). Also, late appearing (between 20 and 30 min into dark

adaptation) low-amplitude waveforms were observed (Figs. 1b, 2b). The final red, blue, and white stimuli produced waveforms of low amplitude.

Flicker Stimuli. — A change in waveforms were observed as the flickering stimuli were increased from low to high intensities and flicker frequencies; this was best demonstrated by the Eastern Screech Owl. At low intensities and low flicker frequencies, waves were evident as they followed the stimuli on a 1:1 basis (Fig. 3a). There was a fusion of this response as intensities and flicker frequencies increased, with a subsequent waveform taking over at high intensities and high flicker frequencies (Fig. 3b). The Great Horned Owl also displayed the above pattern, but with less clarity (Fig. 4).

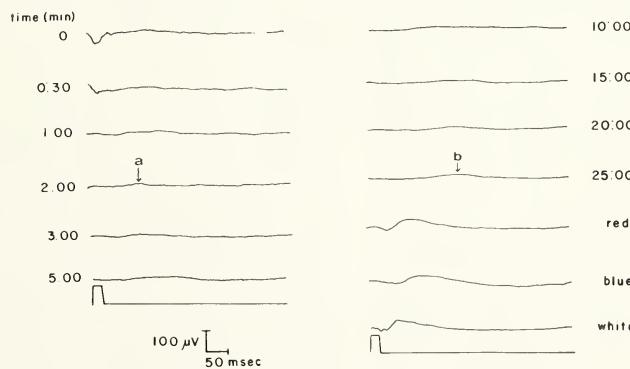


Figure 2. ERGs during dark adaptation in the Great Horned Owl. Time indicates minutes into dark adaptation. Stimulus: 1.076×10^4 mL attenuated with #2 neutral density filter and #26 red filter; 20 msec duration. a) Slight regeneration of photopic b-wave after 1-2 minutes into dark adaptation. b) Slight regeneration of scotopic b-wave after 20-30 minutes into dark adaptation.

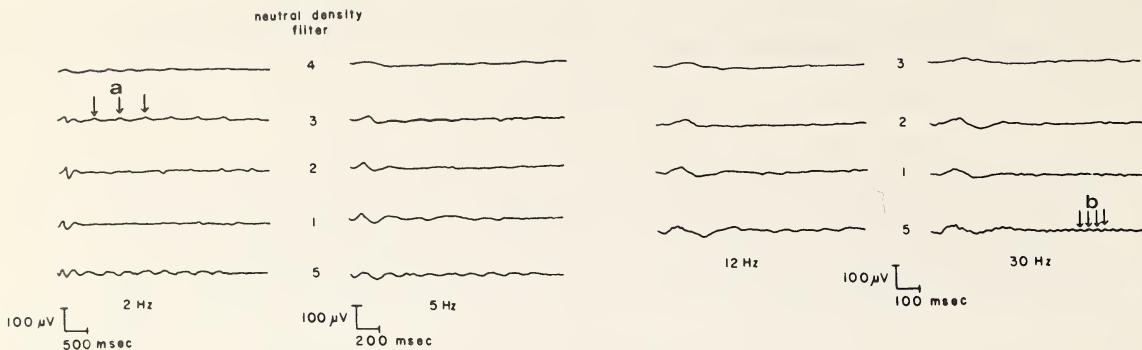


Figure 3. Flicker ERGs of the Eastern Screech Owl. a) Arrows indicate one-to-one response of waveforms to individual flickers at low intensity and low flicker frequency. b) Arrows indicate one-to-one response of waveforms to individual flickers at high intensity and high flicker frequency. 1.076×10^4 m² light source attenuated with indicated neutral density filters.

Histology. — The retinal layers of the Eastern Screech Owl could be clearly discerned histologically (Fig. 5). Retinas were composed primarily of rods; indicated by the elongated and cylindrical morphology of their outer segments in the receptor layer. The nuclei in the outer nuclear layer were also identified as rod nuclei because they were typically more elongated and were fairly evenly distributed throughout the outer nuclear layer (Walls 1942; Duke-Elder 1958). The rod nuclei of the Great Horned Owl were extremely elongated and closely packed.

A few cones were also seen in owl retinas. These were identified by their nuclei, which are typically rounder than rod nuclei and lie adjacent to the external limiting membrane. In all sections, cones were always few in number and were greatly outnumbered by the high density of rods.

DISCUSSION

The typical ERG waveform is composed of the a, b and c waves. The initial negative deflection (a-wave) is followed by a positive deflection (b-wave) normally of greater amplitude. The late-occurring

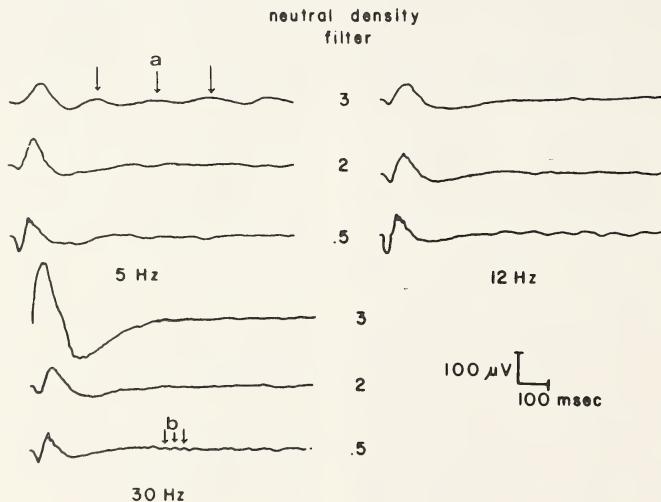


Figure 4. Flicker ERGs of the Great Horned Owl. a) Arrows indicate one-to-one response of waveforms to individual flickers at low intensity and low flicker frequency. b) Arrows indicate one-to-one response of waveforms to individual flickers at high intensity and high flicker frequency. 1.076×10^4 m² light source attenuated with indicated neutral density filters.

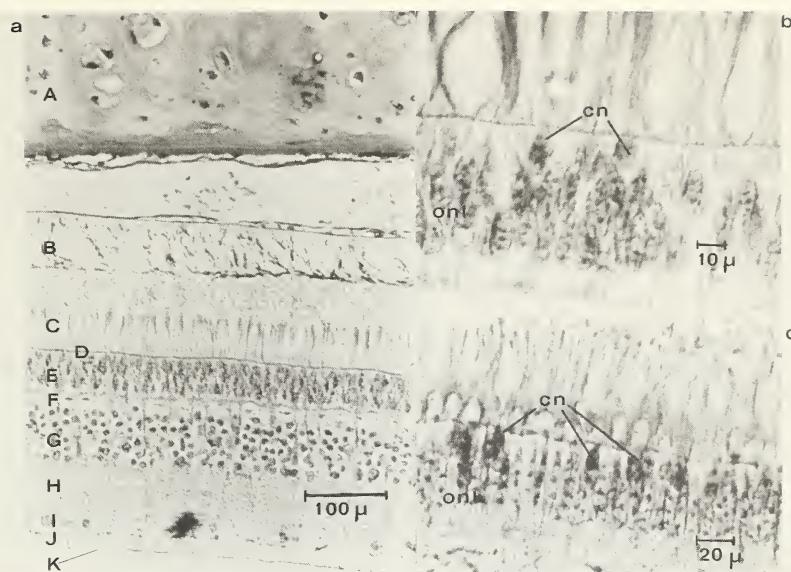


Figure 5. a). Layers of the Eastern Screech Owl retina. A) cartilaginous cup; B) pigment epithelium; C) receptor layer; D) external limiting membrane; E) outer nuclear layer; F) outer plexiform layer; G) inner nuclear layer; H) inner plexiform layer; I) ganglion cell layer; J) nerve fiber layer; and K) internal limiting membrane (200x); b) Eastern Screech Owl and c) Great Horned Owl retinas. cn = cone nuclei; onl = outer nuclear layer (primarily rod nuclei). (787.5x and 500x respectively).

positive deflection (c-wave) is not commonly evaluated in comparative studies. Brown (1968) explained that the a-wave is produced in the receptor cell layer, the b-wave through bipolar cell activity, and the c-wave by metabolic activity of the pigment epithelium. The a- and b-waves can be further subdivided into photopic (cone generated) and scotopic (rod generated) components. In general, the photopic components have shorter latencies and steeper slopes than scotopic components (Armington 1974). These patterns were evident in the owls studied (Figs. 1, 2)

The dark adaptation results revealed typical patterns associated with retinas composed predominantly of rods. The late regenerating wave forms were most likely scotopic b-waves suggesting that rods were regenerating after having been bleached during light adaptation. Latency of these b-waves suggested the response was from the scotopic system. Longer latency or implicit time (approximately 100 msec) is indicative of a scotopic rather than photopic b-wave (approximately 50-70 msec). Earlier low-amplitude responses were probably cone responses because of their early appearance during dark adaptation. Latency of these responses was also shorter than the scotopic responses, again

suggesting generation by a cone component. As dark adaptation progressed, these early responses diminished and were replaced by the scotopic responses. After 25-30 min, there was still no complete regeneration of the scotopic responses in either owl, denoting that many of the rods were not yet adapted to the dark. The reduced effect of the blue light on the scotopic system also verified this since blue light is primarily a rod stimulator. These observations suggested a retina predominated by rods, but with a small cone component. However, it could mean that the initial light adapting intensity was too high. This seems unlikely since an absence of complete regeneration of the scotopic response was also observed in the Great Horned Owl which was exposed to a lower light-adapting intensity.

The shift from scotopic to photopic systems during the flicker procedures was indicated by a decrease in latency and an increase in amplitude of the initial b-wave as flicker frequencies and intensities were increased. The initial a-wave also became more prominent at higher flicker frequencies and intensities, providing further indication of the shift to the photopic system (Armington 1974). The rods and cones were also able to follow the individual flickering stimuli. At low intensities and low flicker

frequencies, rods were able to follow individual flickers, having not yet exceeded their critical flicker fusion frequency. As intensity and/or frequency was increased, rods "fused" the stimuli. Fusion occurred when the receptors could no longer respond to individual flickers on a 1:1 ratio but instead responded to them as if there was one constant stimulus. At high intensities and high flicker frequencies, cone response became dominant and was able to follow individual flickers since they possess a higher critical flicker fusion frequency than rods (Armington 1974). Histological results in combination with the ERG data indicated that the retinas were predominantly composed of rods. This supports the findings of previous workers (Bornschein and Tansley 1961; Hocking and Mitchell 1961; Oehme 1961; Fite 1973; Yew et al. 1977; Bowmaker and Martin 1978) who histologically demonstrated a retina composed predominantly of rods in the Great Horned Owl and other owl species. However, histological results and ERG data also demonstrated the presence of a cone component that was small but active.

My results and those of Bowmaker and Martin (1978) and Martin and Gordon (1975) verify that the retina of owls, even the most nocturnal species, possess cones in numbers large enough to contribute to the visual process. Existence of such a cone component could be the remnants of an ancestral cone-dominated retina. Nocturnal owls such as screech and Great Horned Owls are occasionally active during the day. It is reasonable to assume that the few cones that are present contribute to the owl's visual process in the brighter illumination of daylight hours.

ACKNOWLEDGMENTS

I extend special thanks to Charles J. Parshall, Animal Specialty Clinic, Richfield, Ohio, for help and expertise with electroretinography and to Richard F. Nokes, The University of Akron, who assisted with anesthesiology. F. Scott Orcutt, John H. Olive, Steven P. Schmidt, Edwin W. House, and Carolyn Wilson made positive critical comments on the manuscript. This study was supported in part by a Grant-in-Aid of Research from Sigma Xi, The Scientific Research Society.

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Received 8 March 1984; Accepted 1 July 1984.

FOOTPRINTING OF RAPTORS FOR IDENTIFICATION

ERIK H. STAUBER

ABSTRACT - The feet of 15 Peregrine Falcons (*Falco peregrinus*) and 25 Red-tailed Hawks (*Buteo jamaicensis*) were photographed for evaluation of the dorsal scale patterns of their toes. Visual analysis of the middle toes (digit #3) showed recognizable scale pattern differences between toes from individual birds as well as for all related and unrelated birds. Scale patterns remained unchanged for birds that were available in successive years. It is suggested that the toe scale pattern is unique for any Peregrine Falcon or Red-tailed Hawk and could be used for permanent individual identification.

Methods of differentiating individuals within certain species, including man, have been explored and used for many decades. Artificial markers consisting of either bands, tags, tattoos or hot or cold brands are used to identify individuals when readily identifiable and unalterable natural markers do not exist. However, there are a few species in which each individual has unique, unchanging markings which can be recorded and used effectively for purposes of identification. The most notable example is the use of fingerprinting in humans. Other examples where unique markers have been used for individual identification are the stripe patterns of zebras, the reticulation on the pelage of giraffes, the noseprints on bovine animals, or the dorsal fin shapes and spots on killer whales.

Most birds have scale patterns on their feet and legs, but there is no evidence that the scale pattern of any species has ever been analyzed for the purpose of developing an identification system. The foot scale patterns of Peregrine Falcons (*Falco peregrinus*) and Red-tailed Hawks (*Buteo jamaicensis*) were characterized to determine their usefulness in individual identification.

MATERIALS AND METHODS

Individual birds representing 2 raptor species were chosen for photographic evaluation of the scale pattern of the dorsal aspects of their toes. Birds included in the study were 15 Peregrine Falcons and 25 Red-tailed Hawks. Several were siblings and three were compared in successive years.

Feet were placed so that the entire dorsal aspect of the 3 forward pointing toes (digits # 2,3,4) could be photographed with a close-up lens. Black and white prints (5"x7") were developed and the scale patterns of the toes of all birds were visually analyzed. Only the middle toes (#3) were considered in this study. For evaluation and comparison among individuals, scales of corresponding areas on each toe were characterized according to size, arrangement of scales in relation to adjacent scales, and network of interscale spaces. For convenience of comparison, the area occupied by the dorsal scale(s) closest to the talon was designated as row 1L3 (scale row 1, left foot, digit #3) for the first scale of the middle toe of the left foot and 1R3 for the right foot. Subsequent scales were designated 2L3, 2R3, etc. depending on how many rows of scales were discernible.

RESULTS

Evaluation of photographs taken of the dorsum of the middle toes of 15 Peregrine Falcons and 25 Red-tailed Hawks clearly showed that the scale patterns of each bird differed from the corresponding scale arrangement of all other birds (Fig. 1-4). The number of scale rows varied between the 2 species studied. The evaluation included comparison of 2 sibling (male) Red-tailed Hawks (Fig. 3) and 4 sibling (3 females, 1 male) Peregrine Falcons (Fig. 1 and 2 showing related females E.S., C.F., L.B.). Comparison between right and left foot of each individual bird further revealed that scale patterns were never identical.

Birds which were available the year following the first evaluation and had completed a full molt of their plumage were re-evaluated and shown to have unchanged scale patterns in 2 successive years (Fig. 1 and 4).

Obvious differences for scale patterns for Peregrine Falcons were frequently noted between rows 6 to 8 and commonly between rows 11 to 18 and beyond. The differences in the scales of rows 1-5 and 9 and 10 were more subtle relating primarily to scale size and the ratio of width to length (Fig. 1 and 2). Readily visible differences of scale patterns for Red-tailed Hawks started at rows 5 or 6 and remained distinct for all following rows (Fig. 3 and 4).

DISCUSSION

The principal objective of this study was to develop an identification system for Peregrine Falcons. It was important that the system be simple and could be used for identification of individual birds. Red-tailed Hawks were included primarily because they are a common raptor with a prominent foot scale pattern and were readily accessible for study through the raptor rehabilitation facility at Washington State University.

All birds were identified by the use of photography and by visually comparing the scale patterns

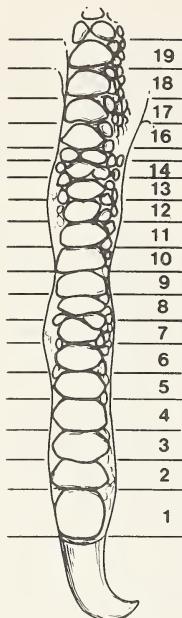
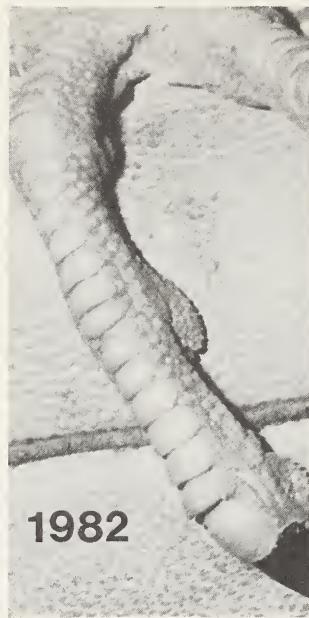
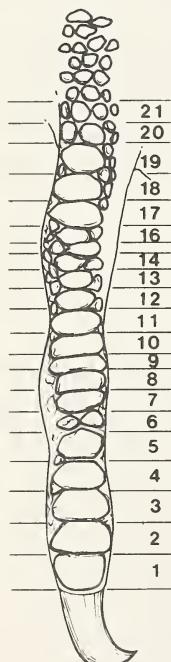
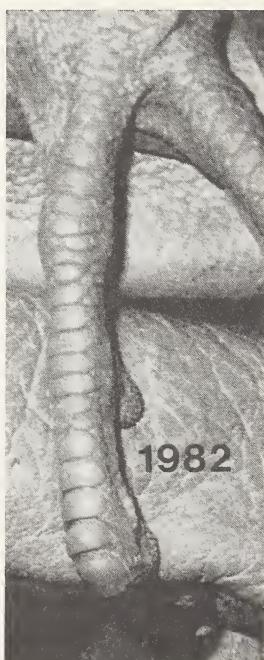
Peregrine Falcon**C.F.****Right Foot****Peregrine Falcon****E.S.****Right Foot**

Figure 1.

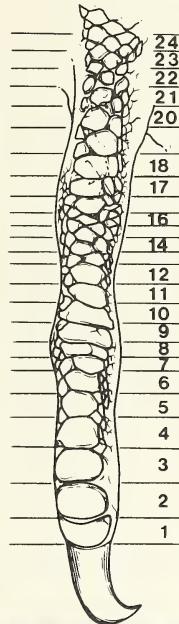
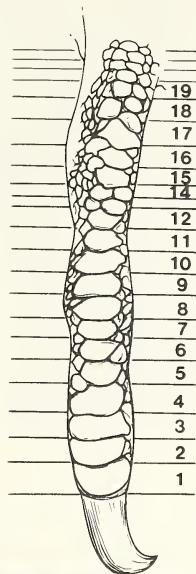
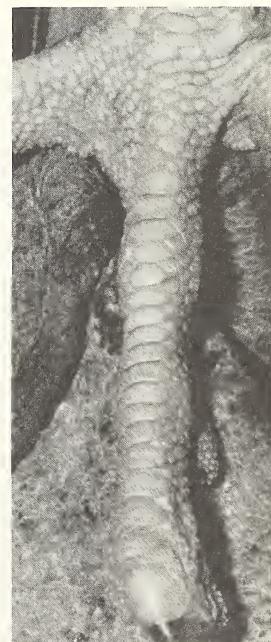
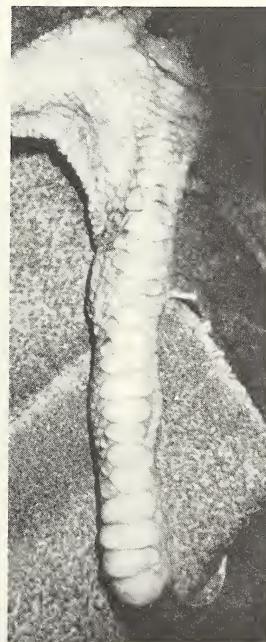
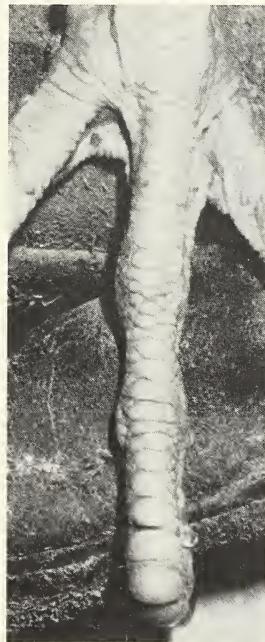
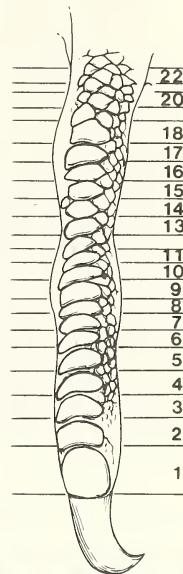
Peregrine Falcons**22555-070****Left Foot****T.E.****Right Foot****L.B.****Right Foot**

Figure 2.

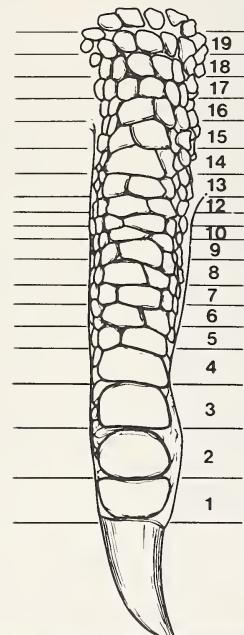
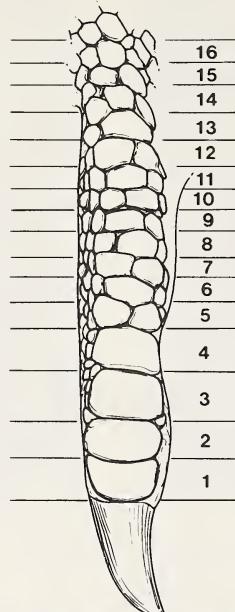
Red Tailed Hawks**22555-033****Left Foot****22555-034****Left Foot**

Figure 3.

Red Tailed Hawk 8411-131

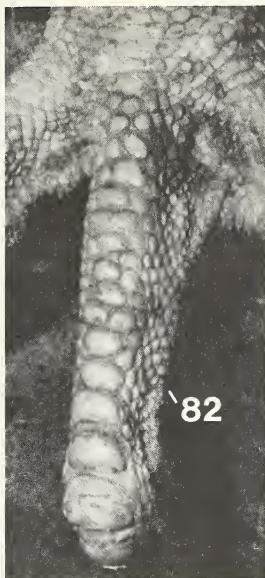
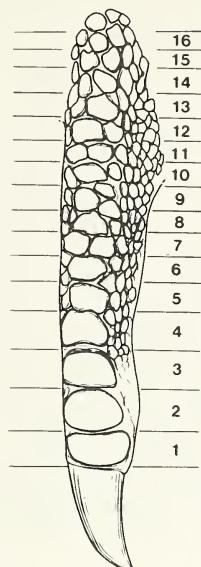


Figure 4.

and shapes of only the middle toe of both feet. In most instances, a mere glance at the scale patterns revealed distinct differences between left and right middle toe of individual birds as well as any 2 birds (including siblings) and these differences remained constant over an extended period.

While it was not difficult to identify birds by photography of the toe scale pattern, it became apparent that magnification of feet and scales was not always uniform since the camera was held at varying distances and angles in the first year of the study. For purposes of this study, measurement of scales was considered unimportant, but scale size and dimensions should certainly be considered in perfecting a reliable identification system. This could be accomplished by making a clay print or by placing the foot on a grid with known dimensions. A study exploring the use of some techniques which will yield a good estimate of the scale size and dimensions is currently underway.

The availability of a reliable identification system for Peregrine Falcons would be of considerable value in light of the status which this bird has occupied in the history of civilization, in general, and in its contemporary management in particular. Proper identification of individual Peregrines held in captivity has been a concern of state and federal

wildlife officials for many years. Illegal substitution of lost or deceased birds by replacement of federal bands or the switching of federal bands on stolen birds has been known to occur but nearly impossible to prove. The system of identification described herein would preclude the substitution of one falcon for another and thereby greatly facilitate the management of Peregrine Falcons held in captivity or other bird species to which the system would be applicable. Regardless of whether analysis of foot scale patterns by photography or another system will prove to be the simplest and most feasible approach to the identification of Peregrine Falcons (and other birds), a "footprinting" system offers great promise to document the uniqueness of a raptor so identified.

ACKNOWLEDGMENTS

The author acknowledges the assistance of Dennis Cancellare and Jerry McCollum (photography), Amy Werner (medical illustrator), and William Geoffroy and Lester Boyd for their suggestions. This study was supported in part by funds from the Agricultural Experiment Station, University of Idaho, Moscow. Published with the approval of the Director of the Idaho Agricultural Experiment Station, Moscow, as Research Paper No. 83819.

Department of Veterinary Sciences and WOI Regional Program in Vet. Med. Ed., Univ. of Idaho, Moscow, ID 83843.

Received 30 March 1984; Accepted 25 June 1984.

PSEUDOMEMBRANOUS GASTRITIS COMPATIBLE WITH (*Clostridium* sp.) IN A CAPTIVE PEREGRINE FALCON

JAMES H. ENDERSON AND MORGAN BERTHRONG, M.D.

ABSTRACT - There have been several instances where the Peregrine Falcon (*FALCO PEREGRINUS*) used for captive-breeding for many years have died rapidly after being removed from the breeding lofts (W. Burnham, J. Weaver, C. White pers. comm.). This is an account of such an instance where the benefit of a complete necropsy is available and reveals one possible explanation for these losses.

A female Peregrine in captivity over 19 y had produced nearly 100 eggs during the last 10 y while in the loft with a male. Because no eggs were produced in the last year the bird was hooded and transported to a new location. She appeared calm after subsequently consuming a portion of a thawed quail. She seemed relaxed and normal the next morning, but at 1000 h was lethargic. By 1200 h she was breathing heavily and rapidly, and was very weak. She died within the hour.

PATHOLOGIC OBSERVATIONS

Complete autopsy revealed a good state of nutrition. Body weight was 860g. The lateral air sacs were smooth and glistening without parasitic worms or fungi. The oral cavity, crop, esophagus, trachea, lungs and heart were entirely normal. The stomach was empty and contracted with resulting thickening of its mucosal folds. A gray-green exudate was adherent to the mucosal surface. No ulcerations were noted. The remainder of the intestinal tract was grossly normal. The adrenal glands were smaller in comparison to a wild peregrine. The spleen was slightly enlarged. The ovary was small and nodular without developing ova. The kidneys, pancreas, and brain appeared grossly normal.

Histologic examination revealed a fibrinopurulent layer which covered the gastric mucosa where only the most superficial mucosal cells were necrotic and only a superficial mucosal infiltrate of inflammatory cells was observed. The mucosal capillaries were dilated. Gram stains revealed swarms of gram positive rods, large, straight with slightly rounded ends and numerous oval subterminal and central spores, characteristic of a clostridial species within the fibrinopurulent membrane (Fig. 1 and 2). These organisms were not found in the mucosa itself or in the muscularis of the stomach. Large numbers of bacilli, mostly gram positive and similar to those in the stomach, were found in the lumina of both small and large intestine but no mucosal alterations or pseudomembranes were seen. The spleen

showed plasmacytoid cells in the red pulp consistent with an immunologic reaction, a so-called "acute splenic tumor".

Kidney sections showed small cysts of a possible congenital cystic disease but large areas of normal glomeruli and tubules suggested normal renal sufficiency. Minimal osteoarthritis was found in the upper humeral joint surface. A small para-adrenal microscopic nodule was found, thought to be a benign neoplasm resembling a human neoplasm known as a carcinoid. Several cysts were found in one of a number of sections of skeletal muscle recognized as those of quiescent avian malaria, possibly *Plasmodium relictum*. These cysts were not surrounded by any tissue reaction and the liver, spleen, bone marrow and heart showed no evidence of active malaria.

DISCUSSION

The development of a pseudomembranous enterocolitis of the intestinal tract with toxic shock, often fatal, has been well recognized in man (Goulston et al. 1965). It was known to occur during the post-operative period, usually after abdominal surgery, before the advent of antibiotics. Presumably because of an alteration of the bacterial environment, pseudomembranous enteritis or colitis became much more common after widespread use of antibacterial agents in man. At first, cases may have been the result of highly virulent staphylococci but in recent years evidence indicates that most human cases are now the result of overgrowth of clostridial species in the gastrointestinal tract (Bartlett et al. 1978). Epidemics of this condition occurred in Germany immediately after World War II (MacLenan 1962), and in New Guinea (Murrell et al. 1966) from *Clostridium perfringens*, presumably due to ingestion of food massively contaminated with this organism. Recently, most human cases have been shown to be the result of overgrowth of the antibiotic-resistant *Clostridium difficile*, the exotoxin of which has a potent cytotoxic effect and



Figure 1. Low power photomicrograph of gastric mucosa covered by a fibrinopurulent pseudomembrane containing swarms of bacteria but with only superficial erosion of the glands.



Figure 2. High power photomicrograph of the pseudomembrane with large grampositive rods characteristic of a clostridial species.

after absorption has frequently lethal action (George et al. 1978). Most human cases are seen in patients on antibiotics, after serious surgical procedures, in newborn infants, and in patients in whom, for many different reasons, immunosuppression exists. Essentially identical pseudomembranous enterocolitis can be produced experimentally in rabbits (Kata et al. 1978) and hamsters (Rifkin et al. 1978). This falcon developed acute pseudomembranous gastritis histopathologically identical to human cases. That the bird died of resulting clostridial toxemia is suggested although not confirmed by culturing the suspected etiologic agent. It is possible the falcon ingested food with large numbers of clostridial organisms, a bacterium known to multiply with great rapidity under proper circumstances and that the stress of moving led to the rapid growth of those organisms in the gastrointestinal tract resulting in pseudomembranous gastritis. It is of interest that some birds and mammals are known to carry *C. difficile* in the intestinal track (McBee 1960).

Of some clinical importance, while most clostridial species are susceptible to penicillin, *C. difficile* is

sensitive only to Vancomycin. Furthermore, the oral administration of cholestyramine resin, which apparently binds the toxin in the lumen of the gut, has proven efficacious in human cases of pseudomembranous gastrointestinal disease due to *Clostridium difficile* (Kreutzer and Mulligan 1978).

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Received 12 November 1983; Accepted 15 August 1984

BIOTELEMETERED DAILY HEART RATE CYCLES IN THE RED-TAILED HAWK (*Buteo jamaicensis*)

DAVID E. BUSCH, WILLIAM A. DEGRAW AND N.C. CLAMPITT

ABSTRACT - Daily fluctuations in resting heart rate (HR) were studied in a captive ♀ Red-tailed Hawk (*Buteo jamaicensis*) using radiotelemetry. HR's were recorded hourly during 10 consecutive days while the hawk was housed in an outdoor pen. Daytime HR's averaged 202 beats/min and were significantly higher than the average nocturnal HR of 134 beats/min ($P < 0.001$). Maximum HR's (>200 beats/min) occurred crepuscularly, just after sunrise and before sunset.

Daily cycles of several physiological factors have long been known for a number of birds and mammals. In birds for example, marked nocturnal depression of body temperature has been demonstrated in Snowy Owls (*Nyctea scandiaca*) and Short-eared Owls (*Asio flammeus*) by Irving (1955). Odum (1941) commented on the marked changes in heart rate (HR) occurring between day and night in avian species. Smith et al. (1976) reported that telemetered HR is lower and less variable during darkness in the domestic Mallard Duck (*Anas platyrhynchos*). One method, that of telemetered HR, allows physiological study of unrestrained birds under near-natural conditions. This method has also been promoted as a suitable indicator of relative metabolic rate in homeotherms (Johnson and Gessaman 1973; Gessaman 1980).

Indications that HR can be a good relative metabolic indicator come from studies in which HR and O₂ consumption were measured simultaneously (Morhardt and Morhardt 1971; Lund and Folk 1976). Similarities between HR-ambient temperature curves and metabolism-ambient temperature curves have been demonstrated for birds such as the Burrowing Owl (*Athene cunicularia*) (Coulombe 1970) and Blue-winged Teal (*Anas dis-*

cors) (Owen 1969). Because of circulatory adjustments occurring during more intense locomotor activity, HR is only considered a valid metabolic indicator when an animal is unstressed and at rest, or exercising moderately (Jones and Wang 1976). We have used telemetered HR's to demonstrate stress in the Ferruginous Hawk (*Buteo regalis*) (Busch et al. 1978), but in order to use HR as a metabolic indicator, activity levels must be low and stress minimal.

Little of the aforementioned types of research have focused on birds of prey in spite of the emphasis on raptor conservation, rehabilitation and captive breeding. Our goal was to assess diurnal fluctuations in resting HR's of the Red-tailed Hawk via telemetry. Changes in HR were also compared with time of day and with extrinsic factors such as ambient temperature and elevation of the sun.

METHODS

The subject of this study, a ♀ Red-tailed Hawk, was considered non-releasable by rehabilitation personnel because of an unmendable broken wing. This disability did not conflict with the study's goals since the bird's feeding and perching were not affected, and since our focus was on daily variations in resting HR.

The hawk was maintained in an outdoor pen measuring 56 m²

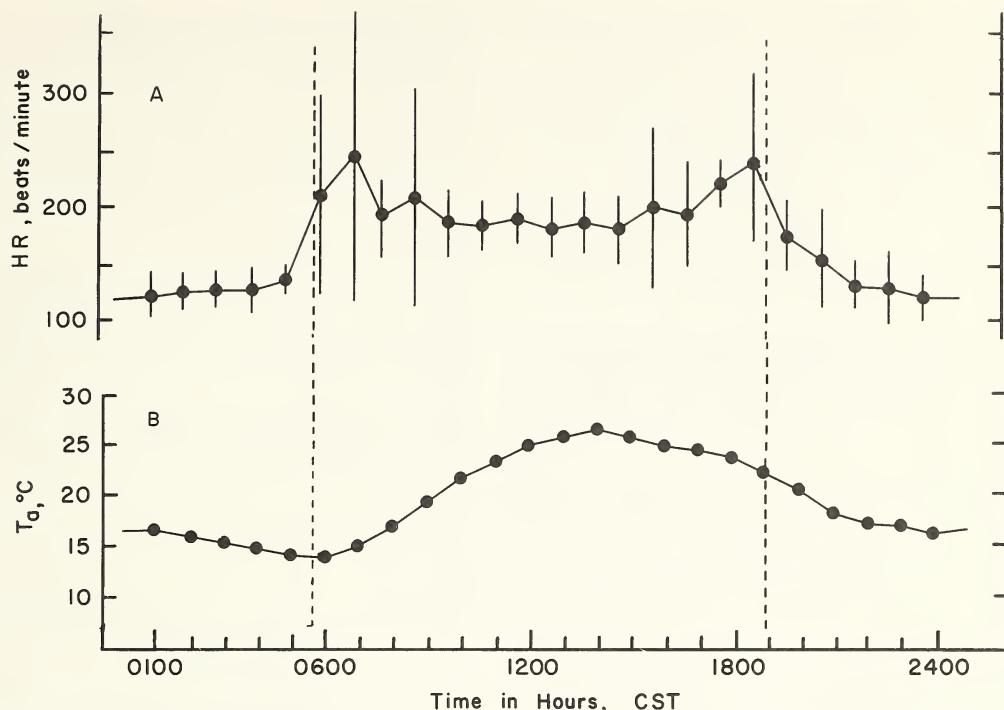


Figure 1. (A) Mean heart rates (HR) and (B) mean ambient temperatures during 10 consecutive days of recording. Vertical bars depict standard deviations for each hourly sample period ($n=10$ d).

located on the Allwine Prairie Preserve of the University of Nebraska at Omaha. Sources of disturbance were few at this rural site. A small building adjacent to the pen provided portholes for observing the bird, as well as electrical power and housing for the recording instruments. The desirability of such conditions was highlighted by Owen (1969) who measured significantly higher HR's in Blue-winged Teal under semi-natural conditions than under controlled laboratory conditions. Food for the hawk consisted of freshly killed laboratory rats placed in the cage at randomly selected times which did not coincide with hourly data collection.

Electrocardiogram electrodes were surgically implanted on the pleural surface of the bird's sternum through a mid-line abdominal incision, using a modification of the method of Sawby and Gessaman (1974). Leads from these electrodes provided the input to a Narco FM 110-E4 HR telemetry transmitter. The transmitter, packaged in dental acrylic and worn by the bird as a "backpack", weighed 109g with its harness. The transmitter assembly weighed 7.5% of bird's body wt (1.45 kg). This was within the 10% limit considered valid for electrocardiogram telemetry devices (Gessaman 1973).

The telemetered signal was detected with a Narco FM 1100-7 receiver. A switching device was designed to record a 2-min segment from each h of the day. This device also operated a tape recorder on which data were recorded in digital format as audible "clicks." Each click represented 1 QRS complex from the electrocardiogram (1 heart beat). High heart rates made counting

audible clicks impractical so these data were converted to an analog format using a Physiograph Cardiotach. The resulting chart records were analyzed to determine \bar{x} HR for each 2-min sampling period, and to evaluate changes between hourly \bar{x} HR's for more than 240 sample times. Data were collected continuously for 10 d between 9 and 18 April 1977. During this period daily \bar{x} max. temp. was $24.1 \pm 3.7^\circ\text{C}$ ($n=10$), while the \bar{x} min. temp. was $12.4 \pm 3.1^\circ\text{C}$ ($n=10$).

RESULTS AND DISCUSSION

The pattern of changes in \bar{x} HR is displayed in Fig. 1A. The bimodality of the cycle, exemplified by 2 daytime peaks, prevented the use of sophisticated biorhythm analysis. However, simpler methods such as t-Tests are considered sufficient to demonstrate existence of daily biological cycles (Koukkari et al 1974). In this instance, one way ANOVA confirmed the existence of highly significant variation in HR ($F=6.589$; $df = 23, 216$; $P < 0.001$). Furthermore, the diurnal \bar{x} HR (202 beats/min) for the 14 h between sunrise and sunset was significantly greater than the nocturnal \bar{x} (134 beats/min) (t-Test, $P < 0.001$). Resting HR's were

highest in periods just after sunrise and just before sunset.

Variability (i.e., standard deviation) in instantaneous HR was greatest near sunrise and sunset (Fig. 1A). For example, the average coefficient of variation was 80% between 0600-0900 but was only 28% during mid-day (1000-1400). Bartlett's test revealed highly significant heterogeneity in variances ($P < 0.001$). Hourly changes in \bar{x} HR were also greatest in the early morning and late afternoon. When hourly changes in HR's during the 5 h around sunrise (0500-1000) were grouped with those during the 5 h near sunset (1500-2000), mean changes in HR for these 10 h were significantly greater ($P < 0.01$) than changes during the other 14 h of the day.

Although daily metabolic or HR cycles are not unusual for raptors (Coulombe 1970), bimodal patterns such as reported herein have been described infrequently (Nastosescu et al. 1975). The adaptive value of this crepuscular HR pattern is somewhat puzzling.

Parallel changes in \bar{x} HR's and \bar{x} ambient temp should not be regarded as a causal relationship, despite the well-established inverse relationship between avian metabolism and air temp outside of the thermoneutral zone. There is strong evidence that metabolic rhythms are more closely linked to photoperiod (Folk 1974) and that daily changes in HR coincide somewhat with those of ambient temp only because of their common relationship to solar periodicity. The distinctly bimodal peaks we observed contrast with the curve for ambient temp (Fig. 1B).

The possibility that higher heart rates near sunrise might represent elevation of metabolic rate required to raise the bird's body temp from a slightly torpid nocturnal condition was examined using the Van't Hoff relationship. Assuming a Q_{10} equal to 2.3, we calculated that a difference of 4.95°C would be required to account for the difference between nocturnal and daytime \bar{x} HR. A change in body temp of this magnitude is unlikely in view of reports of body temp cycles in large raptors (Coulombe 1970; Gessaman 1978) and would not explain the evening peak at all.

We might expect to find an explanation for the bimodal pattern in HR in *Buteo* behavior, however Red-tailed Hawks do not seem especially crepuscular in their activities in the wild. Their soaring activity is greatest near midday when thermal con-

vective currents are most favorable (Henty 1977). For most buteos many potential prey species are crepuscular. Since the foraging success of Red-tailed Hawks has been linked to behavior of primary prey species (Stinson 1980), the possibility cannot be discounted that the HR cycle demonstrated here parallels activity patterns of prey.

ACKNOWLEDGEMENTS

This research was completed by the senior author in partial fulfillment of the requirements for the M.A. degree in Biology at the University of Nebraska at Omaha. It was made possible by the cooperation of the Raptor Rehabilitation Society, Lincoln, Nebraska, and assistance from R.A. Lock of the Nebraska Game and Parks Commission. We are particularly indebted to L. Phillips who assisted with surgery and to L. Simmons, Director of the Henry Doorly Zoo, Omaha, NE, who generously provided facilities and support equipment for the surgery.

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Received 17 May 1983; Accepted 10 April 1984

SHORT COMMUNICATIONS

Status of a Population of Bald Eagles Wintering in Western Connecticut

STEVEN D. FACCIO AND HOWARD I. RUSSOCK

In a previous study (H.I. Russcock, *Raptor Research* 13(4): 112-115, 1979) a population of 4 Bald Eagles (*Haliaeetus leucocephalus*) was observed on wintering grounds in western Connecticut during the winter of 1976-1977. The eagles congregated below a hydroelectric dam on the Housatonic River. The dam's generators kept the otherwise frozen river open and killed or injured large numbers of fish which the eagles preyed upon. This paper presents the results of subsequent observations made during the winter of 1982-1983 on the same population of eagles which grew to 17 individuals.

Eagles were observed in the vicinity of the Shepaug Hydroelectric Dam, Housatonic River, approximately 4.6 km north of Newtown, Connecticut. Above the dam, and created by it, is Lake Lillinoah with a surface area of 769 ha. Directly west, across Lake Lillinoah, is the Upper Paugussett State Forest extending for 3 km north along the western shore of the lake. On the south side of the river, below the dam, is a large privately owned wooded hillside where eagles congregated. North, across from the hillside, is a hydroelectric plant owned by Connecticut Light and Power Company.

Most observations were made from the top of the dam and from a canvas blind constructed on the south side of the river, approximately 25 m from a frequent perching area. Other observations were made from a road running

parallel to the north side of the river and from several locations northwest of the dam (when attempting to determine roosting sites). Observations were made with field binoculars (7x35) and a 600 mm photographic lens and were results dictated into a taperecorder or handwritten. A total of 178 h of observation were made between 8 December 1982 and 8 April 1983. Trips were made to the dam on 52 separate days, 34 of which resulted in sighting of eagles.

The first eagle observed was on 3 January 1983; 9 observation days in December did not result in any sightings. Eagles were last observed on 24 March 1983; during 6 observation days in late March and early April none were seen.

Due to unusually mild weather, the Housatonic River remained virtually free of ice during the entire winter. Therefore, the departure of eagles could not be correlated with the opening of the river in spring as it was during the winter of 1976-1977. It was not determined if the greater availability of open water elsewhere affected the number of eagles wintering in the vicinity of the Shepaug Dam. However, due to the abundance of fish at the dam, it is likely that all eagles wintering in the area frequented the dam.

Seventeen individuals were positively identified using plumage characteristics and other outstanding features;

10 were adults and 7 immature. Eight (4 adults, 4 immatures) were observed frequently from early January to early or mid-March. Two other immatures were observed between 6 and 24 February 1983. Seven others (5 adult, 2 immatures) were seen on 1 or 2 observation days each, between 13 January and 12 March 1983.

Night Roosts — Three night roosts were tentatively 2.5-7.5 km north and northwest of the Shepaug Dam. All 3 were located in undeveloped mixed hardwood forest. The first 2 sites were located by direct observation of eagles leaving or returning in early morning and early evening, respectively. The third was located with a police scanner by tracking a radio-tagged eagle.

Breeding grounds — The 17 eagles wintering in the vicinity of the Shepaug Dam can be divided into 2 groups, 8 observed throughout the winter and 9 observed over a period of 1 to 18 d. It is reasonable to assume that the latter group is made up of transient birds. Three of these have been traced to breeding areas in Maine. Two immatures observed only during February were identified by leg bands as hatch year birds from Maine. A third immature, observed on 1 d in February, had both leg bands and a backpack transmitter which identified it as coming from a nest in the Cobscook Bay area of the Main coast. Two others (1 adult, 1 immature), seen on 1 or 2 d each, also had leg bands, but could not be further traced.

There is no direct evidence of an active nest in the area. However, 7 of the 8 eagles observed throughout the winter could be divided into 2 groups which virtually always moved as separate units. One group consisted of 2 adults and 1 immature and the other group consisted of 2 adults and 2 immatures. This suggests that there were 2 family groups. The senior author observed a single adult

on 3 separate occasions during the first week of June 1983, approximately 7 km north of the Shepaug Dam.

Feeding — Eagles arrived at the dam area 5-15 min before sunrise; they remained perched until the hydroelectric plant started operation at 0700 when they began feeding on fish killed or injured by the plant's turbines. Feeding continued for 1-3 h after which the birds perched or soared over the hills on the south side of the river. Feeding often resumed in early afternoon before the birds returned to their roosts.

Eagles were observed making dives to the river to catch fish on 232 occasions, 170 (73%) of which were successful. Adults were successful on 103 (75.7%) of 136 attempts while immatures were successful on 67 (69.8%) of 96 attempts (NS, X^2 Test). Fish caught included trout (*Salvelinus* spp.), bass (*Micropterus* spp.), catfish (*Ictalurus* spp.), and shiner (*Notropis* spp.).

We thank Connecticut Light and Power Company for allowing access to their property. We also thank Lawrence Fisher, Janet Mitchell and Stewart Mitchell for their help and personal observations of Bald Eagles in western Connecticut and Francis Gramlich, NSBERT, for his help in tracing several eagles to Maine. Dr. Frank Dye and Dr. Susan Maskel, Western Connecticut State University, commented on an earlier version of this manuscript.

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Received 8 March 1983; Accepted 10 May 1984.

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Nest Defense by Northern Harriers Against the Coyote in Southwestern Idaho

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Predation on Northern Harrier (*Circus cyaneus*) by Striped Skunk (*Mephitis mephitis*), Badger (*Taxidea taxus*), foxes (*Fulpes* sp.) and Mink (*Mustela vison*) has previously been reported. (Craighead and Craighead 1956; Hamerstrom 1969; Watson 1977). Although Murie (1940) reported that Coyotes (*Canis latrans*) prey on the Short-eared Owl (*Asio flammeus*), an ecological equivalent of the Northern Harrier, we are not aware of reports of Coyote predation on Northern Harriers. Herein we report several Northern Harrier — Coyote interactions observed during 1981 in the Snake River Birds of Prey Study Area in southwestern Idaho.

On 29 March at 1020, T.C. observed a pair of nesting harriers perched in a small tree (*Crataegus* sp.) near a spring bordering the Snake River. Riparian habitat surrounded the spring for a distance of 15 m with senescent

reed (*Phragmites communis*) and stinging nettle (*Urtica* sp.) the predominant vegetation. Beyond the spring, big sagebrush (*Artemesia tridentata*) and June grass (*Bromus tectorum*) covered the nearby canyon side. Shortly, the female harrier flew from the tree followed by the male, and both began emitting a call usually associated with agnostic displays. The male then started diving repeatedly at the edge of the riparian growth. By the male's changing position it was obvious that the object of his dive was moving toward the center of the riparian vegetation. As the hawk completed a dive, a Coyote rose on its hind legs above the vegetation and snapped its jaws at it. The Coyote again attempted to grab the harrier, and then stopped with his back visible. It appeared that it was moving its head near the ground as if eating. The female harrier circled and called overhead while the male con-

tinued to call and dive, although not as closely. After about 5 min, T.C. approached the spring and the coyote fled with the male harrier in close pursuit, diving with both feet swung forward attempting to grab the coyote. A single, pale-blue, harrier egg was found in the nest at the spot where the coyote had appeared to be eating. Both harriers circled and called over the human intruder but neither dived. A single adult male harrier was observed near the nest area on 24 April but on 2 subsequent visits no birds were seen. On 7 July the nest was visited again and only a few bits of egg shell were found; however, no harriers were present.

On 30 May at 1146 L.P. observed a male harrier escort a Golden Eagle (*Aquila chrysaetos*) from the harrier's territory. The harrier circled back toward its nest in a shallow undulating flight and began to vocalize and dive at something on the sagebrush slope above the nest site. As the male continued its vigorous dives, the object of the attack, a Coyote, appeared. A female harrier soon began circling over the area, occasionally making shallow dives at the Coyote. Shortly, a second male harrier flew into the area from a neighboring nesting territory to the east and joined the pair. The second male appeared to "sky dance" (Hamerstrom 1969) around the female at first but soon began to vocalize and dive at the Coyote also. The Coyote, followed by the defending hawks, gradually moved out of view toward the neighboring harrier territory. At 1155 a male harrier reappeared from the east and soared above the original harrier's territory.

Later that day at the same harrier territory, a male flew across the river from its nest area and dove several times at a Coyote that trotted eastward. After 1 to 2 min the harrier veered off, perched on a sagebrush briefly and then flew at an angle away from the Coyote and intercepted a second male harrier which was approaching the Coyote from the northeast. The first male briefly chased the invading hawk which attempted to dive at the Coyote. Soon, the first harrier flew back toward its territory and began to hunt. Within 5 min he captured a small prey item and delivered it to his mate at the nest across the river. When we visited the nest on 7 June, 1 egg and 2 nearly-hatched nestlings were found. Twenty-seven days later on a second visit the nest had been destroyed and only pin feathers of juveniles remained. The adjacent harrier nest to the east successfully fledged at least 3 young.

J.M. frequently saw Coyotes in the vicinity of harrier nests on the study area, and observed both male and female harriers, individually and jointly, diving at

Coyotes. More often the male was the lone defender. As in the previously described observations, J.M. also observed a Coyote leap into the air after a defending adult male and at times observed several harriers cross well defined territorial boundaries to pursue a Coyote. Newton (1979) reports such communal nest defense among Marsh Harriers (*Circus aeruginosus*). In one location J.M. found a Coyote den at one end of a large marsh which contained 7 harrier nests. Five of those 7 nests failed, and 3 showed evidence of Coyote predation.

Although eye-witness accounts of predation at raptor nests are not common, our observations indicate that Coyotes do prey on Northern Harrier nests, especially in desert areas, perhaps where sparse riparian habitat attracts both animals. Furthermore, our report suggests a danger of leading this predator to harrier grounds nests by investigator's scent trails (Fyfe and Olendorff 1976) as reported by Craighead and Craighead (1956) for a farm dog (*Canis familiaris*).

We thank Drs. F. and F.N. Hamerstrom for helpful comments on the manuscript.

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Received 26 December 1983; Accepted 10 May 1984

NEWS AND REVIEWS

BEHAVIOR OF FLEDGLING PEREGRINES BY STEVE K. SHERROD; drawings by Karen Lynn Allaben-Confer. 1983. Fort Collins, Pioneer Impressions. xi + 202 pp., 59 figures, 23 tables. Price \$10.00. Available from the Peregrine Fund, Inc., Ithaca, New York.

Peregrine Falcons are renowned for their spectacular aerial feats. How they develop this unique behavior is unfolded as 4

broods of fledglings, 2 broods from Australia and 2 from Greenland, are followed from first flight to dispersal. The book's sequ-

ence of chapters follows the development of fledgling behavior. Initial sections cover simple perch-to-perch flight behavior, followed by behavioral descriptions of soaring, stooping, pursuits of parents and siblings, pursuits of inanimate and animate objects, play, and development of the ability to kill. Later, types of food transfers from adults to offspring and various types of aggression are described. The final section covers the length of post-nestling dependency, including a discussion of stimulus for dispersal and parental care during migration.

The 1 overriding observation that leaps out to the reader is the aggressiveness of the young. Sherrod states "Aggression is a component common to the behavioral repertoire of the peregrine, and it is incorporated into many of the displays of this bird". A common phrase "don't bite the hand that feeds you" is scoffed at by fledglings. Parents are bitten, footed, bumped off their perches and chased relentlessly by juveniles seeking food — even when there is none to be had. Such aggressiveness provides the basis for the author's reinterpretation of the "luring" behavior reported by early observers of peregrine behavior. It has been thought that when adults flew by their nests with prey they were "luring" their young to fly from the nest. The author, however, provides many observations to indicate that adults are simply reluctant to land because they "fear" being rushed by thier young, bitten, footed or pushed off the ledge itself.

In addition to fledgling behavior of wild peregrines, extremely valuable behavioral comparisons were made with broods of fledglings without parents that are "hacked" from artificial nests. Most behaviors observed in wild young also recurred in hacked young but distinctions were present. For example, "Although hacked fledglings instinctively recognize other raptors, wild offspring probably learn which predators are an immediate threat in their natal territory by observing the defensive behavior of their parents".

I found this book valuable because it 1) provides a wealth of background information for future comparative behavioral studies of congeners, 2) provides a clear picture of the development of fledgling peregrine behavior (and associated adult behavior) for people who have never had the opportunity to observe nests, 3) provides descriptions of behavior that fill in gaps of knowledge for even experienced observers who are not fortunate enough to observe, uninterrupted, fledgling behavior from first flights to dispersal and 4) focused attention on aspects of my own behavioral observations of peregrines that I did not put into con-

text until after reading the book. For example, while I watched shorebirds at high tide on 3 November 1975 at the northern end of Humboldt Bay, California, 2 peregrines flew by and the adult male captured a small shorebird, Western Sandpiper (*Calidris mauri*) size, killed it, and then dropped it 10 m and recaptured it. Meanwhile the female struck a shorebird that fell into the water. She made several passes at it but was unable to pick it up. When the 2 falcons rejoined in flight the male dropped his kill to the female below him but she failed to catch it. Moments later she captured a Willet (*Catoptrophorus semipalmatus*) sized shorebird but then dropped it into the bay. The male then caught another small shorebird, carried it out over the bay, accompanied by the female and heading south where they eventually disappeared. After reading Chapter 9, it occurred to me that what I may have observed was parental care during migration or, continuation of the adult pair bond after leaving the nesting cliff, although I could not be sure if the female was an adult.

Numerous format irregularities were distracting. When I first opened the book I was immediately struck by the contrast in type sizes, and then by the narrow margins. The feeling of being squeezed was further compounded by the narrow bar widths in Figures 3, 26a & b, 33a-e, and 56. Table and figure captions in the text are inconsistent with those given at the beginning of the book. The drawings ranged from excellent to extremely poor. (Fig. 48 looks more like a Potoo (*Nyctibius*) than a Peregrine. Some figures seem irrelevant (Figs. 1, 20, 21) and 1 figure (38) appears to have been printed upside down. The eyes are virtually obscured in all Peregrine drawings. In defense of the book, however, all drawings do illustrate what is being demonstrated behaviorally.

The author seemed (understandably) reluctant to summarize much of his data because juvenile Peregrines show wide variation in the initiation of a behavior and its expression. Instead, numerous bar graphs are presented to visually depict the variation and midpoint of the data. A valuable addition would be a single timeline, summarizing when the mean onset of each behavior occurs in terms of fledgling age or time on the wing since first flight.

Despite a few shortcomings in the format, I highly recommend the work. It has immediate appeal to raptor biologists for behavioral descriptions. There is also a broader appeal because Sherrod makes numerous behavioral correlations between the offspring of Peregrines and the offspring of mammalian carnivores. — DOUGLAS A. BOYCE JR.

Temporary Position - Research Associate - Department of Veterinary Biology, University of Minnesota. Ph.D. degree with experience in teaching and research at the college level is required. Must have experience working with raptors and must be interested in gastrointestinal (GI) physiology and energetics. Individual who holds or has held a university faculty position is preferred. Duties include conducting research on regulation of GI function in raptors and assisting in teaching physiology to veterinary medical students as time permits. Application deadline: 15 November 1984. Position is available for four months from 1 December 1984 through 31 March 1985. Salary \$1,608 per month. Send curriculum vitae and three references to: Dr. Gary E. Duke, Department of Veterinary Biology, University of Minnesota, 295 AnSci/Vet. Med. Bldg., 1988 Fitch Ave., St. Paul, MN 55108, USA.

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RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

Volume 18, Number 3, Fall 1984

(ISSN 0099-9059)

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 18

FALL 1984

No. 3

THE PEREGRINE FALCON (*Falco peregrinus macropus*) Swainson IN SOUTHEASTERN QUEENSLAND

G. V. CZECHURA

ABSTRACT - Most studies of Peregrine Falcon (*Falco peregrinus*) biology have been conducted in Europe and North America (Hickey and Anderson 1969; Ratcliffe 1980; Cade 1982). Information concerning southern hemisphere Peregrines is restricted to the studies of Clunie (1972, 1976) on Fiji, reviews by Cade (1969), Brown (1970) and Steyn (1982) of African populations, while Chaffer (1944), Jones and Bren (1978), Norris et al. (1977), Olsen and Olsen (1979), Olsen et al. (1979), Olsen (1982), Pruett-Jones et al. (1981 a, b), Walsh (1978) and White et al. (1981) provide important contributions for Australia.

Declines in some northern hemisphere populations due to the effects of pesticides (Hickey 1969; Billefeld 1974; Newton 1979; Ratcliffe 1980; Cade 1982) have served to focus considerable attention on the distribution and dynamics of regional Peregrine Falcon (*Falco peregrinus*) populations. Concern has been expressed about the potential affects of pesticides on populations of this falcon within Australia (Olsen and Olsen 1979, 1981; Pruett-Jones et al. 1981b). Existing studies on the status of the peregrine within Australia have been conducted in the southeastern corner of the continent (Olsen and Olsen in press) and little is known of the status of northern and western populations. The following reviews the present state of knowledge of the peregrine in southeast Queensland. A more detailed, long-term study is underway.

MATERIALS AND METHODS

Information for this review was obtained from Queensland Museum records, literature, and previously unpublished observations of both myself (1968 to present) and others. Geographic units referred to as southeastern Queensland and Moreton and Wide Bay — Burnett region follow Roberts (1979) and Mather (1976), respectively. Note that a bias toward the Moreton region exists - reflecting distribution of observers. Sufficient information is available for the presentation of a broad outline of distribution, breeding, hunting and conservation problems of peregrines over southeastern Queensland as a whole. Vegetation terminology follows Groves (1981).

DISTRIBUTION

Peregrine Falcons have been recorded over much of southeastern Queensland (Fig. 1; Table 1). In addition, they have been recorded in the im-

mediate vicinity of the regional boundary (Broadbent 1889; Barnard and Barnard 1925; Longmore 1978; Passmore 1982). Vegetation type appears to exert little or no influence on the overall distribution here, as closed-forests, open-forests, woodlands, wetlands and agricultural areas are all frequented by falcons. For example, Dwyer et al. (1979) recorded peregrines from 8 of 12 habitat types found across Cooloola. The vegetation types represented here included vine forest, various forms of open forest and woodland as well as heath, herb and sedgeland. Wide occupation of vegetation types has been noted also in the Rockhampton area to the north (Longmore 1978).

Vernon (1976) and Roberts (1979) both note that peregrines favour mountainous areas with extensive cliffs and rocky outcrops. Examination of records used to construct Fig. 1 indicates that this is essentially correct with some modification. Certainly peregrines are well represented in mountainous areas as they have been seen on 11 of the 14 major mountain systems. However, they are also frequently observed in coastal districts where they may be locally abundant (Cooloola; Roberts and Ingram 1976). Examination of inland localities where peregrines are regularly encountered indicates an association with cliffs, gorges, and outcrops. Similarly, coastal records involve areas where eroded high dunes/coastal cliffs (Fraser, Moreton and North Stradbroke Islands), subcoastal highlands (MacPherson Range-Gold Coast) or isolated peaks (Mt. Cooroy-Peregian, Pumicestone Passage - Glasshouse Mountains) are found nearby.



Figure 1. Distribution of *Falco peregrinus macropus* in southeastern Queensland based on both published and unpublished sightings.

BREEDING, DENSITY AND MOVEMENTS

Twenty-four active eyries (eggs and/or adults plus young present) are known from southeastern Queensland. In addition, several areas containing suspected eyries have yet to be examined and 1 eyrie previously known to be active was inactive. Most eyries were located within major range systems although 6 outlying sites are known. With the exception of 1 eyrie located on a high coastal foredune, vertical or subvertical rock faces along exposed cliffs or along gorges were utilized. Rock faces were variously composed of granite, trachyte, basalt or sandstone. The dune nest was situated on exposed sandrock-fossil hardpan. Individual eyries were placed on ledges, crevices or shallow caves (Fig. 2 A,B) between 30-270 m above ground level. The surrounding vegetation was either subtropical rainforest, open-forest or woodland.

Most eyries appeared to have been active for some time. One located within the northern Moreton region was active since the early 1940's, although peregrine records within this area indicate at least 50 yr occupation of the site. Activity as-

sociated with another Moreton region eyries indicates that it has been active for about 60 yr. The earliest records available for the southern Moreton region are from the early 1940's, and mid-1950's for the western Moreton region. Only very recent records are available for the Wide Bay-Burnett region.

Observations made within the northern Moreton region suggest that breeding starts mid-August or early September. Beruldsen (1980) records a nesting season of "July to October, sometimes November in the south, and April to June in the north". The earliest known egg-laying occurred in late July (1980) and the latest early November (1968). The latter cases appears somewhat anomalous and may represent either a late breeding or a replacement clutch. Display was noted during October and 2 fledglings were present during December. Little activity had been detected during September of that year. Pre-egg-laying display flights were typical of those used by peregrines elsewhere and consists of mixtures of components such as High-circling, Figure-of-eight, Flight-rolling and Z-flight (Cramp and Simmons 1980;

Table 1. Summary of available published sightings of Peregrine Falcons in Southeastern Queensland.

LOCALITY	SOURCE
Callide Dam	Zillman 1974
Sandy Cape	Makin 1968
Fraser Island	Vernon and Barry 1972
Mt. Walsh	Frauca 1970
Maryborough	Anon. 1972; Jones 1981
Auburn River	<i>Darling Downs Naturalist</i> Dec. 1978:43*
Cooloola	Roderick 1975; Roberts and Ingram 1976; Dwyer et al. 1977
Teewah Creek	Ingram 1972
Noosa Heads	Wheeler 1959 (probable)
Jimna	Q.O.S. July 1978:2*
Kilcoy Shire	McEvoy et al. 1979
Blackall Range	Czechura in press
Maleny	Czechura 1970, Q.O.S. Jan. 1975:2
Conondale Range	Roberts 1977; Czechura in press
Glasshouse Mountains	Jack 1941; Fien 1966; MacArthur 1978
Pumicestone Passage	Mayo 1934; MacArthur 1978
Redcliffe	Q.O.S. May 1974:3
Crows Nest	Q.O.S. Oct. 1977:3
D'Aguilar Range	Illidge 1923; Vernon 1976
Pinkenba	Q.O.S. Nov. 1982:4
Lytton	Q.O.S. Nov. 1982:2
Bardon	a.S. May 1974:3
Stones Corner	Q.O.S. Nov. 1982:2
Murphy's Creek	Lord 1956
Pt. Lookout	Q.O.S. May 1977:4
North Stradbroke Is.	Vernon and Martin 1975
Cecil Plains	Q.O.S. June 1979:2
Cooper's Plains	Q.O.S. March 1976:3
Redwood Park	Q.O.S. July 1978:3
Cunningham's Gap	Vernon 1976
Dalrymple Ck.	Q.O.S. June 1977:2
Tweed R. District	Keast 1944
Warwick district	Kirkpatrick 1967
Emuvale	Q.O.S. Sept. 1977:2
Stanthorpe	Passmore 1982
Lamington N.P.	Robertson 1948
Binna Burra	Wheeler 1973; Q.O.S. July 1979:4

* Newsletters are cited in table only. 'Q.O.S.' refers to Queensland Ornithological Society Newsletter.

Monneret 1974; Ratcliffe 1980). In addition, a flight termed herein the V-flight, has been observed in which a circling or flying peregrine suddenly stoops with wings closed, terminates the stoop by spreading its wings and regains altitude using a combination of momentum and flapping flight

(Fig. 3). The speed at which the stoop is terminated and altitude regained often leaves the impression of a stoop followed by a 'bounce'. The V-flight usually followed a period of High-circling, linear flight or undirected activity. Several flights may be conducted in quick succession. All display flights were

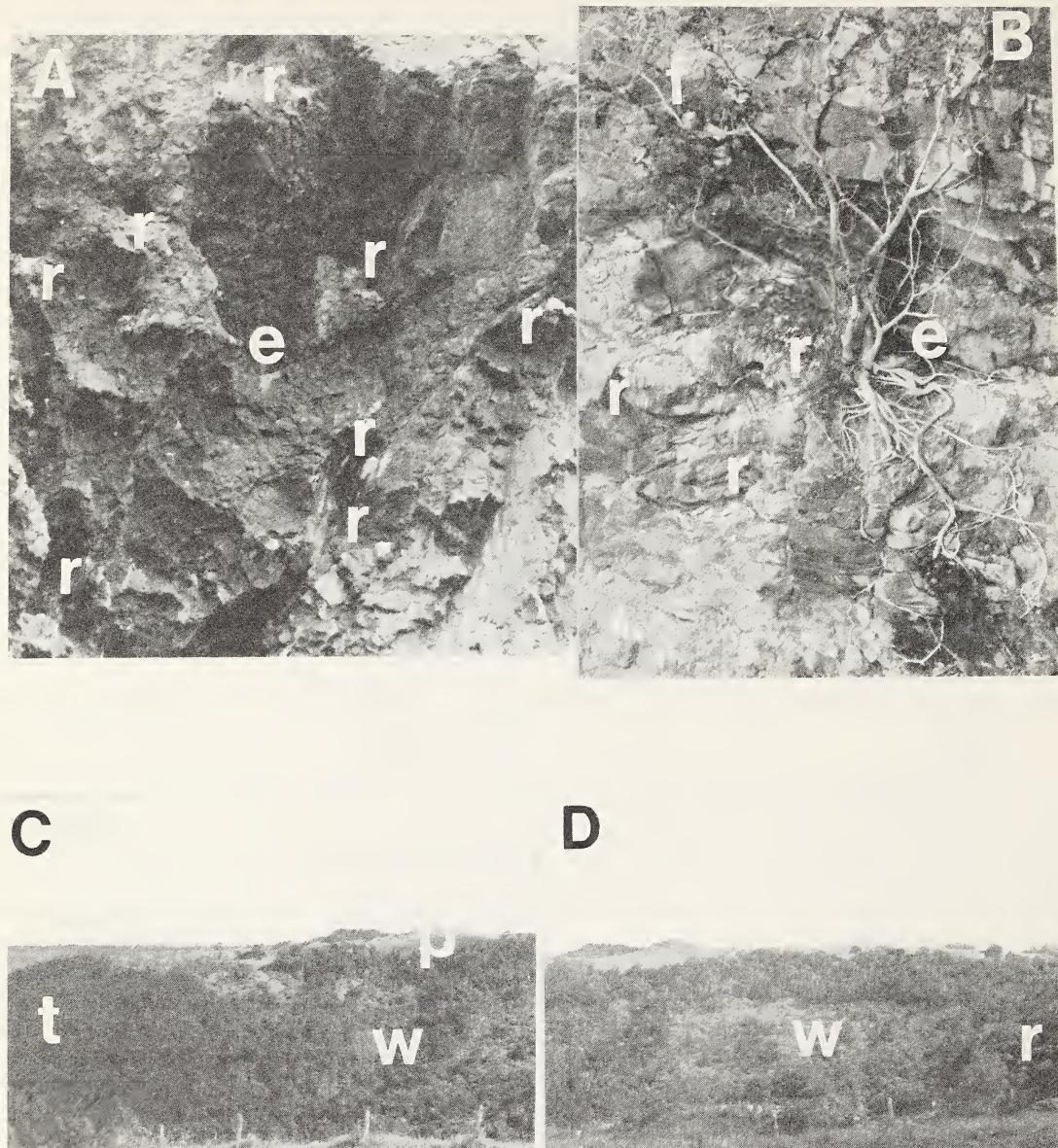


Figure 2: A. Ledge eyrie (e), eastern Moreton region; adjacent roosts (r) are also indicated. B. Cave eyrie (2), eastern Moreton region; perched peregrine (l) and adjacent roosts are indicated. The location of this eyrie is shown by its entrance. C-D. Peregrine hunting area (approx. 4 km SW Maleny). This area has been regularly used since 1970. Note different vegetation types present (r-rainforest, t-tall open-forest, p-pasture, w-regrowth).

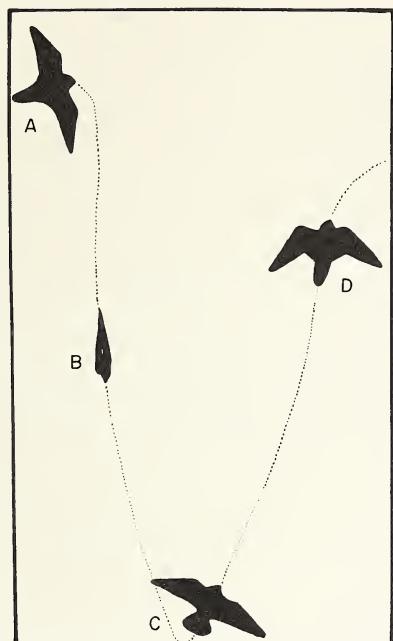


Figure 3. The 'V-flight' display. The display commences (A) from earlier circling or similar activity. The falcon abruptly stoops with wings closed (B), terminates the flight (C) by spreading the wings and regains altitude (D) using momentum and later flapping flight.

accompanied by much vocalization. Copulation usually occurred late during the display period and on areas surrounding the nest (ledges, projections of the cliff-face or adjacent trees).

Little information is available concerning clutch size. P. Olsen (pers. comm.) has examined 3 clutches (1 questionably from southeastern Queensland). All consisted of 3 eggs. Indirect evidence, such as the number of fledglings at active eyries, suggests that a clutch size of 3 is usual (G. Geruldsen pers. comm.; pers. obs.). Typically 2 young fledge (Table 2). The maximum number of fledglings observed at a number of sites is 3 (pers. obs.; P. Slater pers. comm.; D. Evans pers. comm.,) suggesting either high productivity or occasional larger clutches. Olsen and Olsen (1979) record a mean clutch size for Queensland peregrines of 2.5 pre-1947 and 3.1 post-1947. Savidge (in Mathews 1916) records cliff-face nesting in the Clarence River district of northeastern New South Wales and collected the following successive clutches from 1 pair

of falcons; 16 August, 3 eggs; 13 September, 3 eggs; 14 October, 2 eggs.

Data from southeastern Queensland appear consistent with similar data from southeastern Australia. The presumed clutch size of 3 in southeastern Queensland compares favourably with both the State means (above) and the combined means for New South Wales, Victoria, South Australia and Tasmania (pre-1947, 3.0; post-1947, 2.7; data from Olsen and Olsen 1979). Olsen (1982) did not find any significant correlation between clutch size and latitude, longitude or temperature. Similarly, comparison of the mean numbers of fledglings of the 2 Moreton region eyries (2.13, 2.25; Table 2) indicates that these values are within the range for numbers of young at successful eyries in New South Wales (2.2), Victoria (2.1), South Australia (2.2) and Tasmania (2.5) (data from Pruett-Jones et al. 1981; Olsen and Olsen in press).

Pending the completion of survey work currently in progress, only approximate values of peregrine density over the entire region are available. Estimates, based on known pairs in the Moreton region, indicate a density of about 1 pair/2600 km², while taking suspected pairs into consideration a value of 1 pair/1500 km² is suggested. These values com-

Table 2: Fledgling number at 2 adjacent northern Moreton Region Eyries 1968 - 1982.

YEAR	NUMBERS OF FLEDGLINGS OBSERVED	
	EYRIE A	EYRIE B
1968	2	*
1969	2	*
1970	3	*
1972	3	*
1976	2	*
1977	1	*
1979	2	2
1980	*	3
1981	*	2
1982	2	2
Mean	2.13	2.25

* - No data available

pare with a density of 1 pair/100 km² for one area under study. Distances between neighboring eyries range from 4.8 - 65 km (mean 40.9, N = 221 km). The above density values are tentative. This uncertainty reflects the difficulty in locating alternate nesting sites (e.g., stick nests) in dense forest (rain-forest, tall open-forest) and poor accessibility to some highland areas supporting suitable cliff faces. The current estimates indicate a nesting density well below that of Victoria (1 pair/600 - 800 km², White et al. 1981) and slightly higher than Tasmania (Olsen and Olsen in press).

Storr (1983) considers *F. p. macropus* to be nomadic and evidently migratory over much of Queensland. He noted that most records involved

the period April-October. Monthly observations at several more accessible Moreton region eyries strongly suggested that breeding birds are relatively sedentary with roosts being maintained around the eyrie outside the breeding season. Observations made by Jones and Bren (1978) and Olsen and Olsen (in press) indicate the same in southeastern Australia. Hunting is less frequent but conducted over much the same area as used during the breeding season. In general, it seems that the apparent nomadism of peregrines may be attributable to the unconsciousness of adults around eyries outside the breeding season and movements of immature birds. Locally high densities have been reported (*Elks in* Roberts and

Table 3. Prey recorded for the Peregrine Falcon (*Falco peregrinus macropus*) in Southeastern Queensland.

PREY ITEMS	SOURCE
Insects	
Orthoptera	P. Slater pers. comm.
Odonata	Pers. obs.
Birds	
Prion (<i>Pachyptila</i> sp.)	C. Corben pers. comm.
Cormorants (<i>Phalacrocorax</i> spp.)	Mayo 1934
Sacred Ibis (<i>Threskiornis aethiopicus</i>)	Czechura 1971, pers. obs.
Black Duck (<i>Anas superciliosa</i>)	R. Lutkins pers. comm.
Grey Teal (<i>Anas gibberifrons</i>)	R. Lutkins pers. comm.
Australian Kestrel (<i>Falco cenchroides</i>)	B. Cowell and G. Czechura obs. ¹
Stubble Quail (<i>Coturnix novaezelandiae</i>)	Czechura 1979
Brown Quail (<i>Coturnix australis</i>)	Czechura 1979
Red-kneed Dotterel (<i>Erythrogenys cinctus</i>)	G. Roberts pers. comm.
Red-necked Stint (<i>Calidris ruficollis</i>)	C. Corben and G. Czechura obs.
Feral Pigeon (<i>Columba livia</i>)	C. Corben pers. comm., D. Evans pers. comm.
Crested Pigeon (<i>Ocyphaps lophotes</i>)	P. Veerman pers. comm.
Bar-shouldered Dove (<i>Geopelia humeralis</i>)	pers. obs.
Rainbow Lorikeet (<i>Trichoglossus haematodus</i>)	pers. obs., D. Evans pers. comm., C. Corben pers. comm.
Scaly-breasted Lorrikeet (<i>Trichoglossus chlorolepidotus</i>)	pers. obs. ¹ , D. Evans pers. comm.
Pale-headed Rosella (<i>Platycercus adscitus</i>)	Prey remains at eyrie
White-throated Needle-tail (<i>Hirundapus caudacutus</i>)	G. & R. Czechura obs. ¹
Black-faced Cuckoo-shrike (<i>Coracina novaehollandiae</i>)	pers. obs.
Lewin Honeyeater (<i>Meliphaga lewinii</i>)	pers. obs. ¹
Noisy Friar-bird (<i>Philemon corniculatus</i>)	pers. obs. ¹
Noisy Miner (<i>Manorina melanocephala</i>)	pers. obs. ¹
Yellow-faced Honeyeater (<i>Lichenostomus chrysops</i>)	pers. obs.
Common Starling (<i>Sturnus vulgaris</i>)	pers. obs. ¹

¹ Includes observations made at eyrie during breeding season.

Ingram 1976) but as with most reports, it is not known if these involve adults or immatures. Immatures once independent, rarely remain in the vicinity of the eyrie for longer than 4 - 8 weeks approximately, although lone birds may take up residence in areas rarely frequented by the adults (pers. obs.). Otherwise little is known of movements or fate of the majority of immature birds.

Hunting and Prey - Peregrines were observed hunting in a variety of habitat and landscape types. Some regularly hunted over both very open (mudflats, waterways, pastureland) and densely vegetated (rainforest, tall open-forest, heathland) areas (Fig. 2 C, D). Presumably, hunting areas were determined by the location of nesting sites.

Prior to the advent of European settlement in southeastern Queensland, peregrines were largely associated with forested habitats. Rainforest vegetation was more extensive in coastal and subcoastal districts than at present (Illidge 1925; Francis 1970). Indeed, Cade (1982) noted that Australian populations of *F. peregrinus* show modifications of the feet and beak typical of "forest" races of the peregrine, *F. p. peregrinator* (India), *F. p. ernesti* (New Guinea) and *F. p. nesiotes* (Fiji) and the two large, forest-dwelling species, Orange-breasted Falcon (*Falco deiroleucus*) and New Zealand Falcon (*Falco novaeseelandiae*). Similarly, Pruett-Jones et al. (1981a) have commented on modifications of hunting techniques for dense woodland and forests in Victoria.

Birds were the chief prey (Table 3). Brief descriptions of some hunting flights are given by Mayo (1934) and Czechura (1970, 1971). Comparison of published and unpublished observations with the descriptions of Treleaven (1977), Ratcliffe (1980) and Cade (1982) indicate most hunting consists of a period of "still hunting" or "waiting on" followed by the traditional stoop or direct pursuit. "Still hunting" (Fig. 4-1A) involves the falcon launching an attack from a perch, such as an emergent tree in rainforest, on passing birds. On leaving the perch, the peregrine either gained altitude and then stooped onto the prey, made a level dash towards it (Mayo 1934; Czechura 1971) or stooped directly onto it. "Waiting On" (Fig. 4-1B) involves the raptor initially spending some time circling and/or engaged in active flight before stooping. The actual stoop (Fig. 4-2B) is usually conducted with wings closed or partly closed in a rather shallow angle of attack. The final stages of the stoop

may result in complex aerial manoeuvres as prey attempts to evade the falcon (Fig. 4-1B). Once the prey is struck by the peregrine, a loop may be performed to retrieve the body (Fig. 4-2B) or the bird may be simply seized and carried. Direct pursuit usually culminates in the peregrine seizing the prey.

Under special circumstances other hunting techniques were employed. "Solitary flushing" may be employed against ground-dwelling quail (Czechura 1979). The peregrine will make rapid, low-level passes above the vegetation sheltering the quail. If quail flush, direct pursuit will result. Peregrines, at other times, will "hawk" flying insects by leisurely circling amongst the insects and snatching them out of the air or snatch birds sheltering on the ground as they pass overhead, e.g., waders on mudflats.

It is difficult to determine hunting efficiency of peregrines. On many occasions a falcon will indulge in numerous attacks for up to an hour before a successful kill is made. Many attacks, however, do not appear to be pressed with determination (low intensity attacks, Treleaven 1977) e.g., the falcon breaks off early, stoops are short and relatively slow. During such times, and sometimes after feeding, "playful" attacks are made on large birds such as ibis (*Threskiornis* spp.) and Torrsian Crow (*Corvus orru*). Under the circumstances, lone crows or ibises are stooped on, with the peregrine often looping around the intended victim and then flying away. Similarly, flocks may be attacked with the apparent objective of breaking them up into smaller units. Bouts of such playful behaviour are interspersed with periods of soaring, slow flying and perching. Attacks on flocks of birds are usually unsuccessful if the flocks maintain their structure (Fig. 4-1C). Lone birds that attempt to leave the flock often are very quickly captured (Fig. 4-2C). Fruit pigeons and lorikeets will often attempt to out-maneuvre the falcon and seek shelter in the canopy of nearby trees by perching or flying through them. Frith (1942) reported such behaviour among fruit pigeons in northern New South Wales but notes one case where the pursuing peregrine pressed its attack below the forest canopy. While successful attacks have been observed on lorikeets (*Trichoglossus* spp.) and honeyeaters, no successful attacks have been reported on either Topnot Pigeon (*Lopholaimus antarcticus*) or White-headed Pigeon (*Columba leucomela*) flocks.

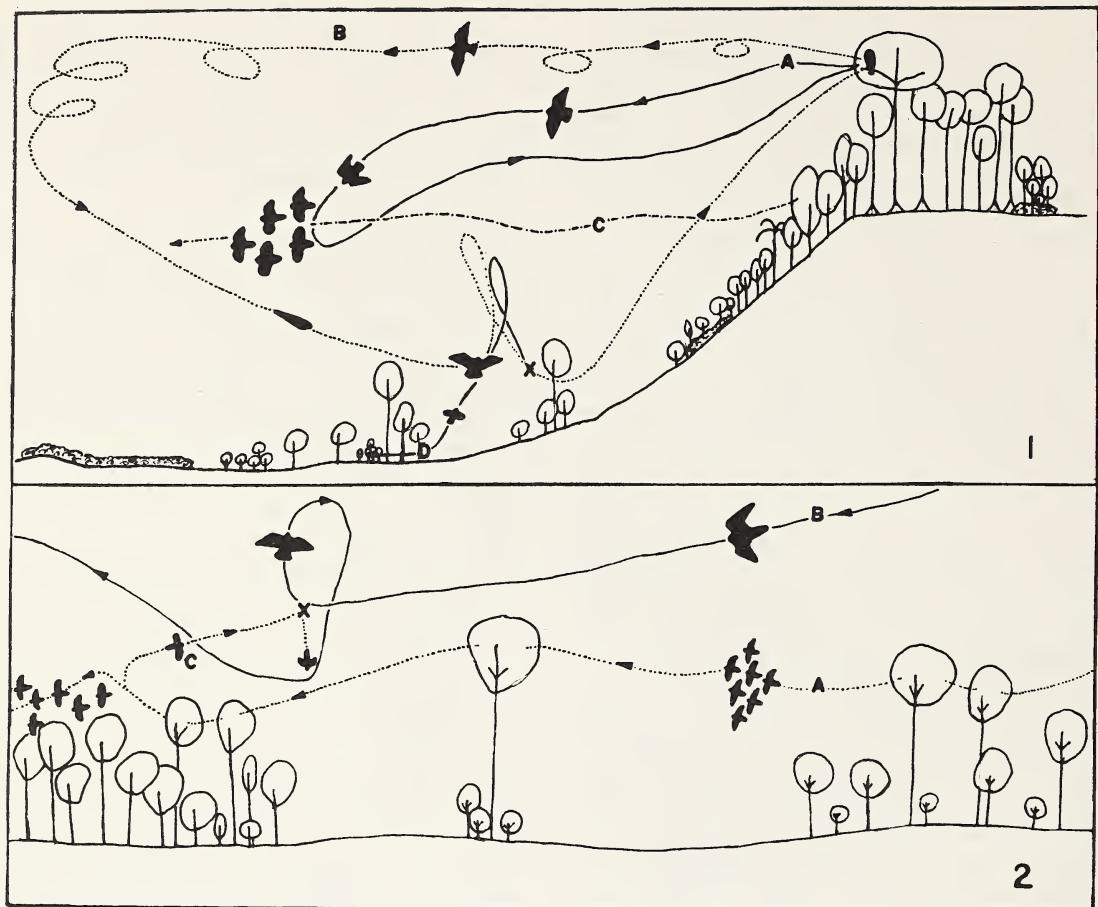


Figure 4. Peregrine Falcon (*Falco peregrinus*) hunting behavior.

- 4.1 Hunting over rainforest and pasture-regrowth area near Maleny (profile taken from transect across part of the hunting area shown in Plate 1 C-D). A. Unsuccessful (?low intensity) attack on a flock of Topknot Pigeons (flight path C) leaving rainforest canopy. The adult female peregrine was perched in an emergent *Ficus* sp. and returned after this attack. B. Successful attack on an unidentified honey-eater (D) after a period of soaring. The honeyeater attempted to climb, then dive away from the falcon prior to its capture (x). Plucking and feeding was conducted on the perch atop the emergent *Ficus* sp. This attack was conducted approximately 15 mins after attack A.
- 4.2 Successful hunt over woodland - pasture - low riverine rainforest near Woodford. A. Feeding flock of lorikeets were attacked by an adult female peregrine (B) after leaving the central tree. The flock, except one bird (C) fled through the canopy of adjacent trees. Bird C was struck by the falcon, caught after a rapid loop, then carried.

Although very little is known of hunting and prey species of peregrines in the region during early settlement, observations made by Savidge (*in Matthews 1916*) in the Clarence River district of north-eastern New South Wales suggest little change has taken place. Savidge records the following prey, Black Duck (*Anas superciliosa*), Rainbow Lorikeet (*Trichoglossus haematodus*), Pale-headed Rosella (*Platycercus absitus*), Australian Magpie-lark (*Gralina cyanoleuca*) Feral Pigeon (*Columba livia*) and Feral Chicken (*Gallus gallus*). All but *G. cyanoleuca* and *G. gallus* have been recorded among prey from southeastern Queensland (Table 3).

Interactions with Other Raptors - Interaction between the Australian Hobbie (*Falco longipennis*) and peregrines occur in many areas with the exception of heavily timbered and some upland areas (Czechura *in press*). Both falcons may be found hunting in the same areas on occasion (e.g., Woodford, Caboolture), especially when lorikeets are abundant. At these times peregrines largely hunt the Rainbow Lorikeet (*Trichoglossus haematodus*) and Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*), while Australian hobbies hunt *T. chlorolepidotus* and the smaller Little Lorikeet (*Glossopsitta pusilla*). The Brown Falcon (*Falco berigora*) occurs with peregrines in many areas with the exception of densely timbered country. Interactions between Brown and Peregrine Falcons appear to be mildly aggressive. Brown Falcons will often leave hunting areas after the appearance of peregrines. At other times peregrines may make 1 or 2 casual stoops at flying Brown Falcons or Brown Falcons may stoop at perched peregrines. The Australian Kestrel (*Falco cenchroides*) comes into contact with peregrines in the same habitats as Brown Falcons. Kestrels readily mob perched peregrines, while Czechura (1970) has reported a possible 'play' encounter. On one occasion a kestrel was among prey brought to an eyrie (Table 3).

Peregrines have been observed mobbing the Whistling Kite (*Haliastur sphenurus*) on 2 occasions along Pumicestone Passage. Both of these involved the same immature female peregrine. Otherwise observations are restricted to encounters near eyries. On several occasions the Wedge-tailed Eagle (*Aquila audax*) and once a Grey Goshawk (*Accipiter novaehollandiae*) were mobbed by one or both falcons as they approached eyries.

Mortality and Conservation - Little is known of natural mortality among peregrines in southeast-

ern Queensland, although one was found dead after a hailstorm in the Brisbane area (Q.M. ornithological records). The most significant cause of mortality appears to be human persecution. Pigeon fanciers have destroyed adults and interfered with eyries in the eastern Moreton region. Some falcons certainly fall victim to general persecution of raptors. Disturbance at eyries also results from sight-seers, bushwackers and illegal egg-collectors.

The nature and extent of pesticide effects within the region are poorly known. Olsen and Olsen (1979) found greater than 20% eggshell thinning attributable to D.D.T. in clutches from southeastern Queensland; this compares with a State mean of 3.6%. Shell thinning of 15-20% is critical - affected eggs would not be expected to withstand incubation (Newton 1979; Ratcliffe 1980). No peregrines have come to the Small Animal Clinic, Department of Veterinary Science, University of Queensland, suffering from pesticide poisoning (W. Rooke pers. comm.), but the Clinic has received other diurnal raptors suffering from pesticide poisoning.

Some recent developments in the patterns of pesticide use in southeastern Queensland are of concern. *Heliothis* moths are serious crop pests (Broadley 1977) and recent failure of a number of synthetic pyrethrins used in their control has led to renewed use of organochlorines in a number of areas, while serious outbreaks of armyworms (*Pseudaletia* spp., *Spodoptera* sp.; Broadley 1978, 1979) in southern subcoastal pasturelands have necessitated use of pesticides (particularly via aerial application), where their usage has traditionally been of a low level.

Although a number of eyries are within the existing national park-reserve system, there are no specific conservation/management programmes in operation. The species is protected under the provisions of the Fauna Conservation Act of 1974.

ACKNOWLEDGMENTS

I thank Victor Bushing, David Evans, Peter Hughes, Ted Johansen, Kathleen MacArthur, Gary Norwood, Tony Palliser, Chris Pollitt, Gary Silk, Peter Slater, Phillip Veerman, Ian Venables and Eric Zillmann for information used herein. For field assistance, I thank Robin Czechura and Gunter Maywald. Assistance in manuscript preparation was kindly provided by Gordon Beruldsen, Chris Corben (Department of Forestry, Queensland), Glen Ingram (Queensland Museum), Scott Mooney (National Parks and Wildlife Service, Tasmania), Jerry Olsen, Penny Olsen (Division of Wildlife Research, C.S.I.R.O.), Greg Roberts and Clayton White (Brigham Young University).

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Received 15 June 1983; Accepted 1 June 1984.

Attention RRF Members Past and Present!! The Raptor Research Foundation, Inc., is approaching its 20th Anniversary. In honor of this memorable occasion, I am compiling a twenty-year history of the Foundation to be presented in Sacramento at the 1985 annual meeting. In addition, plans are to compose a monograph detailing the Foundation's history from beginning to present. I request the assistance of you, the membership, both past and present, in accomplishing this task. Please contact me if you have any pertinent information in your files, such as photographs, correspondence, etc., that you would be willing to loan to me. All such material will be acknowledged in publications, of course, and I will make copies of the materials for my use and return the originals immediately. If you have anything you wish to contribute, please contact me as follows: Jimmie R. Parrish, Department of Zoology, 159 WIDB, Brigham Young University, Provo, Utah 84602, USA.

SPRING AND FALL MIGRATIONS OF PEREGRINE FALCONS IN CENTRAL ALBERTA, 1979-1983, WITH COMPARISONS TO 1969-1978

DICK DEKKER

ABSTRACT - In central Alberta, 1979-1983, 339 sightings of migrating Peregrine Falcons (*Falco peregrinus*) were recorded between 15 April and 31 May. Mean sightings per hour afield were 0.23 for the entire period and 0.29 for the main migration period 4-23 May, respectively 11 and 19% lower than for 1947-1978. Mean early dates, mid-dates and mean late dates for adults were respectively 6, 7 and 2 days in advance of immatures, and nearly identical to 1969-1978. Fall sightings were similarly scarce as in 1969-1978, totalled 24, and occurred from 17 September to 3 October. In fall, the ratio of adults to immatures was roughly 1:3 and in spring 1:1. The success rate of 191 hunting attempts was 9.4%.

Since the 1950's, the Peregrine Falcon (*Falco peregrinus*) has suffered serious population declines in North America (Hickey 1969). As a breeding bird it was extirpated in southern and central Alberta by the early 1970's (Fyfe et al. 1976), although captivity-raised and released falcons nested in Edmonton and Calgary in 1982 and 1983 (G. Erickson, Alberta Fish and Wildlife Division, pers. comm.). In spring and fall, northern peregrines migrate through central Alberta (Dekker 1979). Field surveys along the Atlantic and Texas coasts have recently shown substantial increases in the number of peregrines sighted during fall migrations (F.P. Ward, pers. comm.). This paper presents data on the characteristics of migrating peregrines in central Alberta from 1979 to 1983. Pooled data for these 5 yrs can be juxtaposed to data from 1969 to 1978 when I did similar field studies (Dekker 1979), although data for 1969-1973 are incomplete and based on less expertise. The most recent 10 yrs allow valid comparisons of number of sightings/h, age ratios and timing of migrations.

STUDY AREA AND METHODS

The study area was a crescent-shaped strip of grainfields and open pastures, roughly 10x2 km in size, bordered by Beaverhill Lake, that attracted numerous waterfowl and shorebirds in migration. In searching for peregrines no set procedures were followed, although methods were similar to those of 1969-1978. Each day afield I hiked 5-25 km, frequently pausing to scan through 10x50 binoculars. I often sat in a parked car and used a 20-40X telescope as well as binoculars. Many resting peregrines sitting on fence posts or on the ground were watched until they left of their own accord. Flying peregrines were observed for as long as they remained visible. Alarm behaviour of prey species often alerted me to the arrival of peregrines. The study area was visited from early March to early December. Pooled for 5 yrs, field days totalled 167 and 79 respectively during 15 April - 31 May and 1 September-15 October. Field days lasted 3-17 and averaged 9 h within varying time frames. About 85% of peregrines sighted in spring were positively identified; distant large falcons that I could not identify were assumed to be peregrines unless I suspected

them of being Prairie Falcons (*Falco mexicanus*), that are occasionally seen in the study area in spring (Dekker 1982). During fall, when peregrines are uncommon in the study area and both the Prairie Falcon and the Gyrfalcon (*Falco rusticolus*) occur (Dekker 1983), all sightings of unidentified large falcons were deleted. (For criteria used in field identification see Dekker 1977). I paid little attention to the problem of duplicate sightings other than to delete obvious ones. For 1969-1978 I tabulated maximum and minimum sightings that show a duplication rate of 2.4. This indicates the magnitude of the problem but is only an estimate. The so-called maximum numbers of 1969-1978 "include duplicate counts except the most obvious ones", (Dekker 1979:297) and correspond to sightings in this study. Data on hunting are for 1980-1983 only; 1979 observations were presented elsewhere (Dekker 1980). Methods in recording foraging behavior were the same as in 1969-1978. Observations were written down during or at the end of the day.

RESULTS AND DISCUSSION

Numbers Sighted and Timing of Migrations - In spring, peregrines were seen from 20 April to 31 May (Fig. 1). Sightings pooled for 5 yrs ranged from 0 to 21/d and totalled 339 (Table 1). Mean numbers of sightings/h were 40-60% higher in morning and evening than between 1200H and 1500H (Table 2).

Earliest dates ranged from 20 to 30 April. Mean early dates for adults and immatures respectively, ranged from 20 April to 7 May and from 1 to 9 May. Early arriving falcons appeared to pass quickly. They often hunted over the still-frozen lake and rested on the ice far from shore. I suspect that all April sightings of unidentified falcons involved adults. That assumption would advance their mean early date to 25 April, 9 d ahead of immatures (Table 3). Mean late sightings of adults and immatures respectively, ranged from 17 to 27 and 19 to 31 May. Mean late dates and mean mid-dates (half of total sightings) were nearly equivalent to those of 1969-1978 (Table 3).

To check for the presence of summering falcons, the study area was visited about 4 times/month

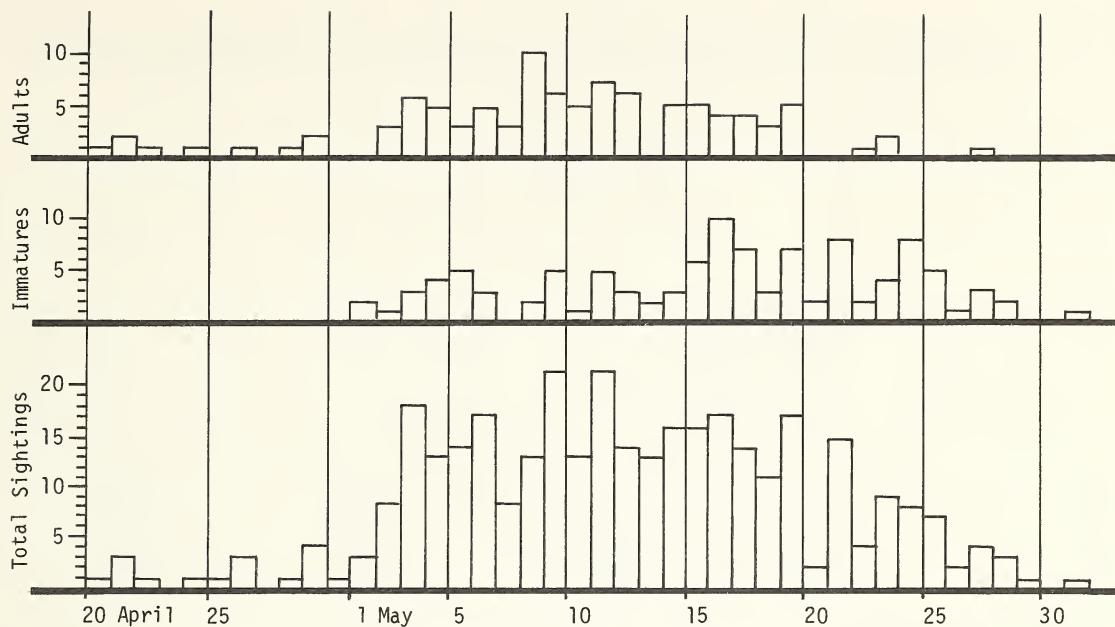


Figure 1. Peregrines sighted during spring migration in central Alberta. Total sightings include peregrines of unidentified age class.

(range 3-7) in June, July and August. One peregrine each was seen on 19 July 1980 and 2 June 1982. Both were immatures. The June sighting probably involved a late migrant, but the July bird may have originated from a captive-breeding program with releases in central and southern Alberta (G. Erickson, Alberta Fish and Wildlife Division, pers. comm.). I saw no evidence that captive-bred peregrines occurred in the study area during spring migration. Data for the autumn were similarly limited as in 1974-1978 and ranged from 17 September to 3 October.

Age and Sex Ratios - The proportion of adults and immatures in spring differed from 1974-1978 (Table 4). I attribute that difference to the following change in my criteria for identification. In 1969-1978 I differentiated the age groups mainly by dorsal coloration; adults are ashy-blue, immatures brownish. However, I have found that dorsal color is not always a reliable fieldmark as some adult peregrines look blackish-brown dorsally, resembling the spring immatures that are often light-chested (Dekker 1979). Since 1979, I have included all dorsally blackish falcons in the unidentified

category unless I saw their ventral markings, barred in the adult, streaked in the immature. The more typically-colored adults are easily identified in flight under good conditions. The proportion of adults (29%) was remarkably close to that of 1974-1978 (28%) but differed from 1969-1973 (38%). The adult and immature percentages for fall differed from 1969-1973 and 1974-1978, but sample size was small (Table 4).

The smallest males are about two-thirds the size of the largest females (Godfrey 1966). However, I was unable to determine the sex of 54% of sightings. Under some conditions, especially when flying falcons interacted with other birds, their relative size could be assessed with confidence. Large peregrines outnumbered small ones by a factor of 3:1 in the adults and 9:1 in immatures. Although females outnumbered males also in 1969-1978, values differed substantially, probably reflecting the unreliability of basing sex ratios on sightings. Females outnumbered males by a factor of 3:1 or more in coastal migration surveys (Hunt et al. 1975; Ward and Berry 1972).

Behavior - I saw falcons attack prey species 254

Table 1. Days and hours afield, and peregrines sighted, 15 April - 31 May 1969-1983. (figures in brackets represent the main migration period 4-23 May, when respectively 79, 85 and 79% of pooled sightings occurred in 3 groups of 5 years).

YEAR	DAYS AFIELD	HOURS AFIELD	SIGHTINGS	MEAN SIGHTINGS/HR
1969	22(12)	-	20(9)	-
1970	25(16)	-	15(11)	-
1971	27(17)	-	33(27)	-
1972	25(16)	-	26(21)	-
1973	23(16)	-	41(39)	-
Sub-Totals	122(77)	-	135(107)	-
1974	26(16)	251(166)	46(43)	0.18(0.26)
1975	29(16)	284(171)	41(35)	0.14(0.20)
1976	30(17)	307(196)	66(53)	0.21(0.27)
1977	38(19)	378(216)	163(153)	0.43(0.71)
1978	34(19)	358(229)	90(64)	0.25(0.28)
Sub-Totals	157(87)	1570(978)	406(348)	0.26(0.36)
1979	31(16)	289(179)	57(46)	0.20(0.26)
1980	34(18)	323(194)	94(55)	0.29(0.28)
1981	34(19)	308(193)	67(59)	0.22(0.31)
1982	33(18)	276(172)	58(53)	0.21(0.31)
1983	35(19)	302(197)	63(56)	0.21(0.28)
Sub-Totals	167(90)	1498(835)	339(269)	0.23(0.29)

times. The success rate of 191 hunting attempts of which the outcome was known was 9.4%, not significantly different from the 7.7% reported for 1965-1979 (Dekker 1980). Prey captured included 9 ducks of 7 species and 9 shorebirds of 4 species.

In the first 2 h after daybreak, when I was rarely in the field (Table 2), I only once saw a falcon attack ducks, but I found falcons feeding on ducks 7 times. In one case the prey was a Gadwall (*Anas strepera*) I had seen killed by a falcon the previous evening at dusk. In the others, sunken eyes of ducks and amount of meat taken from the carcasses led me to suspect that they had been killed the previous evening, during the night or near dawn. On several occasions I saw peregrines attack ducks 0.5-1 h after sundown, and they hunted sandpipers or passerines very late in the evening. Crepuscular

foraging activity of peregrines has been reported by several observers (Beebe 1960; Clunie 1976; Dekker 1980). Some falcons that I watched at nightfall stayed on posts until it was too dark to see them and they probably roosted there. Their locations were not only over water but also on open pasture. All roosting falcons ($n=9$) were gone next morning at dawn.

Most resting falcons that I watched in the morning from 1 h after sunrise remained inactive until 0900-1100 H when some began to hunt; others soared to great heights and sailed away in a northerly direction, apparently resuming migration. In 1969-1978, falcons under observation left the study area in late morning by soar and sail flight at great altitudes (Dekker 1979). Each spring, 1 or 2 recognizable peregrines stayed in the study area for

Table 2. Percent of total field time for 5 daily periods, 15 April-31 May (figures in brackets represent main migration period 4-23 May). Data pooled for periods of 5 years. Mean sightings per hour afield not available for 1974-1978 when the exact time of most sightings was not recorded.

TIME PERIOD	% OF TOTAL HOURS AFIELD		MEAN SIGHTINGS/HR
	1974 - 1978	1979 - 1983	
0500 - 0900	6.7 (7.7)	8.3 (10.5)	0.28 (0.33)
0900 - 1200	19.3 (21.6)	17.8 (19.1)	0.28 (0.36)
1200 - 1500	24.8 (24.3)	20.5 (20.5)	0.17 (0.21)
1500 - 1800	26.9 (24.1)	27.0 (23.7)	0.20 (0.26)
1800 - 2200	22.4 (22.3)	26.4 (26.2)	0.24 (0.31)
TOTALS	100 (100)	100 (100)	0.23 (0.29)

3-8 d, no doubt causing duplication of sightings.

Conclusions - Although mean numbers of sightings/h in spring were 11-19% lower in 1979-1983 than in the preceding 5 yrs, most yearly figures have remained similar, suggesting that no change has occurred in the size of the spring population migrating through central Alberta. An exceptional year was 1977 when sightings/h were 65-95% higher than the 5 yr mean (Table 1). The

spring of 1977 was characterized by dry climatic conditions when peregrines and their prey concentrated on the lakeshore where they were readily located.

Why peregrines were much scarcer in fall than in spring in the study area is not clear. Perhaps some peregrine populations breeding in the northwest migrate in fall via a flight path east of Alberta to the Atlantic coast, but return in spring by a more direct

Table 3. Mean early dates, mid-dates (half of total sightings) and mean late dates for adult and immature peregrines sighted during spring migration in central Alberta. Data pooled for 3 groups of 5 years, 1969-1983. ("All sightings" include falcons of unidentified age).

Table 4. Age composition of peregrines in percent of total sightings during spring and fall. Data pooled for 3 groups of 5 years, 1969-1983.

YEARS	SIGHTINGS	% ADULT	% IMMATURE	% UNIDENTIFIED
Spring				
1969-1973	135	38	36	26
1974-1978	406	28	47	25
1979-1983	339	29	32	39
Sub-Totals	880	32	38	30
Fall				
1969-1973	10	50	30	20
1974-1978	17	6	65	29
1979-1983	24	21	58	21
Sub-Totals	51	26	51	23

route through the continent. Differentiation of spring and fall migration routes has been documented for some shorebird species (Godfrey 1966).

Early and late dates of fall and spring sightings in the study area were respectively 16 and 41 d apart in 1979-1983 and 24 and 45 d in 1969-1978. Why the spring passage lasts so much longer than the fall migration is not known. Perhaps spring migrant peregrines, especially subadults, linger in the study area attracted by the concentrations of migrating shorebirds, which are more numerous in May than at any time during fall.

Although the number of fall migrating peregrines was too small for comparisons, the number of sightings/d increased from 0.24 in 1969-1978 to 0.30 in 1979-1983, consistent with increases in sightings per unit effort during fall migrations along the Atlantic and Texas coasts (F.P. Ward, pers. comm.).

ACKNOWLEDGMENT

This study was financed by the Alberta Fish and Wildlife Division, the World Wildlife Fund (Canada), and the Alberta Recreational

Parks and Wildlife Foundation. I thank W. Wishart for support. A.J. Erskine, R.W. Nelson and F.P. Ward read the manuscript. Denise Fitz did the typing.

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Received 20 November 1983; Accepted 15 April 1984

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WINTER HABITAT SELECTION OF DIURNAL RAPTORS IN CENTRAL UTAH

DAVID L. FISCHER, KEVIN L. ELLIS AND ROBERT J. MEESE

ABSTRACT - A total of 525 observations of 10 species was recorded during a winter roadside survey of raptors around Utah Lake, Utah Co., Utah. Six species; Red-tailed Hawk (*Buteo jamaicensis*), Rough-legged Hawk (*Buteo lagopus*), American Kestrel (*Falco sparverius*), Northern Harrier (*Circus cyaneus*), Golden Eagle (*Aquila chrysaetos*), and Bald Eagle (*Haliaeetus leucocephalus*); accounted for 493 (94%) of the observations. Red-tailed Hawks, Rough-legged Hawks and American Kestrels were found in greater than expected numbers in grassland habitat, Northern Harriers and Golden Eagles in sage/greasewood desert, and Bald Eagles in riparian/lakeshore habitat. Rough-legged Hawks predominantly used utility pole rather than tree perches; American Kestrels predominantly used wire perches; Red-tailed Hawks used tree and pole perches according to availability. All species, except American Kestrels, used areas away from centers of human activity more often than expected.

Ornithological literature contains relatively little information on the winter ecology of diurnal raptors (Newton 1979). Road surveys taken over several months can provide information on distribution, relative abundance and habitat use (Craighead and Craighead 1956; Bildstein 1978). This information may provide a basis for making land use decisions. Although many raptor road surveys have been conducted (Enderson 1965; Johnson and Enderson 1972; Craig 1978; Bauer 1982; Gessaman 1982), few have studied habitat or perch use in relation to availability, a prerequisite for making inferences concerning species preference or selection. Here, we conducted a road survey of wintering raptors and sampled the availability of general habitat types, specific perch types and proximity of centers of human activity along a 125 km census route. We then tested the (null) hypothesis that raptor use is in proportion to habitat availability. Where use of a particular habitat type was found to be significantly greater than expected, we infer selection or preference on the part of the species involved. Some argue that selection can only be demonstrated by detailed behavioral observations in which an active choice on the part of the animal is shown (see Morse 1980). We assume, however, that raptors are highly mobile organisms capable of moving from one habitat or perch type to another in a matter of minutes. Therefore, we infer an active choice on the part of the species if it occupies a particular habitat type significantly more often than could be expected by chance.

STUDY AREA AND METHODS

A 125 km loop around Utah Lake, beginning near Provo and terminating near Lindon, defined the census route (Fig. 1). Average elevation of Utah Valley is 1371 m. Mean annual precipitation ranges between 30.4 and 40.6 cm. Daily mean temperature during the period December–March ranged from approx. –15°C to 10°C. Vegetation was a mosaic of agricultural lands (irrigated and dry),

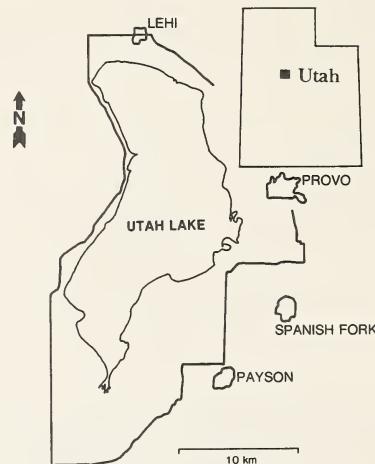


Figure 1. Map of census route, Utah County, Utah.

sagebrush (*Artemesia tridentata*) mixed with greasewood (*Sarcobatus vermiculatus*) desert, grassland/pasture, orchard, and riparian/lakeside woodland. Topography of the census strip was generally flat.

Twelve censuses totalling 42 h were conducted weekly from 8 January to 27 March 1983. Direction of travel along the census route was alternated each week. Roads on the east side of the lake were driven at speeds of 40 kph or less. Those on the west side, where there is little vegetation to impair vision and there are fewer potential raptor perch sites, were driven at speeds of 72 kph or less. Brief stops to identify birds and record data were sometimes made. Mean speed of travel per census was 36 kph. Mean time to complete a census was 3.45 h. The number of observers was usually 2, with 3 observers present on 2 occasions and a single observer present on 1 occasion.

Only those birds seen initially with the unaided eye were tallied. Binoculars and a 20x spotting scope were used to aid identification. For each sighting we recorded location, habitat type, behavior (flying, perched, hovering, soaring, coursing), perch site and distance from centers of human activity (farmyards, residences, commercial establishments, etc.). Habitat categories used were (1) cultivated farmland, (2) sage (cold desert including some greasewood), (3) grassland (including pasture and grass dominated rangeland), (4) riparian (including lakeside woods), (5) orchard, and (6) residential (including urban and commercial areas and the immediate area around farm and ranch houses). Perch

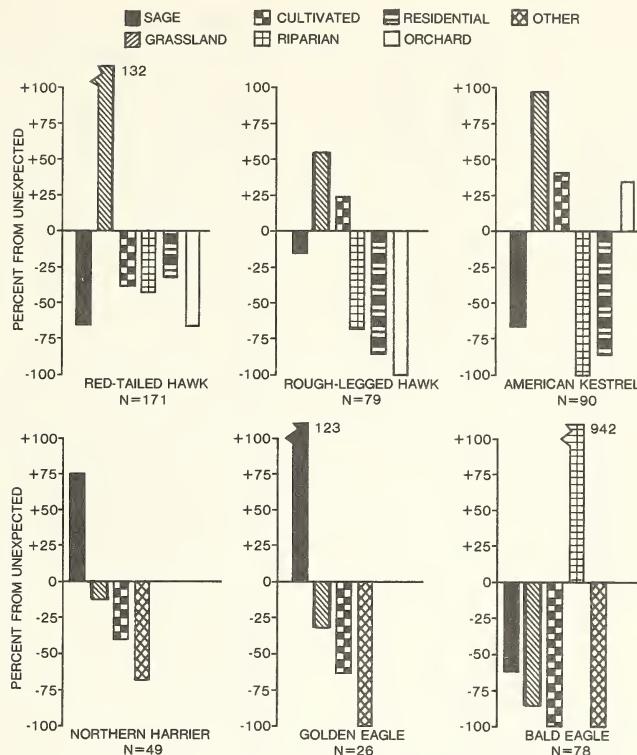


Figure 2. Percent deviation from expected number of raptor sightings by habitat type.

categories were (1) utility pole, (2) fence post, (3) wire, (4) tree, (5) shrub and (6) ground. Distance to human activity was recorded as (1) < 0.16 km, (2) 0.16 to 0.8 km, or (3) > 0.8 km.

Habitat and perch availability were quantified by assuming a census strip width of 1 km (0.5 km each side of road) for that portion of the route on the east side of the lake, and a width of 2 km (1 km each side of road) on the west side of the lake (Fig. 1). These strip widths reflected the maximum lateral distances at which we assumed nearly all raptors present could be spotted with the unaided eye. A random sample of 30, 200-m radius circular plots was taken to estimate the availability of each habitat and perch type within the census strip.

Data were analyzed using non-parametric Chi-square methods in which expected values were calculated from the estimates of relative availability of habitat factors. For example, if 25% of the census strip is cultivated farmland, we expect 25% of the sightings of Red-tailed Hawks to be in this habitat. Categories were lumped when expected values were less than 5 (Cochran 1954).

RESULTS AND DISCUSSION

A total of 525 raptor sightings was recorded on 12 censuses. Most frequently observed species with sample size sufficient to analyze were Red-tailed Hawk (*Buteo jamaicensis*), American Kestrel (*Falco sparverius*), Rough-legged Hawk (*Buteo lagopus*), Bald Eagle (*Haliaeetus leucocephalus*), Northern

Harrier (*Circus cyaneus*), and Golden Eagle (*Aquila chrysaetos*). Species observed in smaller numbers were Prairie Falcon (*Falco mexicanus*), Merlin (*Falco columbarius*), Ferruginous Hawk (*Buteo regalis*) and Cooper's Hawk (*Accipiter cooperii*).

Habitat Use - Red-tailed Hawk were not randomly distributed among the 6 habitat types ($P < 0.01$). (Fig. 2). The observed number of birds in sage/greasewood desert was approximately a third of that expected, while the number found in grassland habitat was over twice that expected.

Rough-legged Hawk were also not randomly distributed among habitat types ($P < 0.1$). They were found at approximately the expected frequency in sage, more often than expected in grasslands and far less often than expected in developed areas (residential, etc.) (Fig. 2). This species breeds in remote, nearly treeless areas of the far north (Brown and Amadon 1968). Consequently it is not surprising that it prefers open habitat and shuns areas of intensive human activity.

Kestrels were also distributed non-randomly among habitat types ($P < 0.01$). They were found

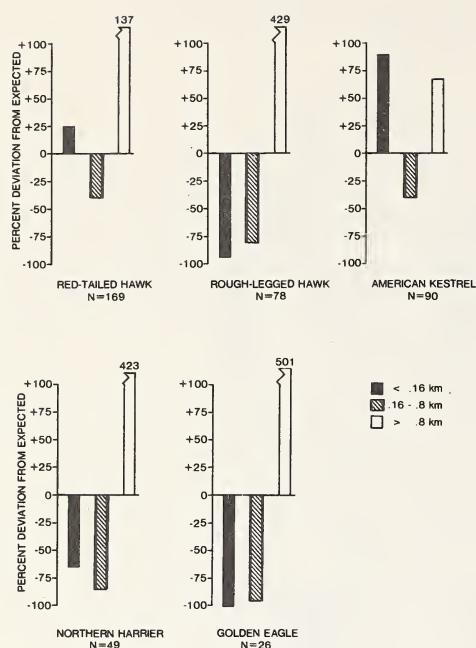


Figure 3. Percent deviation from expected number of raptor sightings by perch type.

twice as often in grassland as expected, but only one-third as often as expected in sagebrush (Fig. 2).

Of 4 habitat categories that could be considered (riparian, residential and orchard habitats lumped due to low expected numbers), Northern Harriers and Golden Eagles occurred more frequently than expected in sagebrush and less frequently than expected in all other habitats (Fig. 2).

Bald Eagles showed the most restricted habitat use pattern (Fig. 2). They were observed almost exclusively along the west shoreline of Utah Lake, and only where open water was nearby. Though the affinity of wintering Bald Eagles for open water is well documented (Fawks 1960; Southern 1963; Steenhof et al. 1980), most wintering Bald Eagles in Utah occur in sagebrush dominated desert valleys and subsist largely on carrion (Edwards 1969; Platt 1976). The narrow habitat choice found in this study is atypical of the normal habitat use pattern of the species in Utah.

Rough-legged Hawks, harriers, kestrels and, to a lesser extent, Red-tailed Hawks are known to prey heavily on cricetine and microtine rodents (Craighead and Craighead 1956). Only Northern Harriers occurred in expected or greater than ex-

pected numbers in the sagebrush habitat. The other species used grasslands more often than expected. Though we attempted no investigation of abundance and distribution of prey species, a previous study in central Utah reported similar numbers of rodents in sage-greasewood as in grassland habitat (Woodbury 1955). Thus, it appears the prey base of the grassland habitat supports more species and greater numbers of wintering raptors than does the prey base of the sagebrush desert. This may be due to greater vulnerability of prey to predation by diurnal raptors in grasslands than in the sagebrush. Furthermore, in the desert, where elevated perches are scarce, the aerial foraging of harriers may be more efficient than the perch and hover hunting strategies employed by Rough-legged Hawks and kestrels.

Perch Use - Raptor perches were primarily (83%) in trees or on utility poles. Rough-legged Hawks used poles more than expected ($P < .01$) whereas Red-tailed Hawks used tree and pole perches roughly according to their availability (Fig. 3). Schnell (1968) and Weller (1964) reported that Rough-legged Hawks tend to perch on poles and lone trees, while Red-tailed Hawks tend to select

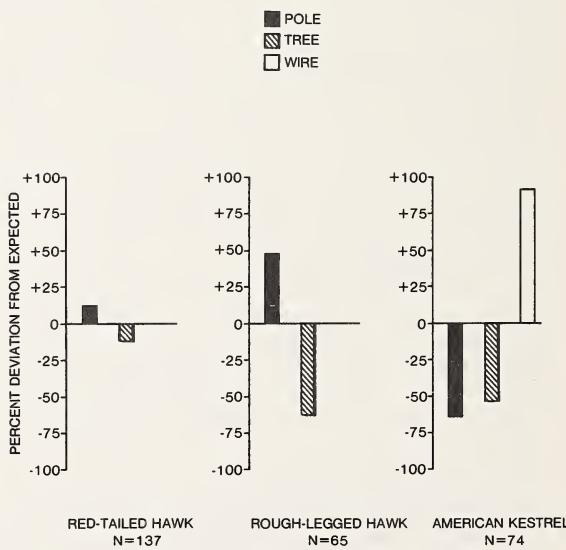


Figure 4. Percent deviation from expected number of raptor sightings by distance from centers of human activity.

perches in groves of trees and along wood edges.

Wires, a frequent (77% of total) perch of kestrels, were crudely quantified as being equal in availability to poles. Although the number of potential perch sites along an interpole length of wire is far greater than on a single pole top (or cross arm), we assume that the choice facing an individual kestrel is essentially a dichotomous one — pole or wire? Kestrels used wire perches more and poles and trees less frequently than expected ($P < .01$, Fig. 3). Bildstein (1978) also reported a preference of kestrels for wire perches.

Sixty-five of 66 perched Bald Eagles were in trees. Too few sightings of perched Golden Eagles and Northern Harriers were recorded to permit a statistical analysis of perch site preference.

Human Disturbance - Red-tailed and Rough-legged Hawks used undeveloped areas more than developed areas ($P < 0.01$, Fig. 4). Over twice as many Red-tailed Hawks were seen more than 0.8 km from human disturbance as would have been expected by chance alone. Only 12 of 79 (15%) observations of Rough-legged Hawks were within 0.8 km of human habitation. Interestingly, slightly more Red-tailed Hawks than expected were recorded within 0.16 km of centers of human activity. Large trees were often present around farmyards and ranch houses, whereas trees were often lacking nearby. The greater than expected number of Red-tailed Hawk sightings close to potential human disturbance may be due to a greater availability of perches. Rough-legged Hawks appeared not to use trees as readily as pole perches, and thus, did not perch as often as expected near centers of human activity. Alternatively, Rough-legged Hawks may be less tolerant of human disturbance than are Red-tailed Hawks, and the Rough-legged Hawk's use of poles may be due, at least in part, to the proximity of a large proportion of the study area's trees to human activity.

American Kestrels were distributed non-randomly also ($P < 0.01$). Almost twice as many kestrels were seen < 0.16 km from human activity as were expected (Fig. 4). Bildstein (1978) found that kestrels used areas nearer centers of human activity than did other raptors wintering in Ohio.

Northern Harriers, Golden and Bald Eagles were seen almost exclusively in undeveloped areas. Therefore, no statistical analysis of this trend was performed. These species seem to avoid developed habitat.

ACKNOWLEDGMENTS

We thank our wives, Darlene Fischer and Barbara Ellis, who either spent weekends looking for hawks or spent them alone. Chris Ellis and Pam Thompson assisted on the censuses. Michael Kochert and Clayton White provided editorial comments which greatly improved this manuscript.

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Received 3 February 1984; Accepted 1 July 1984

Request for Information

Information is being gathered on the post-release behavior and survival of captive-reared and rehabilitated birds and mammals. The objectives of this study are to assess the amount and type of work that has already been done, to summarize the available data and evaluate techniques, and define the reasons for the survival or mortality of released animals.

Published and unpublished reports and raw data would be appreciated. For additional information, individuals willing to cooperate please contact Daniel R. Ludwig, Ph.D., Willowbrook Wildlife Haven, Forest Preserve District of DuPage County, P.O. Box 2339, Glen Ellyn, IL 60138.

Raptor Collisions with Utility Lines — A Call for Information — The U.S. Bureau of Land Management, Sacramento, in cooperation with the Pacific Gas and Electric Company, is assembling all available published and unpublished information concerning collisions of raptors with power lines and other utility lines. Actual case histories — no matter how circumstantial or fragmentary — are needed. Please acknowledge that you have such information by writing to Dr. Richard R. (Butch) Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825 U.S.A. (Phone (916) 484-4541). A form on which to record your information will then be sent by return mail.

DO NORTHERN HARRIERS LAY REPLACEMENT CLUTCHES?

ROBERT EDWARD SIMMONS

ABSTRACT - An ecological difference between North American and European populations of *Circus cyaneus* is the apparent lack of replacement clutches laid by the North American form (the Northern Harrier) on the failure of the first clutch. I present several lines of evidence that Northern Harriers do lay replacements, but only if their clutches are disturbed during laying or shortly thereafter. Two of the five females that renested were successful in their attempts and the quality of the new nest sites was higher, despite most renests being within 200 m of the old sites.

In 2 detailed and long term (> 20 y) studies of *Circus cyaneus*, one in Orkney, Scotland (where it is called the Hen Harrier), and one in Wisconsin, U.S.A., a major ecological difference is evident. Harriers in Scotland may lay 1 and occasionally 2 replacement clutches following the failure of their original clutch (Balfour 1957), while harriers in Wisconsin have never been recorded as laying a replacement (Hamerstrom 1969, pers. comm. 1981; Schmutz and Schmutz 1975). Since Simmons and P.E. Barnard (MS) found few behavioural differences in a comparison of the 2 continents' populations, other than migratory habits, then this apparent difference warrants attention and explanation.

Here, I present evidence that harriers in a large Canadian population laid replacement clutches in all 3 y in which they were studied, and that renesting females picked higher quality sites for their second attempts.

STUDY SITE AND METHODS

One of North America's largest assemblages of breeding harriers was studied on the 60 km² Tantramar Marsh (45°53'N, 64°20'W), New Brunswick. The objectives were to document breeding and feeding ecology of the population in relation to polygyny. In so doing, the location of each nest was mapped and its history detailed; the date of settling, habitat type, courtship displays, clutch size, and male and female activity (see Simmons 1983 for details). About 2500 h of observation were made, of which 562 h were specific nest watches to record feeding rates.

As no birds were marked, the evidence presented here consists of the following categories: (a) recognition of plumage characteristics and voice; (b) identical reaction to human disturbance at both nests, which varied significantly among females; (c) short relaying period; (d) lack of "sky dancing" (Hamerstrom 1969) from any male involved following nest predation; (e) close proximity of nest and renest; and (f) alarm-calling at the nest up to 2 d after nest failure.

To determine nest site quality, I recorded dominant vegetation, moisture level, and visibility at each of 64 nests found. Moisture was ranked as Dry if no water existed within 1 m of the nest, Wet if water appeared due to my weight, and Very Wet if water was already present at the site. Vegetation was ranked as cattail (*Typha* spp.), marsh grasses (*Spartina pectinata* or *Calamagrostis canadensis*), Spirea (*Spirea latifolia* and other low shrubs), and alder (*Alnus* spp. and willow *Salix* spp.). Visibility, which was later found to have no

effect on the success or failure of each nest (Simmons and Smith 1985), is disregarded here since it does not affect quality. Quality reflects the probability of success, and the quality score for each nest site is a combination of the percentage success of moisture and vegetation categories arcsine transformed, and summed (see Simmons and Smith 1985).

RESULTS AND DISCUSSION

Suspected renesting occurred twice among 30 nests in 1980, and in 3 of 22 nests in 1981. The original nest of a suspected renest in 1982 was not found, and details of 2 renests in 1983 (R.B. MacWhirter and G.L. Hansen *in litt.*) were not taken, and are not discussed further here.

In the first case in 1980, a yellow-eyed female distinguished by a very dark terminal tail band had just completed a clutch of 5 eggs (determined by egg colour: Sealy 1967; Hamerstrom 1969, pers. obs.) in Cattails. She reacted to me by flying 300-400 m east and circled at low altitude while alarm calling. On my next visit, a bird already 300-400 m east of me started cackling. Later, the same bird flew to the new nest and was recognized by her eye and rectrix colour. The fact that she alarm-called near her new nest on my first visit would have been unusual for any other harrier with no prior experience of my activities. In my experience at 59 other first nests, a female never called until I was closer than approximately 80 m on my first visit.

The second nest-renest evidence in 1980 ("Alders": Table 1) consisted of (a) close circling and calling but no stooping by the female, (b) a 7-d relaying interval, (c) a lack of sky dancing by her polygynous mate who otherwise performed a greater number of displays than any other male (Simmons 1983), and (d) a renest only 160 m from the original site. She was 1 of 2 polygynous females (Table 1) who relaid with the same male (polygynous males were identified by watching them feed one, then another female in succession).

In 1981, in an effort to gain accurate data on egg laying and incubation periods, I disturbed several females with 0- or 1-egg clutches. Five of 6 females

Table 1. Factors associated with 5 renests located on the Tantramar Marsh of New Brunswick, 1980-1981.

Nest	RENESTING FACTORS*						
	I	II	III	IV	V ^a	VI ^b	VII
Midgic 1	8	320	9 May 1980	Just completed clutch	5	144	
Renest			27 May 1980		5	140	S
Alders γ	7	160	18 May 1980	Egg-laying	4	117	
Renest			31 May 1980		4	114	F ^c
Midgic 2	11	100	14 May 1981	First egg	1	92	
Renest			25 May 1981		2	133	S
Alders β	4	120	14 May 1981	First Egg	1	92	
Renest			18 May 1981		5	118	F ^d
Phoebe	7	200	1 June 1981	First egg	1	140	
Renest			8 June 1981		4	140	F ^e

* — I = days between failure and relaying; II = proximity of nests (m); III = clutch initiation dates; IV = stage at failure; V = clutch size; VI = quality score of nest site; VII = outcome of renest attempt: S = successful, F = failed.

^aAll renest clutches were full clutches and hatched.

^bBased on moisture and vegetation at the nest site (see text); range of scores 92-144.

^cDiseased chicks

^dObserver induced

^ePredation

deserted, and 2 of 5 relaid. A third female, whose 1-egg clutch was taken by a lone Common Raven (*Corvus corax*), also relaid. In each case, a renest was established using 2 or more of the categories outlined in METHODS. One β female continued to defend her destroyed renest for 2 d following its destruction. This is in contrast to evidence presented by Hamerstrom (1969) for Wisconsin harriers which left the area within 24 h of nest loss, and indicates the potential for a female to remain and renest on the Tantramar Marsh.

Three characteristics common to all 5 renesters emerge from their histories: (1) all failed while in the process of egg-laying or shortly thereafter; (2) the distance between the nests was, in 4 of 5 cases, closer than the minimum distance recorded between concurrently occupied nests (260 m); and (3) the period between failure and relaying was short, averaging 7.4 (\pm 3) d. Morrison and Walton (1980), in their review of replacement clutches in raptors, reported that the frequency of relaying was greater among birds whose clutches were disturbed early in

the breeding attempt, and that renesting generally took place within "several hundred metres". These facts concur with (1) and (2) in this study. The significance of the short relaying period (3) can be seen in light of the fact that on the Tantramar Marsh, females settling into new territories (i.e. courting and preparing to lay eggs) required at least 1 wk and usually longer (Simmons 1983) to put on sufficient fat/protein reserves (cf. Newton et al. 1983, Hiron et al. 1984) before laying their first egg. Since the average relaying interval was only 1 wk for renesters, this implies that a female part way through laying finds it easier to begin a new clutch, having not fully depleted her protein reserves, than a female starting afresh. This may explain the short relaying interval (Table 1). It is also significant in this regard that the female with the longest relaying interval (Midgic 2) also produced the smallest repeat clutch (Table 1), and was fed very little by her monogamous mate (Simmons 1983).

A related but paradoxical fact arises from a comparison of relaying intervals reported for other

small falconiforms (12-18 d : Morrison and Walton 1980) and those found in this study (7.4 d). This difference may be related to the fact that many of the falcons and accipiters cited (*ibid.*) were deliberately double-clutched and therefore "failed" after producing a full clutch, while the harriers failed earlier in their attempts. The relaying intervals (Table 1) concur with those found by Balfour (1957) who stated that replacements were often completed within a fortnight by Hen Harriers in Orkney. The frequency of renesting (8 nests in 96: 8% [Simmons 1983, 1983a; G.L. Hansen and R.B. MacWhirter *in litt.*]) over 4 y on the Tantramar Marsh is also similar to that found in Orkney (N. Picozzi, pers. comm.).

Newton (1979:136) argued that the proportion of relaying raptors in a population is determined by food supply; evidence from this study does not support this hypothesis. Microtines and shrews (*Sorex* spp.), principal prey of the harriers on the Tantramar Marsh (Barnard 1983), were sampled each year (*ibid.* and G.L. Hansen *in litt.*) and related to the proportion of renesters. Spring vole abundance could be ranked from highs in 1980 and 1983 to lows in 1981 and 1982, yet renests accounted for 6.3%, 6.6%, 13.6% and 8.3% of all nests in these years respectively. Several factors (other than my research activities) therefore must have been operating over and above food abundance to produce these results.

Further evidence which does not support the food-related hypothesis comes from a survey of other records of renesting among Northern Harriers. Riendahl (1941) reported 1 nest among 5; Craighead and Craighead (1956) reported 1 renest among 9 in a year of low vole abundance, but none in a "high" year; Smith (1971) recorded 1 among 5 nests, and Duebbert and Lokemoen (1977) reported 1 among 3 nests. If low numbers of nests were indicative of a low vole population (cf. Hamerstrom 1979; Simmons et al. *in prep.*) in these studies, then none of them support the food-related renesting hypothesis (Newton 1979).

If nests are destroyed by predators, it is surprising that the harriers studied generally renested within 200 m of their original sites; their mates often held territories up to 1 km in diameter (Simmons 1983), and suitable nesting substrate appeared to be relatively unlimited. This unusual situation was investigated through an estimation of the quality of the nest and renest in terms of

anti-predator adaptations. This was based on the knowledge that Very Wet cattail sites were significantly more successful than most other combinations (Simmons and Smith 1985). The results indicate that harriers could afford to locate their renests close to their original nests, since on average they chose better quality sites. Four of the 5 renests stayed in high quality sites or increased in quality, while overall the quality scores increased by an average of 12 points; this was not significant, however (Wilcoxon test, $U = 10, P = 0.3$). Even so, all 5 renesters hatched eggs; 2 raised flying young and only 1 renest failed again due to predation.

I conclude that North American harriers do lay replacement clutches if their original clutch fails early in the attempt, at about the same frequency as their European conspecifics. As the Northern Harrier is behaviourally very similar to the Hen Harrier, the fact that they both lay replacement clutches adds to the contention that they are also ecologically very similar.

ACKNOWLEDGMENTS

This study was made possible through 2 graduate fellowships from Acadia University and financial support through my supervisor Dr. P.C. Smith. I thank P.E. Barnard and the Canadian Wildlife Service, Sackville, New Brunswick, for their assistance, and Frances Hamerstrom and Nicki Picozzi for their interesting discussions. Mark Fuller helped clarify the paper through constructive criticism, and Bruce MacWhirter and Gay Hansen kindly supplied unpublished material.

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Received 27 December 1983; Accepted 1 August 1984

UNUSUAL PREDATORY AND CACHING BEHAVIOR OF AMERICAN KESTRELS IN CENTRAL MISSOURI

BRIAN TOLAND

ABSTRACT - Caching behavior of the American Kestrel (*Falco sparverius*) was studied 1981-1983 in Boone County, Missouri. Both wild prey and quarry thrown from car windows were cached. Kestrels cached food 116 times and retrieved it 77.5% of the time. Males cached food in elevated sites (at least 4 m high) 64% of the time while females did so only 20%. During spring and summer, 93% of the prey items were cached uneaten. During fall and winter, only 42% of the food cached was uneaten. When a surplus of prey was created by releasing several mice at a time, kestrels killed them while flying to their cache sites. These prey items were stored in the same cache site. Apparently, caching behavior of American Kestrels is not directly correlated with the length of time between feedings, and caching behavior operates independently of food deprivation, especially in spring and summer.

Many reptors have been observed caching prey. Mueller (1974) provided a review of food storing in several captive species. Among the falconiforms, prey caching seems to be most developed and widespread in falcons. Published records of caching include those for the Merlin (*Falco columbarius*) (Greaves 1968; Oliphant and Thompson 1976; Pitcher et al. 1982), American Kestrel (*F. sparverius*) (Pierce 1937; Tordoff 1955; Roest 1957; Stendell and Waian 1968; Balgooyen 1976; Collropy 1977), Prairie Falcon (*F. mexicanus*) (Peterson and Sitter 1975; Oliphant and Thompson 1976), Peregrine Falcon (*F. peregrinus*) (Beebe 1960; Brown and Amadon 1968; Nelson 1970; Cade 1982), Gryfalcon (*F. rusticolus*) (Jenkins 1978; Cade 1982) and many others.

STUDY AREA AND METHODS

Data reported here are from a 48 km² area in Boone County, Missouri, where farmlands are interspersed with woodlots, old fields, meadows and residential areas.

I observed kestrels from September 1981 through August 1983 using a 30x spotting scope and 9x binoculars at distances of 5-200 m. For each observation I recorded species cached, location of

cache, weather conditions, time of day, and duration of caching sequence. Additional live prey was thrown from my car window to kestrels perched within 25 m of roads. The prey thrown were brown, gray, white and black House Mouse (*Mus musculus*) and House Sparrows (*Passer domesticus*) with several primaries pulled to ensure their capture by kestrels.

RESULTS AND DISCUSSION

During the 2 yr study 1210 h of observation of kestrels were made and 30 kestrels were seen caching prey a total of 116 times. They subsequently retrieved food successfully 77.5% of the time. Prey cached were 95% rodents and 5% birds. Both wild and provided prey were cached. Kestrels captured 95% of the prey thrown from car windows and cached 46 (48%). The remaining 70 (60%) prey cached consisted of 55 Prairie Vole (*Microtus ochrogaster*), 6 house mice, 3 White-footed Mouse (*Peromyscus leucopus*) 2 Western Harvest Mouse (*Reithrodontomys megalotis*), 2 House Sparrows, 1 Grasshopper Sparrow (*Ammodramus savannarum*) and 1 Eastern Meadowlark (*Sturnella magna*).

Cache sites were of 8 kinds (Table 1). Males cached prey in elevated sites significantly more

Table 1. Cache sites used by American Kestrels in Boone County, Missouri 1981-83.

LOCATION AND HEIGHT OF CACHES									
Sex	Grass clumps (0-0.1 m)	Hollow railroad ties (0-0.1 m)	Tree roots (0-0.1 m)	Bushes (0.5-1.0 m)	Fence posts (1.0 m)	Building gutters (4.0 m)	Tree limbs and holes (4.5 m)	Tops of power poles (10.0-20.0 m)	Total
M	16	3	1	1	6	2	44	3	76
F	27	0	0	2	3	0	8	0	40

often than did females (Table 1). Males cached prey 4 m or more above the ground 64% of the time, while females did so only 20% ($X^2 = 22.16$, $P < 0.01$, $df = 1$).

During the breeding season kestrels have special courtship feeding ceremonies (Fox 1979; Cade 1982). Food transfer often begins as remote food passing (Nelson 1977) when the male deliberately caches prey within view of the female. When he leaves, she flies to the cache, retrieves and eats the food. I observed that all copulation and courtship activities including hitched wing-displays, food begging, courtship feeding and remote food passing occurred at elevated sites, on or near favorite plucking or hunting perches. Because males alone cache prey at these elevated sites during courtship they may be predisposed to cache in elevated sites during the rest of the year.

Partially eaten carcasses were always decapitated before being cached and only the posterior 2/3 to 1/2 of the body of the prey was placed in the cache. However, kestrels cached 78% (36 of 46) of the presented prey and 69% (48 of 70) of wild prey completely uneaten. Of all prey items cached, only 28% (32 of 116) were decapitated. In contrast Stendell and Waian (1968) reported that 14 of 15 small mammals cached by a single female kestrel were decapitated and Collopy (1977) reported that 10 female kestrels decapitated 13 of 17 (76.5%) small animals cached. In Missouri kestrels cached more (58%, 27 of 48) partly-eaten prey during the fall and winter than the 7% (5 of 68) during spring and summer, which may be explained by the lack of hunger during the breeding season due to greater availability of food and warmer temperatures.

Kestrels hiding food approached the cache site furtively, then thrust, pushed, or nudged the prey into position with the beak (see Balgooyen 1976; Collopy 1977). Sometimes sites apparently were selected before the flight started, and kestrels flew directly to the cache spot. Prey was not placed in any preferential position such as belly-down (as if to take advantage of the prey's protective coloration) as reported by Balgooyen (1976) and Collopy (1977). I found items lying on back or sides as often as on the belly. Kestrels sometimes did make several attempts at repositioning prey until it was better concealed. In all cases when prey was stored on the ground in grass clumps, kestrels chose sites next to fence posts, utility poles, sign posts, or other markers. Tordoff (1955) observed that a captive kestrel

which cached prey used objects nearby to memorize the location of the cache site.

When retrieving prey, kestrels flew to the cache site and if unable to find stored prey, hovered above the area or walked to adjacent grass clumps to search. In several instances kestrels appeared to give up their search when they flew to a nearby perch, only to return and resume the search. One female kestrel spent 15 min investigating grass clumps both on foot and in brief hovers before giving up.

Because my field observations were evenly distributed throughout the day, I assumed that there was no difference in the probability of observing either prey storing or retrieval (see Collopy 1977). On this assumption, I considered my caching data as a representative sample of the relative frequency of prey caching and retrieving and calculated a recovery efficiency of about 78%, similar to the 70% reported by Collopy (1977).

I observed that presenting kestrels with live prey stimulated a response that simulates the reactions of kestrels to natural prey. The typical response was to fly from the perch toward the prey within 20 sec of its detection. Kestrels then would either (1) bind to the quarry on the ground and kill it with a bite to the neck immediately (or after having flown to a nearby perch) or, (2) snatch the prey from the ground without landing and fly to a nearby perch to dispatch it with a bite to the neck.

On 6 March 1982 at 1430H I observed a female through binoculars from a distance of 100 m. The weather was 38°C, calm and clear. I approached in my car to within 25 m, threw a white mouse out the window and waited. Within 2 min the kestrel approached within 4 m of my car, hovered, and then retreated to a wire 20 m away. I then threw out 2 more mice and backed the car 25 m away. At 1440H the kestrel again flew toward the mice but after hovering above them and looking at my car, again retreated to the wire only 15 m distance. I then presented 4 more white mice for a total of 7, all of which were conspicuous against a recently mowed lawn. At 1445H the kestrel flew to a wire only 5 m from the mice and after hesitating for 15 or 20 sec flew down and captured a mouse. However, she immediately flew west 75 m during which flight I saw her bend over several times in midair to bite the neck of the mouse. She immediately landed on the ground and cached the prey in a grass clump at the base of a fence post. She quickly returned to cap-

ture and dispatch in flight the remaining mice in rapid succession. All 7 mice were cached in 1 or 2 grass clumps 1 m apart. None of the 7 mice were eaten at this time.

A month later at the same time of day a male took 7 mice in the same fashion, killing them midair as it flew to the cache site in a white oak tree (*Quercus alba*).

I was able to elicit the capture and caching of as many as 10 mice in sequence by both captive and wild kestrels when presenting them with prey one at a time, over 2 to 8 h periods. Nunn et al. (1976) reported that 1 wild female took 20 white mice thrown from a car window one at a time, over an hour. I found no literature reports of American Kestrels responding to a sudden increase in prey availability by mid-flight killing and caching of successive prey items uneaten.

Caching has been described as a behavioral mechanism to exploit a seasonal or daily abundance of prey, thereby maximizing food intake and dampening the effects of fluctuations in prey availability (Balgooyen 1976; Collopy 1977). My studies agree with other researchers that kestrels, like other falcons, store extra food for periods of a few hours to several days, especially when the capture of sufficient prey may be difficult (i.e., inclement weather, snow cover, or brood rearing).

Although winter food storing in kestrels may be stimulated by a "hunger drive" (see Mueller 1973, 1974) in part, my observations agree with Collopy (1977), Fox (1979) and Cade (1982) that Lorenz' (1937) model of instinctive behavior operating independently of food deprivation occurs in kestrels during the nesting season. Mueller's (1973) laboratory findings, in which the predatory behavior of kestrels was directly correlated with length of time between feedings, was not substantiated. Fifty-eight percent of the prey cached in fall and winter was partially eaten, but only 7% during the nesting season. This indicates that hunger drive does not explain caching behavior of courting males or parental food storing behavior during nesting.

When presented with a surplus of easily captured prey (both in late winter and spring) kestrels killed prey as they flew to a cache site, thus expediting capture of an ephemeral abundance of prey.

The accompanying caching of multiple prey items in the same cache or nearby appears to be yet another example of the flexible behavior of kestrels

attempting to hurriedly exploit sudden surpluses in prey availability. Because I saw kestrels caching 7 prey items together in a 5-min period, I cannot support Mueller's (1973) statement that "excessive killing resulted from the falcon "forgetting" that it had cached food when it was exposed to the prey stimulus." Kestrels cache several consecutive prey items in the same spot in a period of minutes or days, and later retrieve them (Stendell and Waian 1968).

ACKNOWLEDGMENTS

I appreciate the guidance of William H. Elder. Tim Haithcoat and Dave Scarbrough provided valuable field assistance. Thomas S. Baskett and Curtice Griffin provided constructive criticism of the manuscript. The Natural History Section of the Missouri Department of Conservation funded this study, and the Missouri Cooperative Wildlife Research Unit (U.S. Fish and Wildlife Service, Missouri Department of Conservation, Wildlife Management Institute, and School of Forestry, Fisheries and Wildlife, University of Missouri-Columbia, cooperating paid publication costs.

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Received 8 March 1984; Accepted 18 September, 1984.

SHORT COMMUNICATIONS

1981 - An Extraordinary Year for Golden Eagle "Triplets" in the Central Rocky Mountains

M. ALAN JENKINS AND RONALD A. JOSEPH

The clutch size of the Golden Eagle (*Aquila chrysaetos*) ranges from 1 to 4 eggs with a mean near 2 (Brown 1977). Clutches of 3 are unusual, occurring less than 10% of the time (Table 1). Normally, 1 to 3 young fledge/successful nest with a mean of 1.2 to 1.4 (Brown 1977).

and Collopy 1983). We are unable to assess the influence of these factors on the high number of triplets in 1981 with the possible exception of the influence of high prey densities. Clutch size, and therefore, ultimate productivity (number of fledged young/successful nest), are partly in-

Table 1. Frequency of 3-egg clutches in the Golden Eagle.

STUDY AREA	YEAR(S)	NO. OF CLUTCHES	NO. OF 3-EGG CLUTCHES	% OF 3-EGG CLUTCHES	REFERENCE
California		21	3	14.3	Slevin, <i>in Arnell</i> 1971
Scotland		82	8	9.8	Gordon 1955
Colorado		5	0	0.0	Jollie, <i>in Arnell</i> 1971
Montana	1963-1964	60	4	6.7	McGahan 1966
Montana	1963-1968	30	1	3.3	Reynolds 1969
Utah	1957-1958	5	0	0.0	Hinman [no date]
Utah	1967-1968	23	1	0.4	Murphy et al. 1969
Utah	1969-1970	26	8	30.8	Arnell 1971
Idaho, Oregon	1966	15	1	6.7	Hickman [no date]
TOTALS		267	26		
MEAN				9.7	

Various factors, from failure to lay eggs to mortality of nestlings, reduce the probability of a pair of eagles fledgling 3 ("triplets") from a nest. Table 2 compares data on the frequency of 3 fledgling nests from various studies of Golden Eagles in the western United States.

In 1981, we independently surveyed eagle nests for productivity and recorded nests with 3 nestlings. We subsequently discovered that other investigators, in Utah especially, found 5 nestling nests. The mean percentage (3.8%) of nests fledgling triplets in 1981 in Utah, Colorado, and Wyoming is significantly higher $P < 0.10$ than the mean percentage of triplets for other years in the western United States (Table 2). We assumed that mortality of the nearly-grown nestling eagles observed in 1981 was low and that most nearly-grown nestlings fledged. Most studies with which we compared our data also made that assumption by counting nearly-grown nestlings as fledglings.

Many factors can influence productivity in Golden Eagles as reviewed by Newton (1979); also see Edwards

fluenced by the quantity of food adult females eat before egg-laying affecting her nutritional state of health (Newton 1979). Newton (1979) pointed out that rodent-eating raptors lay clutches that can vary directly in size with rodent densities in the nest area. This allows raptors to exploit rodent and other cyclic prey species in high density years by increasing productivity. Evidence suggest that this is true of Golden Eagle-prey relationships, because the eagle's diet in North America is mainly (74%) lagomorphs and rodents (Olendorff 1976) that exhibit cyclic populations (Murphy 1975). This relationship may be moderated by other factors.

In the western United States lagomorph populations appear to have increased in the years leading up to 1981. In southwestern Idaho populations of Black-tailed Jackrabbits (*Lepus californicus*) reached plague proportions in the winter of 1981-82, as reported in the popular press (e.g., Trueblood 1982). Jackrabbit densities were the highest in 9 y in 1981 in the Snake River Canyon of Idaho (Steenhof et al. 1983). In Utah, jackrabbit censuses con-

Table 2. Frequency of three-fledgling (triplet) Golden Eagle nests in the western U.S.

STUDY AREA	YEAR	TOTAL NO. SUCCESSFUL THROUGHOUT STUDY	NO. WITH TRIPLETS	% SUCCESSFUL W/ TRIPLETS	REFERENCE
<u>Years Other Than 1981</u>					
Idaho, Oregon	1966	17	0	-	Hinman, no date
Utah	1957-1958	5	0	-	Hinman, no date
Utah	1967-1968	18	0	-	Camenzind 1968
Utah	1969-1970	19	3	15.8	Arnell 1971
Wyoming, Colo.	1964-1980	882	1	0.1	Den. Wildl. Res. Ctr. data
Wyoming	1979	11	0*	-	Lockhart et al. 1980
Wyoming, Mont.	1975-1978	34	0*	-	Lockhart et al. 1978
Montana	1963-1964	55	3	5.5	McGahan 1966
Montana	1962-1968	22	0	-	Reynolds 1969
Oklahoma	1974-1975	6	0	-	Lish 1965
Texas	1974-1975	5	0	-	Lockhart 1976
TOTALS		1,074	7		
MEAN				0.7	
<u>1981 Data</u>					
Utah	1981	95	6	6.3	Present study
Colorado	1981	94	3	3.2	Pearson, Grode pers. comm.
Wyoming	1981	46	0	0	Phillips and Beske 1981
TOTALS		235	9		
MEAN				3.8	

*Data gathered by personal communication with the author.

ducted by the Department of the Army (R. LeClerc pers. comm.) showed that densities were high (though decreasing thereafter) in autumn 1980 at 3 northwestern Utah study sites, moderate populations at 3 others, and low at 1 Nevada site. Data from both Steenhof et al. (1983) and the Army show similar high densities in 1971 supporting the hypothesis of a 10 yr jackrabbit population cycle in these areas.

Increased prey availability for nesting eagles is probably an important cause for higher than normal frequency of triplets in the western United States in 1981. The only other instance of a high frequency of triplets is the study of Arnell (1971) in Utah. He noted high lagomorph populations in 1971, 10 yr before the high number of triplets in 1981.

Acknowledgment is due to Dugway Proving Grounds (Dept. of the Army), J.M. Lockhart, E.W. Pearson, B. Waddell, P.W. Wagner and the Grand Junction office of the Colorado Division of Wildlife for contributing data.

An earlier draft of the manuscript was reviewed and improved by M.A. Bogan, W.R. Dryer, and R.L. Phillips.

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Received 27 December, 1983; Accepted 11 June 1984.

Food Piracy Between European Kestrel and Short-eared Owl

ERKKI KORPIMÄKI

I studied a raptor community of the large field plain of Alajoki in Southern Ostrobothnia, western Finland ($63^{\circ}05'N, 22^{\circ}55'E$), from 1977 through 1982 (see Korpimäki, et al. 1977, 1979). The most numerous raptor on the study area was the Short-eared Owl (*Asio flammeus*) (315 total pairs, 39.4%), followed by European Kestrel (*Falco tinnunculus*) (36.2%), Long-eared Owl (*A. otus*) (20.0%), Northern Harrier (*Circus cyaneus*) (2.5%), Boreal Owl (*Aegolius funereus*) (1.6%) and Sparrow Hawk (*Accipiter nisus*) (0.3%); for addition details see Korpimäki

1984a). Although the 4 most common species comprise the guild of open-terrain hunting birds of prey in the study area (Korpimäki 1978, 1981), inter- and intra-specific food piracy or kleptoparasitism (see Brockmann and Barnard [21979] for additional details on the terms) was observed only once. Consequently this case may be of some interest.

On 16 May 1982 at 2130 H, I saw a Short-eared Owl in the northern part of Alajoki flying over the field at the height of about 120 m and carrying a vole in its talons. The

owl passed a male European Kestrel sitting on the roof of a barn. The kestrel chased the owl and struck it in the back. It attacked 3 times and the owl took shelter in high vegetation near a ditch. The kestrel stopped attacking and returned to the roof of the same barn. The owl waited for a few minutes on the ground and then started to fly and hunt again. When I examined the location where the owl took shelter, I found a whole Common Vole (*Microtus arvalis*), which was still warm, but no owl nest. The nest in this territory was found on 5 June, when the young were just hatching. Consequently the female was incubating in the middle of May, and the owl observed was probably the hunting male. The kestrel does not breed in the vicinity and was apparently not defending a nest.

The proportion of *Microtus* voles (*M. agrestis* and *M. arvalis*) in the diets of raptors was studied in 1977, when it was 95.5% for Long-eared Owl, 97.6% for Short-eared Owl and 87.7% for European Kestrel (Korpimäki et al. 1977). As rodents are central also in the diet of Northern Harrier (in Norway 57%, Hagen 1952), voles are the most important prey item for raptors of Alajoki, although there are also some alternative prey groups available (e.g., shrews, mice, birds, lizards, frogs and insects; Korpimäki 1984b). Consequently, one might expect a keen inter- and intraspecific competition for food among these birds, especially when voles are scarce. Vole populations crashed in 1980-81 and were in the increase phase in 1982 (Korpimäki 1984a), wherefore a lack of food may have been the reason for piratical behaviour of the kestrel. Also, Brockmann and Barnard (1979) pointed out that kleptoparasitism occurs more frequently during years of a food shortage. The hunting Short-eared Owl flies near the ground and locates its prey by hearing and sight. The hunting technique of the owl is adapted to catching of prey animals in the high grass (for example in uncultivated fields) better than that of the kestrel, which flies or hovers high in the air over the field (Korpimäki 1978). The Short-eared Owl is a vole specialist, while the kestrel preys opportunistically on shrews, birds, lizards, frogs and insects when voles are scarce (Korpimäki 1984b). Thus the Short-eared Owl can probably catch voles of lower densities compared with the kestrel, and it may be advantageous for the kestrel to rob food from Short-eared Owl, which is quite a slow flyer.

Food piracy between the European Kestrel and Short-eared Owl is quite rare. I have found only 6 earlier cases described in literature (from Sweden, Mascher 1963, Nilsson 1975 and from Great Britain, Balfour 1973, Reese and Balfour 1973, Boyle 1974, Clegg and Henderson 1974). Dickson (1971) has described also an interaction of Short-eared Owl, European Kestrel and Northern Harrier on same pipit prey. All above mentioned cases were observed from the end of winter to the beginning of summer when vole populations were at their lowest and the competition for food may have been keenest. Food shortage enhances kleptoparasitism among birds, espe-

cially in falconiforms and charadriiforms (Brockmann and Barnard 1979).

Food piracy is more general between open-country predators in central and western Europe than in my northern study area, because harriers can also take prey from Short-eared Owls (11 cases in Great Britain, Watson 1977 and in the United States, Berger 1958, Clark 1975). On the other hand, Short-eared Owl may sometimes adopt piratical behaviour. Wood (1976) has observed that the owl tried to take a small rodent from a Stoat (*Mustela erminea*); Bildstein and Ashby (1975) saw the owl robbing prey from Northern Harrier and Gordon Riddell (according to Mikkola 1983) described a Short-eared Owl attempting to take prey from a kestrel. This apparent difference in frequency of piratical behaviour between regions may be due to the cyclic fluctuations of the vole populations in northern Europe causing a higher degree of nomadism among raptors compared with a more stable food production in more southern areas where raptors tend to be resident. Most raptors migrate from my study area when voles are scarce (Korpimäki 1984a), and this behaviour decreases the competition for food.

ACKNOWLEDGMENT

I thank Mikko Hast for help in the field work, Clayton M. White and an anonymous reviewer for useful comments on my manuscript as well as the Finnish Cultural Foundation, the Oulu Student Foundation, the Jenny and Antti Wihuri Foundation, the Emil Aaltonen Foundation and the Academy of Finland for financial support of my raptorial studies.

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Received 17 December 1983; Accepted 4 June 1984

An Unusual Observation of 'Homing' To Prey By A Migrating Immature Peregrine Falcon

CARL SAFINA

On 6 October 1981 at 10:05 EST, while operating a raptor banding station on the Long Island, New York barrier beach, I saw a hatching year female Peregrine Falcon (*Falco peregrinus*) land approximately 50 m from my blind and begin eating a small passerine (probably a White-throated Sparrow (*Zonotrichia albicollis*, based on feathers). The falcon was on a low, beach heather (*Hudsonia*) covered rise in a broad, open rolling area. Soon after the falcon began eating, an Osprey (*Pandion haliaetus*), carrying a fish, came over the falcon, vocalizing. The Peregrine flew up and chased the Osprey over the bay to the north, stooping repeatedly at it before flying out of sight. Within 5 min the falcon reappeared on its kill. As the prey was small, cryptically colored, and in a broad, non-descript area of the beach, and since the Peregrine was not seen searching for it, apparently the falcon remembered exactly where it had left its kill and was able to return there from a point out of sight.

Falcons frequently return to cached prey. What is interesting about this incident is that the falcon was a first year migrant and the topography was almost certainly not familiar (the banding station had been manned daily for 3 w prior, and no Peregrines appeared to have been staying in the area). Enderson (Auk 81:332-352, 1964) described wintering Prairie Falcons (*Falco mexicanus*) leaving their prey on the ground and driving off other rapors in a similar manner. His falcons seldom had difficulty relocating the prey, but this is not surprising because they were familiar with the area.

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Received 30 March 1983; Accepted 30 April 1984

Errata - *Raptor Research* 18(2)

Page 44 (Table 1 concluded), 0.420^g should appear in the column for shell thickness, 0.49^h should appear in the column for HE and 0.27^h should appear in the column for DDE; page 47, paragraph 3, line 6, >8 ppm should appear as ≥8 ppm; page 61, Literature Cited, the Sawby et al. reference appeared in *Condor* 76:479-481; page 70, photographs are reversed.



"The Peregrine Falcon At Reelfoot Lake"

By Murrell Butler
Limited Edition Print of 2,500

A tree-nesting "Duck Hawk" populated the Mississippi and Ohio River areas in times past. A remnant nesting population was first documented during the 1930's at Tennessee's Reelfoot Lake by the late Albert F. Ganier. During the 1940's a new nest site was discovered on the west side of the lake by Dr. Walter R. Spofford, then Professor of Anatomy at Vanderbilt University. Dr. Spofford and a few carefully selected observers made yearly nesting observations until the early 1950's.

Mr. Thomas S. Butler was privileged to have been among those who spent many days recording the events of each year's breeding season beneath the enormous cypress tree that served as the falcons' nest site. During the late 1970's a happy circumstance led Tom to meet Murrell Butler, a distant cousin from Louisiana. Murrell was an accomplished wildlife artist and became enthralled by the tales of a Peregrine Falcon that once nested in the snag of the mammoth cypress tree. A subsequent trip to the nest site (the cypress still stands!), the relocation of old photographs and consultation with friends and fellow falconers culminated in this magnificent painting by Murrell Butler.

"The Peregrine Falcon at Reelfoot Lake" portrays the last known North American tree nest of the Peregrine. Available in a 16" by 20" limited edition print of 2500, the introductory price is \$65.00 for prints #1 - #500. The introductory price includes postage within the fifty states and a \$10.00 donation to The Raptor Research Foundation, Inc. The price will advance to \$125.00 per print for #2001 - 2500, according to the following schedule: #1 - 500, \$65.00; #501 - 1000, \$75.00; #1001 - 1500, \$85.00; #1501 - 2000, \$95.00; #2001 - 2500, \$125.00; Arkansas residents will need to add state, city and /or county sales tax). Prints may be ordered directly from Mr. Thomas S. Butler, Butler Galleries, 28 Fairmont Street, Eureka Springs, Arkansas 72632, USA. Payment may be made by check, money order, VISA or MASTERCARD.

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A Quarterly Publication of The Raptor Research Foundation, Inc.



VOLUME 18, NUMBER 4, WINTER 1984

(ISSN 0099-9059)

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The Raptor Research Foundation, Inc.
Provo, Utah

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 18

WINTER 1984

No. 4

RAPTOR COMMUNITY STRUCTURE OF A PRIMARY RAIN FOREST IN FRENCH GUIANA AND EFFECT OF HUMAN HUNTING PRESSURE

JEAN-MARC THIOLLAY

ABSTRACT - The diurnal raptor community of a primary rain forest in French Guiana was studied, both around a small isolated village and far from any human settlement. Twenty species were found in large areas of unbroken forest and 6 additional species only near edges and clearings around the village. The comparison between hunted and non-hunted patches of otherwise similar virgin forest showed that even a moderate hunting pressure (i.e., for food by few people) significantly reduces both mean species richness of sample counts and density of most primary forest raptors. The largest species may eventually disappear.

Other than regional avifaunas and local annotated lists, including birds of prey, I found no studies on any entire raptor community of a particular primary Neotropical rain forest. Most papers are restricted to short observations on feeding (Haverschmidt 1962; Greenlaw 1967; Smith 1969; Lamm 1974; Lemke 1979; Boyce 1980; Fontaine 1980) or breeding behavior (Laughlin 1952; Smith 1970; Strauch 1975). Very few are longer, behavioral (Peeters 1963; Fowler and Cope 1964; Skutch 1965; Rettig 1968; Gochfeld et al. 1978), or ecological studies (Vooous 1969; Smith and Temple 1982).

The number of falconiform species is much higher in tropical American forests than in similar forests of other continents (Thiollay 1984). However, their overall density does not seem to be higher (pers. obs. in Africa, Asia and Central America). Tropical forest raptors are exceedingly difficult to see in their natural habitat, so much so that only one nest of *Micrastur* (5 species), probably the most widespread genus of Neotropical rain forest raptors, has ever been found (Mader 1979).

The avifauna of French Guiana is poorly known (see Tostain 1980), though type specimens of many species (including raptors) coming from this country were described nearly 200 y ago. This paper presents the preliminary results of a larger study designed for a rain forest national park in French

Guiana, and the effect of human hunting pressure on the non-game bird community of primary forest. The objectives were to determine: (1) the composition of the diurnal raptor community of a truly virgin Neotropical rain forest, (2) the closest estimate of the structure (relative abundance of species) of such a community, (3) the forest species occurring only near the edge of large clearings or associated secondary forest and not around smaller natural opening in otherwise unbroken forest, and (4) the result of a moderate human hunting pressure (mostly on non-raptor species) on the raptor community richness and species' abundance.

STUDY AREA AND METHODS

The study site was in south central French Guiana ($3^{\circ} 35'N$ - $53^{\circ} 10'W$) near the small village of Saül (50 inhabitants, mainly goldminers). There are no other settlements or clearings within a 100 km radius. The country was hilly (200 to 500 m) and completely covered with high, dense, primary rain forest. The rich flora (ca. 500 tree species) was described by Granville (1978) and the forest structure by Oldemann (1974). The mean canopy height was 30-40 m with the highest trees up to 60 m. Numerous treefall gaps and small streams (but no large rivers) increase habitat diversity. Mean annual rainfall was 2400 mm, occurring mainly from December to February and April to July. Precipitation was 96 mm in November (17 d) and 206 mm (24 d) in December 1983.

The village was surrounded by about 150 ha of plantations, old re-growth, secondary forest and an airfield. A network of 120 km of small trails helped when searching the forest within about 5 km around the village. Local people hunted there for food. Nearly all

medium-size or large mammals and birds were hunted. The following raptors were killed during my 6 wk study: 1 Harpy Eagle (*Harpia harpyja*), 1 Ornate Hawk Eagle (*Spizaetus ornatus*), 1 White Hawk (*Leucopternis albicollis*), 2 Red-throated Caracara (*Daptrius americana*) and 1 Bat Falcon (*Falco rufigularis*). According to the villagers, about 50 rapors/yr are killed. Hunting has begun there since the first gold miners settled less than 50 y ago.

The second area was located in the Massif des Emerillons, 50 km south of Saül. It is uniformly covered by a strictly virgin rain forest, similar to that of Saül but completely devoid of any human settlement (the nearest is Saül), even of nomadic Indians, and never hunted. The study site was around a bare rocky outcrop which provided the only opening in the forest. Only faint markings were made along line transects which radiated in every direction.

In both areas, only primary, structurally intact forest was considered, but tracks, small openings and edges, from which soaring birds were searched, were included. In Saül this had an influence on the species composition since wider ranging soaring raptors coming from neighboring secondary habitats were recorded above the primary forest canopy.

After a preliminary survey in December 1981 — January 1982, counts were made from 22 November 1983 to 2 January 1984. The Saül area, studied in 31 d, extended over about 100 km², against less than 10 km² in the Massif des Emerillons, which was surveyed during 11 d. This period covered the end of the dry season and the beginning of the rainy season and little time was lost because of afternoon rains.

In spite of numerous attempts in other tropical forests, I have found no single method which can give an accurate figure of a whole tropical forest raptor community. Therefore, the following two complementary methods were used:

1 - The number of birds seen or heard within < 100 m on each side of the line transect, per 2 h spent slowly walking with frequent stops inside the forest, was recorded. Very noisy flocks of caracaras were more often heard than seen, and their flock size could not always be accurately assessed. Therefore, only the number of flocks was computed, irrespective of the actual number of individuals. No significant differences were found among times of day, so all hours have been lumped (rainy periods excluded). This careful search is the only way to detect all the non-soaring species, although more specialized methods (tape records, traps) may help to detect a higher proportion of some species.

2 - From edges, natural gaps on ridges or rocky outcrops dominating the forest, the minimum number of different individual birds seen flying over the canopy, or even sitting on exposed branches, was recorded during 2-hr periods, spent on the same spot in non-rainy weather. To account for the hourly variation of the species' soaring activity, the day was divided into 4 periods. Only birds within < 1 km (the range of visibility of a small raptor to the naked eye) were recorded.

Pooling the data from the 2 methods does not give an accurate figure of the entire community because of very different degrees of conspicuousness, and hence detectability, among species, hours, weather, etc. In spite of this, a rough and tentative estimate of the numerical proportion of each species in the raptor community will be made. The percentages were calculated on the maximum frequency recorded in any of the 2 methods (i.e., mean number of individuals seen per 2-hr period, either under or above the canopy, during the most favourable time of day). Such a treatment obviously underestimates the relative importance of inconspicuous species which rarely, if ever, soar (forest falcons (*Micrastur* sp.), Black-faced Hawk (*Leucopternis melanops*), etc.

RESULTS AND DISCUSSION

The first striking result was the higher mean species richness per sample count and abundance of raptors in non-hunted vs hunted areas, even when the natural primary forest in hunted area suffered no other disturbance than the occasional presence of a few hunters and goldminers. From the hunted to the non-hunted forest, the mean number of species per 2-hr sample increased both under (+ 53.6%, Table 1) and above the canopy (+ 40.9%, Table 2). The frequency of encounters with caracara flocks was 69.4% higher in non-hunted vs hunted area (Table 1). Similarly, the abundance of other raptors increased from the hunted to the protected forest by 46.6% (Table 1) to 93.9% (Table 2). This change in mean number of individuals seen/

Table 1. Mean number of individuals (or whole flocks of *Daptrius*) and species seen/2-hr periods of careful search within a 200 m wide strip under the primary rain forest canopy in hunted (Saül) and not hunted (Emerillons) areas. Vultures and kites seen soaring above the canopy are not included.

	2-HR COUNTS	FLOCKS (\bar{x}) OF <i>Daptrius americanus</i>	INDIVIDUAL (\bar{x}) RAPTORS OTHER THAN <i>Daptrius</i>	SPECIES (\bar{x}) INCLUDING <i>Daptrius</i>
Hunted	128	0.36	0.15	0.56
Not hunted	28	0.61	0.22	0.86

Table 2. Mean number of individuals and species of raptors seen/2 hr period sitting in the upper canopy (excluding *Daptrius*), or most often soaring. Observations are within 1 km of the still observer, during the 4 periods of the day in hunted (Saül) and not hunted (Emerillons) areas.

	0600 H - 0900 H		0901 H - 1200 H		1201 H - 1500 H		1501 H - 1800 H		
	COUNTS	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES	INDIVIDUALS	SPECIES
		(\bar{x})	(\bar{x})		(\bar{x})		(\bar{x})		(\bar{x})
Hunted	33	2.20	1.24	11.90	7.18	4.33	3.25	2.02	1.55
Not hunted	12	1.50	1.50	20.33	9.33	6.83	3.80	11.00	4.00

2-hr period is the closest estimate available of actual density fluctuations. All the differences were statistically significant (Mann Whitney U-test, $P < 0.01$) for both the pooled four hourly periods (as above) and when computing them separately (except for the 6-9 hr period of Table 2). Such a constant trend, whatever the method used or the set of species considered, strongly suggests that a "normal" human hunting pressure from a small isolated village on both raptors (which are killed for food or fun) and more traditional game animals may deeply impoverish the raptor fauna.

Table 3 gives a tentative figure of the whole raptor community in the 2 forest areas. Table 3 takes into account only the highest value of the mean number of individuals recorded for each species either under or above the canopy in any set of the same 2 h samples. Indeed, highly conspicuous soaring species recorded over a 1000 m radius are mixed with smaller, very inconspicuous species of the understory, detectable over a much shorter range. Therefore, percentages cannot be representative of the actual relative densities and they are given only as long as better estimates are not available. The main goal was to compare two areas with the same methods in similar habitats at the same season. In this respect Table 3 shows that all species, except the *Accipiter-Micrastur* group (rarely soaring and thus badly sampled), reach a higher abundance in non-hunted than in hunted areas. However, excluding 4 species linked to secondary habitats (see below) and 4 species not recorded in the virgin forest (probably because of too short a survey or too small an area studied). The 2 communities have a rather similar diversity ($H' = 2.37$

in non-hunted vs 2.28 in hunted zone) and equitability index ($J' = H'/H' \max = 0.59$).

Among the 26 species identified, 6 were associated with clearings and secondary growths around Saül and 4 occurred in the samples when soaring (Black Hawk Eagle (*Spizaetus tyrannus*), Tiny Hawk (*Accipiter superciliosus*) or hunting Plumbeous Kite (*Ictinia plumbea*), Bat Falcon) over the unbroken primary forest, but never far from its edge. The last 2 species of this group, the Crane Hawk (*Geranospiza caerulescens*) and the Gray Hawk (*Buteo nitidus*) have only been recorded at the edge of the primary forest and hence are not included in any count. The lack of species around Saül such as the Roadside Hawk (*Buteo magnirostris*) or the Laughing Falcon (*Herpetotheres cachinnans*), common in secondary habitats at the northern edge of the Guianan forest, reflects the small size of the local clearing and the absence of other gaps over a huge surrounding area. Hereafter, all species will be typical of the undisturbed primary forest, even if most of them also occurred elsewhere in secondary habitats.

Three species continuously soaring high above the forest have a relative density obviously overestimated. The Greater Yellow-headed Vulture (*Cathartes melambrotus*) is the only *Cathartes* identified within the vast expanses of unbroken virgin forest. The two other congeneric species are common in northern Guiana around clearings, savannas and marshes. The King Vulture (*Sarcoramphus papa*) is as widespread as the previous species but it is proportionally more abundant in non-hunted areas (ratio *Cathartes/Sarcoramphus* = 1.1 vs 1.9 in hunted forest). The last very conspicuous species is

Table 3. Relative abundance of raptors in hunted (Saul) and not hunted (Emerillons) primary forests. N max = highest frequency (mean number of individuals seen/2 h) obtained in any method and time period. % = proportion of the species in the community (percentage of the total number) computed from the above frequency. Names are from the A.O.U. checklist, 1983.

	HUNTED		NOT HUNTED	
	N MAX	%	N MAX	%
Greater Yellow-headed Vulture, <i>Cathartes melambrotus</i>	1.66	13.6	3.00	14.0
King Vulture, <i>Sarcoramphus papa</i>	0.88	7.2	2.66	12.5
Gray-headed Kite, <i>Leptodon cayanensis</i>	0.11	0.9	?	a
Hook-billed Kite, <i>Chondrohierax uncinatus</i>	0.44	3.6	?	a
Swallow-tailed Kite, <i>Elanoides forficatus</i>	1.60	13.2	4.00	18.7
Double-toothed Kite, <i>Harpagus bidentatus</i>	1.66	13.7	2.00	9.4
Rufous-thighed Kite, <i>Harpagus diodon</i>	0.22	1.8	0.33	1.5
Plumbeous Kite, <i>Ictinia plumbea</i>	0.90	7.4		b
Tiny Hawk, <i>Accipiter superciliosus</i>	0.11	0.9		b
Bicolored Hawk, <i>Accipiter bicolor</i>	0.22	1.8	0.08	0.4
White Hawk, <i>Leucopternis albicollis</i>	0.99	8.1	1.33	6.2
Black-faced Hawk, <i>Leucopternis melanops</i>	0.04	0.4	?	a
Great Black Hawk, <i>Buteogallus urubitinga</i>	0.33	2.7	2.00	9.4
Crested Eagle, <i>Morphnus guianensis</i>	0.11	0.9	0.50	2.3
Harpy Eagle, <i>Harpia harpyja</i>		c	1.00	4.6
Black and White Eagle, <i>Spizastur melanoleucus</i>	0.88	7.2	1.33	6.2
Black Hawk Eagle, <i>Spizaetus tyrannus</i>	0.44	3.6		b
Ornate Hawk Eagle, <i>Spizaetus ornatus</i>	0.33	2.7	1.33	6.2
Red-throated Caracara, <i>Daptrius americanus</i> d	0.44	3.6	1.66	7.8
Barred Forest Falcon, <i>Micrastur ruficollis</i>	?	a	0.03	0.2
Lined Forest Falcon, <i>Micrastur gilvicollis</i>	0.22	1.8	0.07	0.4
Slaty-backed Forest Falcon, <i>Micrastur mirandollii</i>	0.01	0.1	?	a
Collared Forest Falcon, <i>Micrastur semitorquatus</i>	0.02	0.2	0.03	0.2
Bat Falcon, <i>Falco rufigularis</i>	0.55	4.5		b

a = may exist but not identified

b = not seen and probably lacking

c = formerly known, but now a rare vagrant

d = number of flocks heard within a 1 km radius from vantage points used for the census of soaring species

the Swallow-tailed Kite (*Elanoides forficatus*) gracefully flying over the forest in flocks of 3 to 8 and roosting in high, emergent dead trees.

Two medium size kites, the Gray-headed (*Leptodon cayanensis*) and the Hook-billed are very local and might be associated with forest openings. The Double-toothed Kite (*Harpagus bidentatus*) is the most likely of all small forest raptors to soar over the canopy or spend long periods in upper exposed branches and it appears much more abundant than other similar sized species. It has certainly a higher

density than the congeneric Rufous-thighed Kite (*Harpagus diodon*) (6-7 times higher in the counts) which has only a slightly less conspicuous behavior. These 2 Kites may co-exist since I have seen them in the same patch of forest at two different localities. On the other hand, the Bicolored Hawk (*Accipiter bicolor*) is probably commoner than suggested by the results (see Table 3) since it rarely soars and is restricted to low levels of the understory.

The White Hawk is mostly found on the edge of clearings or natural gaps and often soars, whereas

the congeneric Black-faced Hawk has only been seen in dense undergrowth at medium height. Their conspicuousness is very different and their actual relative frequencies might be closer to each other than suggested by Table 3. The Great Black Hawk (*Buteogallus urubitinga*) is a conspicuous raptor (pairs often perform noisy displays) but patchily distributed along some forest streams or rocky openings.

The Harpy Eagle is the only species not recorded from the hunted forest (although one was shot just outside the study area). Thus, it appears to be the species most sensitive to human hunting pressure, directly and through lack of prey. During this study, I have never seen it soaring, unlike *Morphnus*, but adults are easily seen in the morning from granite outcrops dominating the forest, when they perch on exposed branches of the upper canopy. The Crested Eagle (*Morphnus guianensis*) has probably a higher overall density or a wider distribution than the Harpy. One pair of each of these species was followed from a vantage point above the Emerillons virgin area. From the distribution of their perch sites and display flight circuits, their respective territories seemed to be contiguous but not overlapping. No interspecific aggressive behavior was observed.

The Black and White Hawk-eagle (*Spizastur melanoleucus*) is the commonest eagle (but also the one which most often soars). The Ornate Hawk Eagle is the only *Spizaetus* in pure primary forest where it may be more abundant than *Harpia* and *Morphnus* together, but slightly less than *Spizastur*.

The Red-throated Caracara (*Daptrius americanus*) is by far the most noisy and conspicuous raptor, but it never soars. Nevertheless, it actually reaches the highest density of all raptors both in hunted and virgin primary forest, if the number of individuals, and not only flocks, is taken into account. They are always in territorial flocks of 3-9 birds often loosely associated with Toucans (mainly *Ramphastos vitellinus*) and Oropendolas (mainly *Psarocolius viridis*). Around Saül, on 6000 ha intensively surveyed, there were 12 flocks (at least 71 individuals). Elsewhere, the Yellow-throated Caracara (*Daptrius ater*) has been recorded only along rivers, and the lack of any sizeable river in the study area may explain why this species has never been seen there.

The 4 species of *Micrastur* (forest falcons) are exceedingly secretive and inconspicuous (unless

their voices are known). They are probably more abundant than suggested by the results and may be, together, as abundant or more than *Accipiter* and *Harpagus* because, among small raptors, they are the most frequently seen in the understory. The commonest species is the Lined Forest Falcon (*M. gilvicollis*). The Barred Forest Falcon (*M. ruficollis*), if accepted as a separate species (according to the criteria given in Meyer de Schauensee and Phelps [1978] and Schwartz [1972]) was definitely identified only once. The Collared Forest Falcon (*M. semitorquatus*) is widespread and the Slaty-backed Falcon (*M. mirandollei*) seems to be the rarest species of the genus.

CONCLUSION

The virgin state over several million ha of the forest in French Guiana affords a fair opportunity to answer the main question of this study which was to ascertain the influence, on the raptor community, of a small human settlement, with associated clearings and hunting pressure, within a large tract of primary rain forest. Although it is difficult to assess the accurate structure of a rain forest community, because of very different degrees of conspicuousness between species, the results strongly suggest that (1) small clearings of shifting cultivation and secondary growths attracted 6 additional species, apparently very rare and local (large gaps) in natural conditions and thus increased the overall species diversity, and (2) hunting pressure, though mainly on a few game animals, lowers the density of most primary forest raptors, especially the large species, some of which may eventually disappear (Harpy Eagle).

Hunting may depress raptor density both through occasional direct killing of sensitive hawk species (the largest ones which are likely to have the lowest natural density and reproductive rate), through reduction of their food resources (game species as well as other components of the disrupted food chains), or disturbance of shy species. Hunting pressure is the most widespread form of human activity in tropical countries, which usually adds its effects to those of forest destruction (logging, cultivation). Raptors are among the first non-game species to disappear in the process of human population growth and exploitation of the rain-forest and are thus suitable indicators of habitat disturbance.

ACKNOWLEDGMENTS

This program was supported by a grant from the French Ministry of Environment and the Ministry of Defense Nationale (helicopter transportation). I am grateful to J.L. Dujardin, experienced ornithologist, for his invaluable help both in the field and in preparing the expedition.

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Received 11 March 1984; Accepted 1 November 1984

BIOLOGICAL AND ETHOLOGICAL NOTES ON *Falco peregrinus cassini* IN CENTRAL ARGENTINA

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ABSTRACT - We describe the hunting range of a pair of Peregrine Falcon (*Falco peregrinus cassini*) near Cordova Argentina. Main food was the Eared Dove (*Zenaida auriculata*) and of 9 food pursuits seen the success was 66%. The hunting strategies used are outlined. The cliff used by the peregrines was also used by several other species and of these only the raptorial species were attacked aggressively while such species as the Ringed Kingfisher (*Ceryle torquata*) was attacked as displacement activity.

The subspecies of Peregrine Falcon (*Falco peregrinus cassini*) (Plate 1) has been found nesting with greater frequency in southern Argentina than in northern Argentina. Thus, finding a pair nesting in the centre of the country (Province of Cordoba) was important for us, inasmuch as it is the most northern nest we are aware of, located in Los Reartes Valley (31°60' S-64°50')¹, and it provided at the same time an excellent opportunity to study the species. The synthesis of our observations that follows occurred on 12 regular visits that spanned the breeding period (our first visit was on 20 July 1977, our last on 15 January 1978).

MATERIALS

Photos were taken from a hide situated 12 m from the nest. (Plate 2). The falcons became perfectly accustomed to it immediately. Super 8 film and voice recordings were also made.

RESULTS

Daily Non-Breeding Cycle - While most hunting took place at distant hunting grounds, the rest their activities take place around the breeding cliff. Our observations indicate that the pair was resident from at least July until the end of January, and perhaps they were there year round. As the sun first struck the cliff (ca. - 0900 H in August), each bird left its separate overnight roost and flew to stumps or sticks about 400 m in front of the cliff where they preened or sunned themselves. These preening roosts were about 150 m apart.

As they flew towards roosts, the Southern Lapwing (*Vanellus chilensis*), common in the area, gave alarm calls (in spite of the fact that the peregrines never preyed on them). After 30 min of sunning

and preening, they set out to hunt. The basic food for this pair consisted of the Eared Dove (*Zenaida auriculata*), which was ubiquitous. The falcons hunted independently or as a cooperative pair.

After feeding they roosted at a shaded spot on the cliff for the remainder of the day, or would bathe, until departing shortly before sunset to hunt again. At twilight their activity ceases completely, each one going to separate night roosts.

Uneaten prey was frequently cached on a ledge to be eaten the following day. They were a particularly noisy pair in their relationship, and the occasions when they were not connected in some way, either by vocalizations or visually, were rare. When 1 of the 2 returned to the gully, the 1 perched on the cliff always gave a characteristic call. Of the 2, the male disappeared from the cliff for longer periods, both in midwinter and during breeding time, when it provided the female with prey. In every case, its absences were never more than 2 h.

Territory and Home Range - The home range could be divided into 3 areas of defense in which they showed different reactions. The greatest area "defended" was the hunting ground, which covered several square kilometers and included the other 2 areas. The second was the territory they defended near the nest, of some 300 m (radius) starting from the nest. The third area was the breeding cliff, formed by the nest and its surrounding shelves. In the province of Cordoba, the limiting factor for the number of established pairs seems to be the distribution of cliffs with a sufficiently difficult approach so as to enable them to nest with relative security and not be disturbed; the other possible limiting factor, food (doves), is more than plentiful in all localities. In their "hunting ground" they displaced other competitive species [the male pursued and severely attacked an Apolloado Falcon (*Falco femoralis*) until it was expelled from the territory] or other unpaired peregrines; but they didn't attack other species that were appar-

¹Ed. Note - *F.p. cassini* is now (1984) known to nest several hundred km northward in Salta province, the northernmost province in Argentina. The authors have since located several pairs of peregrines in the Cordoba region.

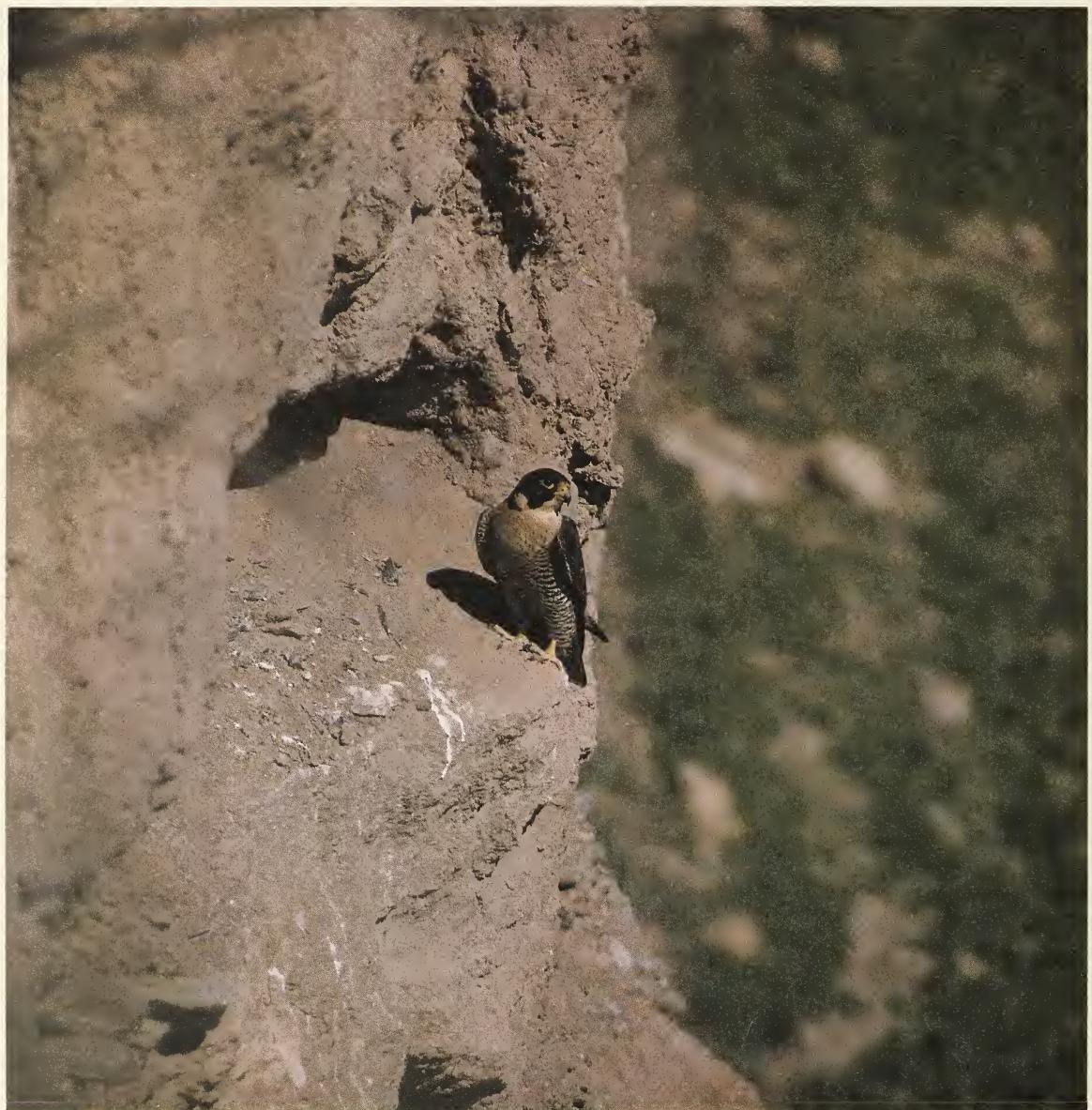


Plate 1: *Falco peregrinus cassini* at nest ledge in Cordova Province, Argentina.

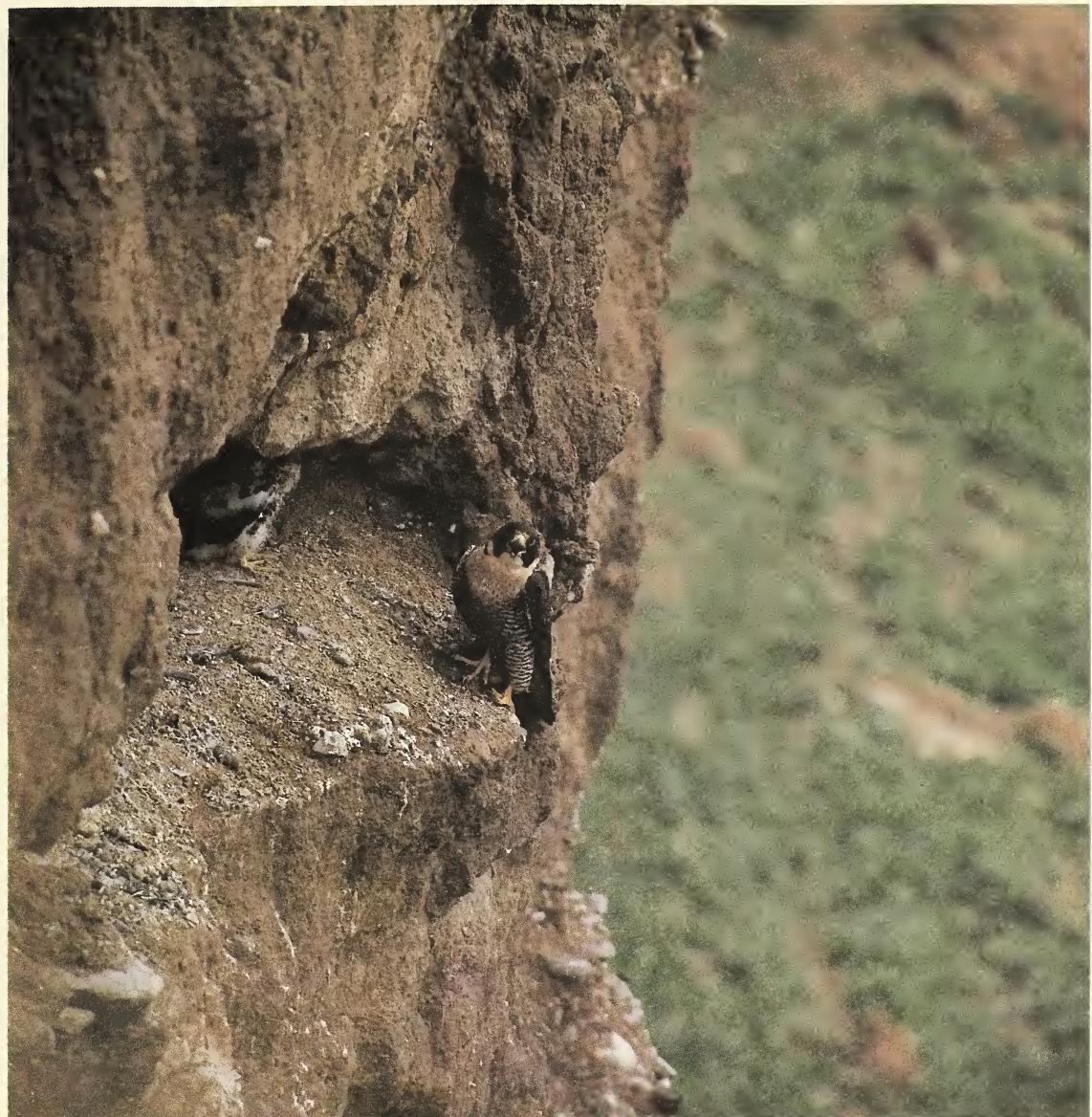


Plate 2: Female *Falco peregrinus cassini* with young at nest in Cordova Province, Argentina.

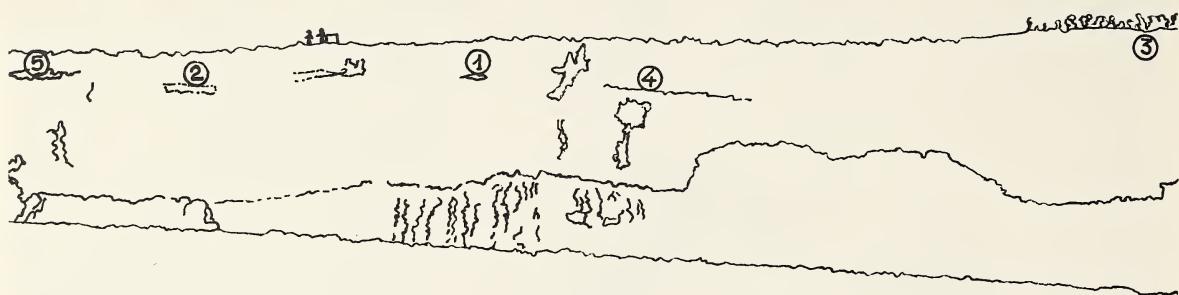


Figure 1. Cliff nest site characteristics for a pair of *Falco peregrinus cassini* nesting in Cordova, Argentina. Site 1 - Prey transfer area; Site 2 - Male's roost; Site 3 - Female's roost; Site 4 - Male plucking perch site; Site 5 - additional perch site also used for sunning.

ently non-competitive or did not serve as food (lapwings, gulls (*Larus* sp.), herons, Chimango Caracara (*Milvago chimango*), or American Kestrel (*Falco sparverius*). In attacks of other species in the "defended area", in all cases the female carried out the most aggressive defense and passed closest to the intruder. The male fulfilled the task of "support" by joining in calling, but his stoops were less decided and he nearly always watched the action flying above the female. The cliff had several characteristic points (Fig. 1) which were: the nest (1); a main eating and plucking ledge for the transference of prey(2); the male's sleeping roost (3); the female's sleeping roost (4); and a plucking and resting ledge of the male (5) also used for sunning

Food and Hunting - The principal prey remains found below the plucking perch was the Eared Dove. Below the male's roost we found the remains of Monk Parakeet (*Myopsittia monachus*) and Screaming Cowbird (*Molothrus rufoaxilaris*) as well as those of the dove. Undoubtedly the male caught smaller birds (*Sicalis*, *Passer*, *Zonotrichia*, etc.), but we didn't find their remains.

Hunting - The principal hunting ground was in front of the nest on low-lying flat ground, partly bordered by the river that was a flying route of pigeons and doves. This hunting ground was where we observed most captures. At the height of the breeding season when large young were in the nest, we witnessed the pair hunting in a highly effective method (in 9 pursuits they achieved 6 captures = 66% success). The hunting method, used with very fast flying, medium sized prey, consisted of the following: in a succession of stoops at the pigeon (one after the other), the female falcon generally hit the pigeon as it tried to watch the male, who cut off its retreat while the pigeon looked for a refuge on the cliff or in the scrub (Fig. 2).

We were particularly impressed by the synchronization of movement they showed when hunting as a pair, from the first moment until they finally caught the prey. A sequence which we frequently observed was the following: they both flew over the cliff at a height of ca. 50 m, soaring against the wind (50-60 m apart); and while making notable head movements they searched the horizon for pi-

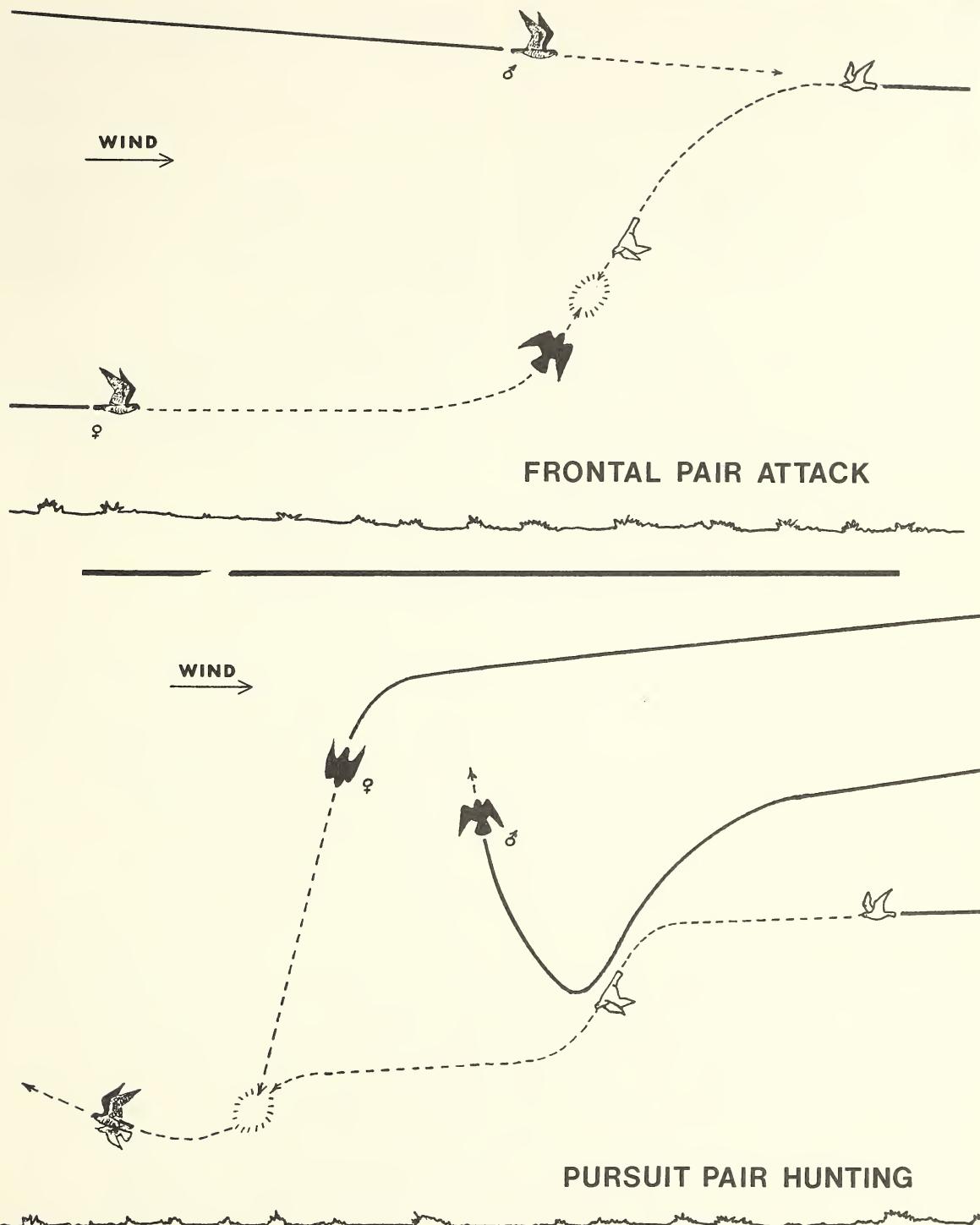


Figure 2. Hunting methods of *Falco peregrinus cassini*.

geons. The male always soared some 10 to 15 m above the female. When the male began to flap his wings, the female followed him at a distance of 30 m, beating her wings in the same rhythm. In an oblique flight, the female began to gain height, ready to stoop onto the prey which dodged the male's first dive. Most times, in the second dive, the female caught the prey. Out of 6 captures observed in 1 day, only 1 was made by the male, and the rest by the female. Similar strategies have been described and diagramed by Hustler (1983).

Young Eared Doves were more easily captured (most feathers found were from young). Some doves, nevertheless, were not able to be caught after a combined chase of more than 500 m, in which the male and female made a succession of stoops; until, to save themselves, the doves flung themselves like stones against the scrub of the cliff, while the peregrine gained height again, and, with repeated stoops to the ground tried to make the dove fly again.

Adaptation to the Surroundings and Relations with Other Species - The cliff face housed several species in addition to the peregrines. Each species seemed to coordinate their activities relative to the peregrines'. For example, a pair of the Ringed Kingfisher (*Ceryle torquata*) nesting near the falcons had to leave the cliff to save their lives when the female peregrine, molested by our presence, directed her attacks at whatever was below her.

when very near, turned in the air and took the prey.

We also observed another very effective combined attack: a dove approached flying towards the falcons, in an oblique direction. The male flew out to meet it and the female, flying behind him but lower (about 5 m above the ground) made her much lower than the dove's line of flight. The dove was apparently unable to see the female falcon, but could see the male.

As it neared the male, the dove turned sharply, descending and practically hitting the female, who had by now gained sufficient speed flying low, that she only had to attack from below, rising upwards to catch her prey (Fig. 2). On this occasion the female killed and partly plucked the dove while still on the wing. Of several prey captured in 1 day, only 1 was killed on the ground, the rest in flight by biting the neck.

During the time we observed the cooperative hunting described, the nestlings were about 20 d old and the female left the nest for long periods to join the hunting male. When the male brought food

to the female, he usually perched 30 m from the nest and called to the female. They were very vocal at the food exchange with a characteristic call (Fig. 3).

Considerations of Food Habits - Of several checks for food on the plucking perches, we only found remains of *Zenaida auriculata*. One, recently killed (still warm) and intact, weighted 130 g. Comparatively, the Spotted Pigeon (*Columba maculosa*), also frequent in the area, must be difficult to hunt; and it is our opinion (which we could not confirm in the field) that the male peregrine (*cassini*) could not transport in flight one of these pigeons that weighs, on average, 260 g.

All the doves were hunted and caught by direct pursuit because their size and agile flight enabled them to successfully evade a stoop. Larger prey that were difficult to carry in flight (ducks, etc.) were hunted by stooping perpendicularly from a considerable height and striking the prey. We found that the "waste factor" of this pair was high. Usually only the breast was gone from the dove. They caught about 3 doves a day and ate about 1/3 of each (40 g of muscles).

Based on the following scenario some calculations can be made. They daily consumed the equivalent of 12% or 15% of their body weight (according to temperature and activity level). The female weighed about 900 g, the male 650 g, and a dove weighed 125 g. During the rearing period each nestling consumed the equivalent of a little more than 1 dove/d (only about 5% of this pair's diet was not doves). Thus, we calculate that the pair and the 4 nestlings raised ate approximately 1750 doves annually. On a kg basis this value is in line with that derived independently by Ratcliffe (1980).

Adaptation to the Surroundings and Relations with Other Species - The cliff face housed several species in addition to the peregrines. Each species seemed to coordinate their activities relative to the peregrines'. For example, a pair of the Ringed Kingfisher (*Ceryle torquata*) nesting near the falcons had to leave the cliff to save their lives when the female peregrine, molested by our presence, directed her attacks at whatever was below her.

Several times we observed these attacks. These were not attacks to kill and eat the kingfishers. On one occasion the kingfisher came in from down river, flying low over the water directly to its nest located about 50 m from the peregrine nest. The female peregrine started a sudden vertical dive-

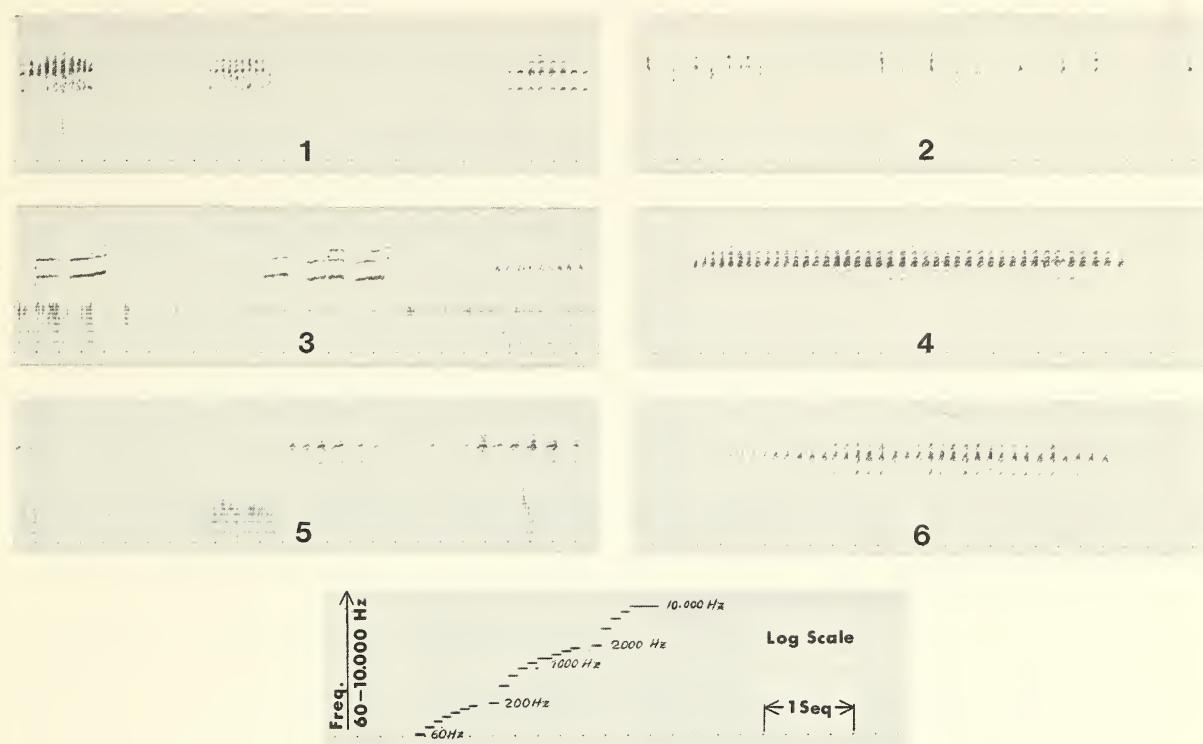


Figure 3. Miscellaneous sonogram patterns of *Falco peregrinus cassini* in central Argentina.

- Pattern 1: Alarm call of nesting female. The female was stooping at us near the nest. She made the calls (chitters) only when near us. The first vocal stanza is more dense than the other two because she was close by. The call ranges from 900-4100 Hz.
- Pattern 2: Contact call of the male. This call was given (*Eechip*, sometimes accompanied by ledge display) from the main eating ledge. Call frequency is from 600 - 5,000 Hz. Of note is that when the female approached him, the number of voices doubled in the same time lapse (ledge display). The latter is easily found in 1.5 sec of the sonogram from left to right. Then, when the female left, the call became more spatial after the 4th sec.
- Pattern 3: Anti-aggression call of perched male. This is also a submission call, since the female, while flying, will disturb or attack the male to make him fly. From the 5.25 sec, the female was close to the male, flying over him. His voice resembles total submission to the point of being like that of the young in front of their mother (compare 1st sec of Pattern 6).
- Pattern 4: Alarm call of the female with young. This sonogram reveals a more definite and persistent voice, more than when the nest contains only eggs (compare to Pattern #1). The call went from 1,000 - 5,000 Hz. In the same sonogram we found that young joined the female in the alarm call. This is noted in the difference in time between their voices, at 3.5 sec and from 4.75 sec, remaining even as the single voice at the end.
- Pattern 5: Alarm call of the male. Note the difference between the alarm calls of male and female. The male call was a mixture of a wail and a typical alarm call. The wail is a single frequency call lasting $\frac{1}{4}$ sec and the alarm call, a great variation of frequencies in $\frac{1}{4}$ sec. Both male and female alarm calls range in the same frequency (compare Patter #3).
- Pattern 6: Call of nestlings. Their alarm call varied from 900 - 4,200 Hz. and resembled the alarm call of the adults in structure but not in the frequency range. The calls before 2.5 sec were the typical submission voice, that the male performs while the female is excited, aggressive or closeby (compare Pattern #3).

Notes: a) On the horizontal scale of the sonogram, each 4 divisions is one second (sec); b) Every character found in the sonogram below the 400 Hz range identifies parasitic and background noises from the wind.

attack the instant the kingfisher passed just below her, which caused the kingfisher to dive violently and loudly into the water. What impressed us most was the stoop of the peregrine, with a sudden movement of the wings, the body down in an almost vertical position, gyrated around the body axis. The wings accelerated the speed and the body returned to its normal position only at the end of the plunge. After passing just a few centimeters over the water, with a movement of the tail and due to the high speed the peregrine gained elevation to get into position for a second attack. The kingfisher surfaced and changed its flight direction, but the second attack forced it back into the water again. After repeating the maneuver several times, the falcon finished the game, allowing the kingfisher to leave the area.

Something very similar happened with a Speckled Teal (*Anas flavirostris*) that nested on the cliff about 30 m from the peregrines. Several times, flying to its nest, it had to enter the water because of the peregrines' attacks. However, unlike the kingfisher, once in the water it did not take wing to avoid the second attack, but swam away. Despite these attacks, the teal fledged a brood of young.

A group of swallows (the Southern Martin, *Progne modesta*, and Grey-Breasted Martin, *Progne chalybea*) also shared the cliff. They nested near the night roost of the male, and their presence was noticeable whenever the peregrines were resting or far away from the cliff. We used the swallows as indicators of the presence of the falcons because when the falcons were present, the swallows flew near the bush — protected cliff. Their alarm-call told us when the male came back to the cliff with prey.

Due to changes in the environment (swelling river after heavy rainfalls that floods lower lands), some species disappear temporarily. Among them, the Southern Lapwings (*Vanellus chilensis*) and Brown-Hooded Gulls (*Larus maculipennis*) made considerable noise whenever the peregrines were flying near despite the fact that they were never attacked.

The peregrine vehemently attacked Common Caracaras (*Polyborus plancus*) to a radius of 300 - 400 m from the nest. On the other hand, the Chimango Caracara (*Milvago chimango*) was not attacked, even when coming as near as 10 m to the nest.

Once we observed the male soaring about 800 m from the cliff. Suddenly he stooped at a Common

Caracara that was flying in front of the nest. On another occasion he pursued and drove away an *Aplopavo Falcon* (*Falco femoralis*) that passed at a very high altitude over the cliff. We can confirm, however, that they do not attack either the American Kestrel (*Falco sparverius*) or the White-tailed Kite (*Elanus leucurus*). A pair of the former nested in a hole of the cliff about 500 m from the peregrines. The kite occupied two little woods of *Eucaliptus* and conifers about 400 m from the cliff.

ACKNOWLEDGMENT

We owe special gratitude to Walter Cerban, Cristian Henschke, and Christopher Clark for their collaboration in this note and to Clayton M. White for comments on the manuscript.

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Received 15 August 1982; Accepted 10 May 1984

BEHAVIOR OF THE AFRICAN PEREGRINE DURING INCUBATION

WARWICK TARBOTON

ABSTRACT - Dawn-to-dusk watches were made during 5 d at a Peregrine Falcon (*Falco peregrinus*) nest with eggs in the Transvaal and all activity was recorded. The male incubated 35% of the day and the female 65%. Their incubation shifts averaged, respectively, 1 h 30 min and 2 h 25 min. Eggs were covered for 98% of the day. The female slept on the nest at night. The non-incubating bird was absent from the nest-cliff for periods averaging 2 h at a time and totalling about 3 h each day. It may have hunted during this time. Hunting by chasing and 'flushing' is described. Twenty-one prey items from 3 eyries were all birds, especially pigeons and doves (46%). The high share of the incubation done by the male, the abnormal hunting by the female during incubation, and the apparent rarity of Peregrines in the Transvaal are discussed.

The status of the African race of the Peregrine Falcon (*Falco peregrinus minor*) is poorly documented, though it appears to be scarce and very localized throughout its range (Cade 1969; MacWorth-Praed and Grant 1957, 1962; Snow 1978). It is described as being a rare breeding resident and possibly threatened in South Africa (Siegfried et al. 1976). During a 3-yr survey of falconiforms in the Transvaal only 10 breeding pairs were located in 286,300 km² (Tarboton and Allan 1984). Data herein may give insight into the factors contributing to its rarity in South Africa, and may provide useful comparative data for similar studies being done on the Lanner Falcon (*Falco biarmicus*) (Kemp, *in prep*).

Detailed observations were made during 5 d at an eyrie in the eastern Transvaal Escarpment Region (Site 1). This paper describes observed breeding and hunting behavior of this pair and includes observations made at 2 other eyries (Sites 2 and 3). Obviously the behavior of a single pair may not represent the species as a whole; in the absence of other published data on the biology of the African Peregrine, these observations are given.

STUDY AREA AND METHODS

The peregrine pair at Site 1 laid eggs in 1979 on an old nest probably built by the Black Stork (*Ciconia nigra*) on a ledge 40 m from the base of a 140 m east-facing cliff overlooking a long, sloping valley extensively planted under pines and eucalyptus. When first located in May 1979 a single male peregrine was seen at the nest-cliff. Observations were made between 5-11 September when the site was occupied by a pair incubating 3 eggs. On 2 November the pair was accompanied by 2 just-fledged young. Both male and female were adult and they could be distinguished by their size difference and the male's noticeably brighter-yellow eye ring, cere and feet.

The nest-cliff was observed continuously from dawn to dusk for 5 d (5-8 and 11 September) totaling 61 h with an additional 2 h 5 min on 10 September. Three observers watched in rotation from a vantage point on the slope directly below the nest. Two tripod-mounted telescopes were used, one trained on the nest and the

other following the movements of the non-incubating bird. All activity, including nest change-overs, agonistic behavior, activities while perched (e.g. preening), vocalizations, and flights were recorded. During periods of rapid action a cassette recorder was used to record activity.

Local sunrise and sunset at the site were, respectively, 0600 H and about 1745 H during the observation period, but it became too dark for observations after 1800 H and before 1530 H. The nest was shaded after 1330 H and the nest-cliff after 1550 H. During 3 d weather was cloudless and warm with little or no wind, and on 2 d it was cold, overcast and windy. No behavioral difference by the birds on clear and overcast days were noticed.

RESULTS

Eggs were incubated for 97.9% of the daytime (n = 61 h); on 4 d this averaged 99.3%, whereas on 1 d the eggs were covered for only 92.2% of the time. Both sexes incubated during daytime, but only the female spent the night on the nest (n = 5). Overall the female did the greater share of incubation, although on 1 d the male's exceeded the female's. The respective proportion of incubation (\bar{x} /s.d.;range) during 5 d was, for the male: 34.7/17.5; 11.6-59.5, and for the female: 65.3/17.5; 40.5-83.4. If the female's overnight incubating is included, the respective male:female proportion of the incubation is 17.7:82.3.

Daytime incubating shifts by the female averaged 2 h 25 min (s.d. = 1 h 6 min, range = 29 min - 4 h 3 min, n = 11) and those of the male averaged 1 h 30 min. (s.d. = 1 h 17 min, range = 8 min - 4 h 14 min, n = 14) (the difference is not significant). The male had both the longest and shortest daytime incubating shifts (respectively, 4 h 14 min and 8 min), although if the female's overnight shifts are included, these would exceed the longest shifts by the male. Her longest continuous incubation shift in this case was 15 h 52 min.

Most observed nest change-overs (n = 27) were similar in that the relieving bird flew unannounced to the nest and alighted beside the incubating bird. One or both birds then uttered a series of 'tjak-ak'

Table 1. Total time during 5 d, given in min and as a percentage, in which the non-incubating bird was present at, and absent from, the nest-cliff.

WHEREABOUTS OF NON-INCUBATING BIRD	TIME (MIN)		% MALE FEMALE	
	MALE	FEMALE	MALE	FEMALE
Present at nest-cliff	562	735	42.0	30.7
Absent from nest-cliff	777	1637	58.0	68.3
Unknown	0	26		1.0
Totals	1339	2398	100.0	100.0

notes before the incubating bird flew off and the relieving bird incubated. Occasionally other vocalizations (e.g. whining 'weee-e-k') were used at change-overs. The male often (10/15 times) appeared to be reluctant to give up incubating when relieved by the female. On such occasions one or both birds called much longer than usual, uttering 25-30 'tjak-ak' notes. Invariably the female supplanted the male in these instances, whereas the male frequently ($n = 10$) came to the nest to relieve the incubating female but was unable to dislodge her. Occasionally ($n = 3$) the female had already left the nest when the male arrived to incubate and he took over silently.

There was no regular pattern of shifts by sex during the 5 d, apart from the first and last shift each day by the female. The male relieved her before sunrise (averaging 28 min before sunrise) on 4 of the 5 d. The female's last shift continued overnight and commenced at various times between 47 min - 3 h 59 min before sunset ($\bar{x} = 1 \text{ h } 54 \text{ min}$).

Activity of the Non-incubating Bird — Often the non-incubating bird left the vicinity of the nest-cliff, presumably to hunt since both birds returned after absences with bulging crops. When not incubating, the male was absent a significantly greater proportion of the time than the female ($P < 0.0001$, see Table 1). On average, the non-incubating bird was absent from the nest-cliff for about two-thirds of each day ($\bar{x}/\text{s.d.} = 8 \text{ h } 3 \text{ min}/1 \text{ h } 35 \text{ min}$; range = 5 h 17 min - 9 h 7 min, $n = 5$). The incubating bird was alone at the nest-cliff for 71% of the day (female) or 62% of the day (male).

The Crowned Eagle (*Spizaetus coronatus*), Jackal Buzzard (*Buteo rufofuscus*), Gymnogene (*Polyboroides radiatus*) and the White-necked Raven

(*Corvus albicollis*) were invariably chased and harassed by the non-incubating bird if they passed the nest-cliff when he or she was present. The incubating bird was never seen to leave the nest and assist its mate during these pursuits, nor did it attempt to chase off passing birds of prey when the mate was absent. On 1 occasion the nest-cliff and eggs were left entirely unattended for 55 min when the female left the nest to pursue, catch and eat a passing pigeon (see *Hunting Behavior*). Black Storks, which came and went continuously from an active nest about 500 m away on the cliff were not molested.

Typically both birds, at the end of an incubating shift, flew to a favored perch, defecated, and commenced preening, and later started other maintenance activities such as stretching, scratching or (occasionally) casting a pellet. On average, male and female spent, respectively 86 and 90 min/day (s.d. = 29 and 39 min respectively) actively preening on a perch (about 12% of each day). After a period of preening they usually became alert, looking about, making perch-changes or 'flush-hunting' (see *Hunting Behavior*) before taking flight, soaring high, and going out of view behind the nest-cliff.

Hunting Behavior — Most hunting and eating of prey apparently occurred away from the nest-cliff since only 2 successful prey strikes were observed in 5 d. In one of these the female left the nest to catch a passing pigeon which it ate away from the nest-cliff. In the other instance the male caught a small bird which it took back to the nest-cliff to eat. There was little prey pluckings below favored perches, and none at the nest, suggesting that during incubation prey was not frequently brought back to the nest-cliff to eat. During 5 d the male never brought food to offer the female and she appeared to provision

herself entirely. In the instance where the male returned to the nest-cliff to eat prey, the female left the nest and attempted to take the remains from him after he had eaten for 10 min. They grappled for the prey on the male's perch before it fell and was lost in the forest below.

In addition to 2 successful strikes, 5 unsuccessful chases (2 by female, 3 by male) and 1 probably successful strike (female) were initiated from the nest-cliff. Three of these 8 attempts (all by the female) involved chasing birds, twice pigeons, which were flying past at least 2-3 km distant. In one case she soared briefly to gain height before at-

tacking passing birds, flying with rapid wingbeats to a point ahead of the birds so as to intercept them. In one unsuccessful chase the 2 pursued pigeons changed direction as she approached, then dived downwards. She stooped unsuccessfully at them 3 times before they reached shelter in trees. In a second apparently successful chase the female's flight from take-off to strike lasted 120 ± 5 sec. It followed the same pattern in which the prey attempted to evade the peregrine by diving and the female spiralled down after it.

At site 2 a male stooped at and caught a swift (probably *Apus melba*) which was one of a large flock

Table 2. Peregrine prey recorded at 3 Transvaal eyries. Sites 1 and 2 are in the Escarpment Region, Site 3 is in the Lowveld.

SOURCE OF DATA	PREY SPECIES	No.
1. Prey remains found below perches on nest-cliffs;		
Site 1	Domestic Pigeon, <i>Columba livia</i>	4
	Red-eyed Dove, <i>Streptopelia semitorquata</i>	1
	Laughing Dove, <i>Streptopelia senegalensis</i>	1
	Cuckoo, <i>Chrysococcyx</i> sp.	1
Site 3	Red-eyed Dove <i>Streptopelia semitorquata</i>	1
	Green Pigeon, <i>Treron australis</i>	1
	Burchell's Coucal, <i>Centropus superciliosus</i>	1
	Swift, <i>Apus</i> sp.	1
	Red-faced Mousebird, <i>Colius indicus</i>	1
	Lilabreasted Roller, <i>Coracias caudata</i>	1
	African Hoopoe, <i>Upupa epops</i>	1
	Rock Martin, <i>Hirundo fuligula</i>	1
	Blackheaded Oriole, <i>Oriolus larvatus</i>	1
	Starling, <i>Lamprotornis</i> sp.	1
	Small passerine	1
2. Prey observed being caught		
Site 1	Domestic pigeon, <i>Columba livia</i>	1
	Small bird	1
Site 2	Swift, probably <i>Apus melba</i>	1
3. Unsuccessful prey strikes		
Site 1	Rock Pigeon, <i>Columba guinea</i>	1
	Pigeon, <i>Columba</i> sp.	2
	Redwinged Starling, <i>Onychognathus morio</i>	1
	Small bird	2
Site 2	Rock Pigeon, <i>Columba guinea</i>	1

spiralling around in the valley below the nest-cliff. The stoop lasted about 10 sec. The bird covered about 1 km and dropped about 300 m during the strike. It took the swift in its feet as it passed through the flock.

In a second hunting method peregrines attempted to flush prey ('flush-hunting') from the nest-cliff and then pursue it. Both male and female frequently did this, though never successfully. In 'flush-hunting' the peregrine changed its perch on the cliff frequently, doing small aerial circuits before re-alighting, sometimes flying up into small crevasses, clinging there briefly, and flying out again. Flushed birds which were unsuccessfully chased included a Rock Pigeon (*Columba guinea*), Redwinged Starling (*Onychognathus morio*) and two smaller birds. 'Flush-hunting' was also observed being used by the female peregrine at Site 2. In this case she flushed, but failed to catch, a Rock Pigeon. This method was frequently used by immature peregrines in the Aleutian Islands, Alaska, and by adults in Argentina (C. M. White, pers. comm.).

The non-incubating bird's frequent absences from the nest-cliff may have been for the purpose of hunting. These absences lasted, on average, about 2 h (respectively, \bar{x} /s.d.; range, for male: 2 h 8 min/55 min; 1 h - 3 h 40 min; n = 9, and female: 1 h 50 min/1 h 30 min; 33 min - 4 h 1 min; n = 7). On at least 2 occasions returning birds had bulging crops.

Prey — Prey data from 3 Transvaal peregrine eyries are given in Table 2. These include items identified from plucking found below perches on the nest-cliffs (18), prey observed being caught (3) and potential prey unsuccessfully chased (7). In all cases prey was avian, and in the wt.-range 25-300 g. Thirteen (46%) were pigeons and doves. The sample from Site 3, a low veld eyrie, includes several bird-species which are absent from the escarpment region.

DISCUSSION

Of special interest was the high proportion of incubation done by the male (35%) and independence of the female in obtaining food during incubation. This compares with the findings of Hustler (1983) in Zimbabwe. In some peregrine populations (e.g. in Alaska, Enderson *et al.* 1972) males may share up to a third of the incubation, but it is usual for females to take the major share (Cramp 1980). The independent hunting by the female at

Site 1 is exceptional, since other studies indicate that she is provided with most or all of her food by the male during incubation (Brown and Amadon 1968; Cramp 1980). It would be instructive to determine whether these observations reflect an isolated occurrence or occur generally in populations of *F.p. minor*.

These two features are at variance with a general pattern in falconiforms where reversed size dimorphism is closely correlated with rapaciousness, a difference in prey size taken by the sexes and often with the nature of parental roles (Selander 1966; Reynolds 1972; Amadon 1975). Thus bird-catching hawks which are the most rapacious tend to have the greatest size dimorphism, take prey in 2 size-classes according to sex and, during breeding, partition parental duties such that the female does most of the incubation while the male does most or all of the provisioning (Newton 1979). Peregrines have a large size dimorphism and are highly rapacious, yet the observations recorded here do not conform to the predicted model of partitioned parental roles. The behavior of the pair at Site 1 may have been atypical.

The rarity of the peregrine in the Transvaal (and elsewhere in southern Africa) has not yet been adequately accounted for. The Lanner Falcon, by contrast, is a relatively common bird (McLachlan and Liversidge 1978). A measure of the relative abundance of the two species in the Transvaal is shown by the number of breeding sites of each recorded during the survey of birds of prey during 1975-1981 when 14 peregrine and 151 lanner eyries were located (Tarboton and Allan 1984). I believe that indirect competition between the two species is partly responsible for the peregrine's rarity, and that the following contribute to this situation:

(1) **Prey** — Whereas peregrines take almost exclusively avian prey, lanners, that prey largely on birds, also take a variety of non-avian prey, including rodents, bats, lizards and locusts (Brown and Amadon 1968; Cramp 1980, pers. obs.).

(2) **Hunting Methods** — The peregrine is a specialized hunter, securing avian prey in the air by stooping on it at great speed, and it requires sufficient air-space in order to chase and catch its prey. The lanner often hunts by stooping, but also hunts from perches and frequently chases avian prey in level flight, pursues prey flushed by vehicles, animals or persons on foot, and snatches prey such as

young gamebirds and poultry from the ground (Brown and Amadon 1968; Cramp 1980, pers. obs.).

(3) Nest-sites—All 14 Transvaal peregrine eyries were on high cliffs (mean height 187 m), only one being on a cliff lower than 140 m. Most recorded lanner nest-sites in the Transvaal ($n = 175$) were similarly on cliffs (57%), but mainly on small cliffs (45%) less than 60 m in height. Many were also in crow nests on pylons (25%), on crow or eagle nests in trees (14%), and on buildings or in quarries (4%).

Lanners, with a broad feeding niche, may outperform peregrines (on an energy/time-cost basis) in some situations, while in other situations the opposite will occur. During breeding, when food demands are greatest, this difference between the two species will reflect their choice of breeding sites and their reproductive output. It is predicted that optimal breeding sites for peregrines will be on high cliffs overlooking airspace through which there is a steady passage of high-flying birds within striking range. In such situations a breeding pair can search for prey while perched on the nest-cliff and simultaneously be able to defend the nest from predators. Lanners, less specialized in making high-speed, long-range stoops, may not match the performance of peregrines breeding in such circumstances. However, on progressively lower cliffs (which offer peregrines a less effective striking height) or in situations where there is less prey passing within range of the cliffs, breeding sites become marginal for peregrines, and a threshold would be reached where lanners, with their wider prey range and more diverse means of taking prey, outperform peregrines.

Peregrines breeding at marginal sites may incur higher energy costs than those breeding at optimal sites; both hunting away from the nest-cliff (necessitating frequent climbing in order to make stoops) and transporting food back to the nest, may be more time and energy consuming. Such disadvantages could leave nests exposed to potential predators and may result in a reduced provisioning rate, affecting reproductive performance negatively. The site observed may have been marginal since most hunting was done away from the cliff, and once during the 5-day watch the cliff was left entirely unattended for 55 min. This may also be why the female hunted for herself during incubation.

Elsewhere in the world the peregrine's prefer-

ence for high cliffs has been noted (Hickey 1942; Ratcliffe 1962); and during the extirpation of *F. p. anatum* from northeastern America through pesticide contamination in the 1950's it was noted that the first eyries to be deserted were those on low cliffs, and the last to go were those on the highest cliffs (Hickey 1969). This supports the hypothesis that occupation of high cliffs has energy/time-cost benefits for peregrines breeding there. In areas where lanners (or other *Falco* species filling the 'lanner-niche') are absent, peregrines may occupy a wider range of breeding sites than otherwise, although the reproductive performance of pairs at marginal sites may not match that of pairs at optimal sites. Where lanners occur in sympatry, peregrines are excluded from many marginal sites by lanners because of the latter's more generalized hunting capabilities and efficiency at low sites.

Thus it is hypothesized that the rarity of peregrines in the Transvaal is the result of (1) the general scarcity of optimal breeding sites (i.e. high cliffs overlooking airspace offering sufficient prey-capture opportunities), and (2) the presence of lanners which outcompete them (on an energy/time-cost basis) and exclude them from marginal sites. Lanners are generally much more common, since by far the greater part of the Transvaal is a plateau with little or no relief. However, in parts of the Transvaal Escarpment Region where conditions favor peregrines, lanners are outnumbered by them. In one such area 4 peregrine eyries are known, compared with only 2 of lanners.

ACKNOWLEDGMENTS

I thank David Allan and Guggi Tarboton for help in all aspects of the fieldwork, the Department of Forestry for cooperation and provision of many facilities, and the Transvaal Division of Nature Conservation who supported this work.

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Received 15 August 1982; Accepted 15 August 1983

ROOST SELECTION AND BEHAVIOR OF THE LONG-EARED OWL (*Asio otus*) WINTERING IN NEW JERSEY

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ABSTRACT - Roosting Long-eared Owls (*Asio otus*) selected conifers with dense foliage that concealed all or most of the main trunk with no apparent regard to tree species. Roosts were established only in clumps of 2 or more closely-spaced conifers (3-15 m in height), always near a variety of open habitats. Communal roosts of 2-4 owls were significantly preferred to solitary roosts. Strong fidelity for a single roosting tree was observed within each winter, although the owls shifted to a new main roost site each yr. Owls concealed themselves in dense foliage; when approached, they would hide or freeze and flush only at close distances. Evidence indicated that these owls had habituated to remarkably close human activity, although they were readily able to detect an intruder. The 2 most frequented roosts were within 8 m of large buildings which may have provided wind protection and increased shade for hiding. The owls remained at roosts well into darkness and when flushed during the day, showed strong aversion to daylight activity.

While the food habits of wintering Long-eared Owls (*Asio otus*) have been extensively studied (see reviews by Marti 1976; Voight and Glenn-Lewin 1978), the literature on roosting sites and attendant behavior is limited and few of the observations have been systematic (Glass and Nielsen 1967; Smith 1981). Here, I document systematic counts of roosting Long-eared Owls in man-made habitat where all vegetation was landscaped and planted in orderly patterns (i.e., an industrial park and a cemetery). This eliminated many of the habitat variables normally encountered in natural ecosystems and facilitated the identification of essential roost-site requirements.

STUDY AREA AND METHODS

Observations on roosting Long-eared Owls were made from 18 January 1981 to 10 March 1984 in the Hackensack Meadowlands District, New Jersey. This area contains estuarine marshes that border the lower Hackensack River. These extensive open marshes are dominated by common reed (*Phragmites communis*), interspersed with small tidal channels and creeks. Ornamental conifers were distributed in a nearby industrial park (office and warehouse buildings).

In 1981, all conifers within 1 km of the originally-discovered roost were checked for owls and/or their sign (pellets, prey remains, feathers, urates). I found that all roosting activity was limited to one 22 ha block of the industrial park. In 1982, I systematically searched this block for roosting owls with 9 flush counts (Craighead and Craighead 1956), by closely inspecting 77 conifers on each census date. These conifers were 2-6 m high and were the following: 73 Austrian pine (*Pinus nigra*), 2 eastern hemlock (*Tsuga canadensis*), and 2 Atlas cedar (*Cedrus atlantica*). The number of flush counts was kept to a minimum and their timing was designed to obtain the most information with the least amount of disturbance to the owls (Table 1). At approximately monthly intervals, other conifers within 1 km were checked but signs of roosting were not revealed. After the snow cover had melted in early February of 1982, pellets were found and collected on each of the last 6 flush counts. A record of the number and location of pellets provided an additional measure of roost-site

use, for each owl ejects approximately 1 pellet per day at the roost (Craighead and Craighead 1956; Birkenholz 1958; Graber 1962). Analysis of these pellets was reported previously (Bosakowski 1982). During the winter of 1982-83, neither owls nor pellets were found during 17 systematic searches. In the winter of 1983-84 the roosts became active again and 9 systematic searches (including pellet collections) were conducted.

RESULTS AND DISCUSSION

Roost Trees. — In the study block, I observed Long-eared Owls roosting in 4-6 m ornamental Austrian pines (36 times) and once in a 2 m hemlock. A few additional observations were made at a cemetery about 2 km from the study block during the second winter. Here, 1-3 Long-eared Owls roosted in a planted row of 4-5 m ornamental arborvitae (*Thuja* spp.) and in a row of 10-15 m hemlocks. Although Long-eared Owls typically exhibit a strong preference for roosting in conifers, a preference for certain species has not yet been indicated (Randle and Austing 1952; Smith 1981; this study). Density of foliage is probably of most importance since it provides protection from wind-chill, precipitation, predators, and mobbing birds. In this study the trees selected for roosting were those that offered the greatest foliage density and concealment of the main trunk. Smith (1981) noted that roost trees had extensive branching to within 2 m of the ground.

Roost-site Use and Characteristics. — In the study block, virtually all roosting was confined to 2 roost sites (Fig. 1). In 1981, the owls showed a strong fidelity for roost 1 as demonstrated by the lack of sightings and pellets elsewhere in the study area. In 1982, 1 or 2 owls stayed in roost 1 for a short period (10 pellets) and joined other owls (maximum = 3) at roost 2 for the remaining winter

Table 1. Systematic flush counts of Long-eared Owl roosts.

DATE		ROOST 1		ROOST 2	
		OWLS	PELLETS	OWLS	PELLETS
First Winter					
20 January	1981	1	+ ^a	0	0
31 January	1981	2	+	0	0
Second Winter					
01 January	1982	0	0	0	0
24 January	1982	1	NC ^b	3	NC
26 January	1982	2	NC	1	NC
04 February	1982	0	10	3	85
10 February	1982	0	0	3	15
23 February	1982	0	0	3	9
02 March	1982	0	0	1	8
18 March	1982	0	0	1	14
24 March	1982	0	0	1	1
Third Winter^c					
31 October 1982- 4 April 1983		0	0	0	0
Fourth Winter					
18 December	1983	0	0	0	0
31 December	1983	4	27	0	0
07 January	1984	0	26	0	0
20 January	1984	4	NC	0	NC
28 January	1984	3	52	0	0
04 February	1984	2	25	0	0
20 February	1984	2	32	0	0
04 March	1984	0	1	0	0
10 March	1984	1	3	0	0
Totals:		22	176+	15	132

^apellets present but not collected during first winter.

^bpellets not collected because of snow cover.

^ca total of 17 counts were made during this period.

(132 pellets) (Table 1). In 1983 there was no evidence of roosting during the entire winter season. This may have been the result of mild temperatures during December and January as compared to other years (Fig. 2). In 1984 only roost 1 was used by 1-4 owls.

Roost 1 consisted of a cluster of two 4 m Austrian

pines that were 2 m apart, three 1 m evergreen shrubs, a 2 m hemlock, and a 6 m white birch (*Betula pendula*). The trees were planted on a 0.5 m mound, bordered with small boulders. Roost 2 was a row of ten 3-5 m Austrian pines that were planted so that the foliage met between almost every tree. The preference of Long-eared Owls to select roost trees

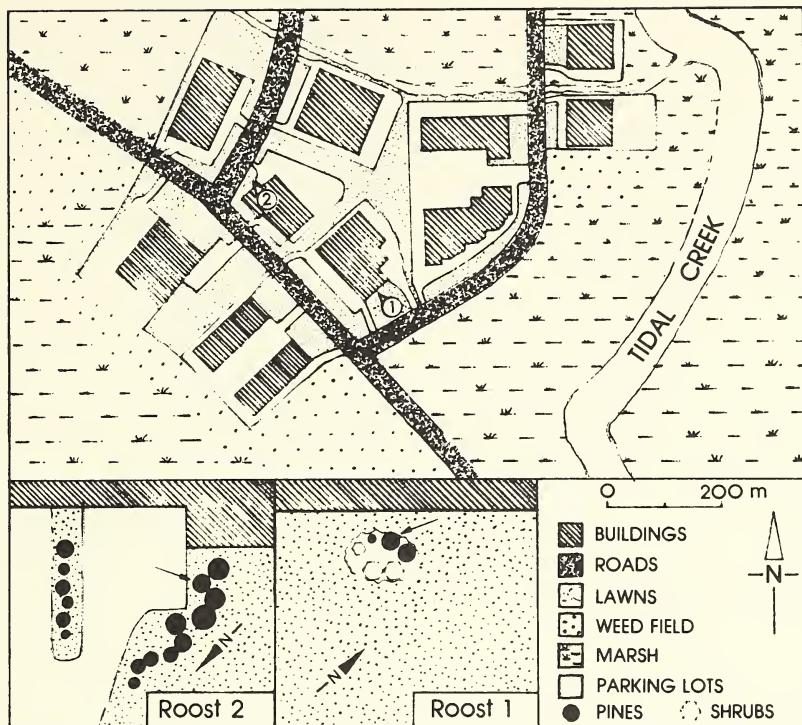


Figure 1. Map of study area with inset maps showing close-up views of two Long-eared Owl roosts. Small arrows indicate most frequently-used roost trees. Systematic searches were conducted in the center block (study block).

from among clumps of two or more conifers was also noted by Bent (1938:153), Randle and Austing (1952), and Birkenholz (1958).

The two roosts that were selected represented 2 of 4 apparently-suitable pine plantings in the study block, yet the other pine groups showed virtually no signs of use during the study (2 and 6 pellets found). The two favored sites were closer to buildings (6-8 m as compared to 19-25 m) and as a result, received less direct sunlight. Protection from the prevailing northwesterly winds was apparent at roosts 1 and 2 but not at the little used pine groups. While the eastern site (roost 1) was shielded directly by the adjacent building, the western site (Roost 2) was also protected by being on the southeastern side of the pine row (Fig. 1).

Roost-site Fidelity. — The fidelity of Long-eared Owls to certain trees within the favored roost sites was evident, e.g., in 1982 there were 119 pellets under one tree in roost 2 and only 27 pellets under 7 additional trees. In 1984 the results were similar

at roost 1 with 147 pellets under 1 tree and 67 pellets under 9 other trees. Some pellets found at alternate roost trees were the result of owls temporarily moving after I flushed them. The Craigheads (1956:88) mentioned the habit of Long-eared Owls to return to the same roost tree and noted one owl on the same perch on 9 consecutive roost counts. I observed 1-3 owls roosting in the same tree on 7 consecutive roost counts (54-day period). Smith (1981) reported the fidelity of Long-eared Owls to certain groups of trees over a period of many years, but no reference was made to fidelity to individual trees.

While I observed a strong fidelity to one roost site during each winter, it was surprising that the owls established their main roost at a different site each year, alternating between roost 1 and roost 2 (Table 1). These data seem to indicate that the initial selection between two suitable roosts is a rather fortuitous event and that a strong site-tenacity develops thereafter. Similarly, Klopfer and Hailman

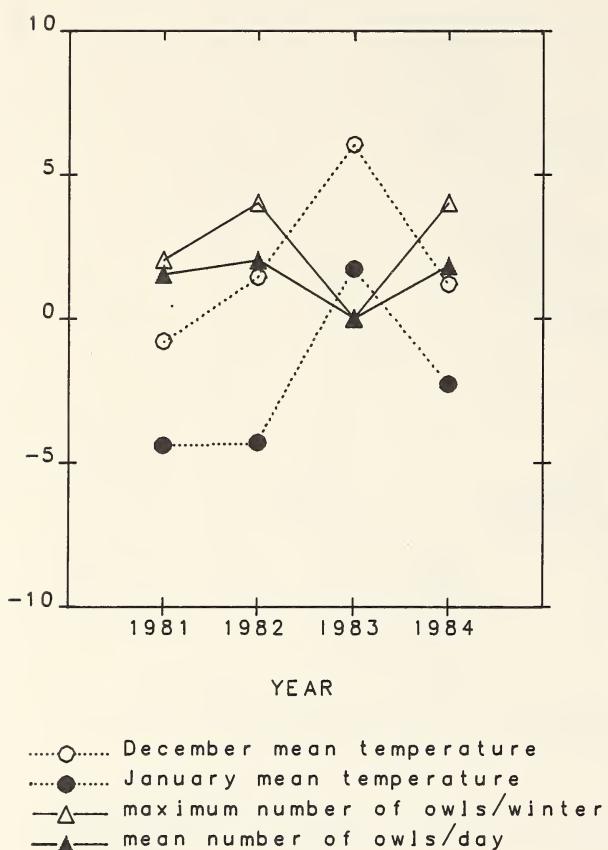


Figure 2. Inverse relationship between mean winter temperatures ($^{\circ}\text{C}$) and owl numbers occurring in the study area. Weather data was obtained from National Weather Service at Newark International Airport located only 13 km from the study site.

(1965:291) have postulated that in their study only one of several available sites was occupied by gulls because of social stimulation.

Proximity to Hunting Areas. — According to the literature, Long-eared Owl roosts are almost always located near open habitats. The significance of this association was revealed by Randle and Austing (1952) who found a "preponderence" of open-field prey species in the pellets. A review of numerous food habits studies (Marti 1976) confirms this finding and suggests that the majority of hunting occurs in open country. In the present study, both roosts were within 200 m of large *Phragmites* tidal

marshes. In addition, five man-made habitats were also present: a few small weed-covered fields (total 15 ha), 2 bulldozed construction sites (8 ha), parking lot and road edge, lawns surrounding the roosts, and large sanitary landfill mounds (70 ha). Hunting in these "disturbed" habitats may have accounted for the unusual dominance of *Mus musculus* in the pellets (Bosakowski 1982).

Roosting Behavior. — In most cases owls concealed themselves completely in a dense portion of the conifer and were not visible until flushed or an intention movement was made. Consequently, it was not always possible to accurately note information such as roosting height, distance from trunk, or individual distances.

On one occasion, a Long-eared Owl was perched on a completely exposed branch, but when I approached, it hopped along several branches and hid behind the tree trunk while keeping a continuous watch in my direction. Similar hiding behaviors were observed on 3 other roost counts. On 2 other occasions, owls were seen trying to avoid detection by elongating their posture, erecting their ear tufts and closing their eyelids nearly completely. The resultant motionless form was maintained unless I approached closer than 3-4 m; then the owls flushed. This concealing posture was identical to the "broken branch" appearance described in Bent (1938:163). Another time, I observed a person, unaware of the owl roost, walk within 4 m of an owl that was roosting on an exposed branch, but the owl remained undisturbed. However, when I approached within 9 m and looked directly at the same owl, it began staring intently, quickly rotated its head back and forth, and then flushed. These contrasting observations suggest that Long-eared Owls will habituate to nearby human traffic, but are readily able to discriminate when they are being watched. Such selective attention to a predator's eyes (in this case, the author's) can have considerable survival value (Suarez and Gallup 1983) in that prey species can monitor the direction of a predator's visual focus and may be able to take advantage of better escape opportunities (Gagliardi et al. 1976). Randle and Austing (1952) reported a similar ability of Long-eared Owls to discern scattered members of a searching party and change the direction of their escape flight accordingly.

Communal Roosting. — In general, these owls roosted or flushed between 2 to 3 m above ground. When 2-4 owls roosted communally, they were

typically distributed on different branches at varying heights. Only once were 2 owls seen roosting together on the same branch. When more than one owl was present in the study block, communal roosting was significantly preferred ($\chi^2 = 18.0$, d.f. = 1, $P < 0.001$) with only 4 solitary roostings observed. Fleming (1981) lists the five most accepted explanations for communal roosting: (1) a shortage of roost sites, (2) huddling for body heat conservation, (3) predation risks, (4) a tendency to exchange information on patchy food locations, and (5) to assess population size in relation to resources. Although suitable roost sites were not plentiful in the study area (hypothesis 1, Fleming 1981) my data show that a major roost can be totally ignored in successive years with the owls clustering at another nearby site. Clustering is not related to huddling (hypothesis 2, Fleming 1981), for the closest individual distance observed was 0.4 m. Reduction of predation risks (hypothesis 3, Fleming 1981) has probably been a major 'ultimate' factor in favor of these owls forming communal assemblages. During many flush counts, one owl would usually detect me first, and then the others apparently were alerted by either intention movements or by the sound of the first bird flushing. Furthermore, when several owls flush simultaneously, momentary confusion may be experienced by an advancing predator. Post (1983) speculated that in a solitary hunting species, communal winter roosts have probably evolved as an anti-predator mechanism. However, hunting by Long-eared Owls may not be a completely solitary event since some owls may follow others to profitable hunting grounds. Therefore, the effect of hypothesis 4 (Fleming 1981) remains unknown for the Long-eared Owl. Finally, I agree with Schnell (1969) that the plausibility of hypothesis 5 (Fleming 1981) is questionable and not likely to be tested in the field.

Flushing Behavior. — The view of the owls was frequently obstructed by dense cover or they were dozing with closed or partially closed eyes. Hence the flushing distance was usually between 2 to 4 m with a quiet approach (no crusty snow or leaves). During the study period, the owls were flushed a total of 22 times, either singly or in groups. On 8 occasions, some owls immediately returned to the same roost site within a period of several min. Two owls attempted to return repeatedly (4 and 6 times) to the same roost tree within 10 min of being flushed. Apparently disturbed by my presence,

these owls were unable to resettle at each return. This reluctance to leave the roost has not been previously described, but was probably related to the scarcity of roosting cover in the study area. Owls that did not attempt an immediate return to the roost were generally seen perched in the nearest available conifers. This further attested to the strong aversion of Long-eared Owls for daylight activity. Like the observations of Randle and Austing (1952), the owls I studied were often clumsy and disoriented when flushed, and twice were observed to fly into black non-reflective windows of an adjacent building. Apparently, the dark windows were mistaken for large cavities. No injuries were evident and the owls continued to seek cover immediately. The tendency of Long-eared Owls to hide, freeze and flush only at close distances explains why this raptor is able to roost very close to human habitations.

Roost Departure. — The nocturnal inclination of the Long-eared Owl was further characterized by their late emergence at dusk. On 2 evenings, owls were still roosting 26 and 40 min after sunset at roost 2, but on 2 other evenings, could not be found at this roost 49 or 81 min after sunset. From these 4 evenings, it appears that roost departure is most likely to occur between 40 and 49 min after sunset. Similarly in England, Armitage (1968) observed a group of Long-eared Owls on one night departing from the winter roost 35 min after sunset. In Denmark, Glass and Nielsen (1967) observed departures of Long-eared Owls from a winter roost on 40 nights and found a departure time of 39 ± 8 ($\bar{x} \pm S.D.$) min after sunset.

ACKNOWLEDGMENTS

I thank Robert Speiser and Richard Kane for valuable discussions throughout the course of the study and for their critical reading of the manuscript. Appreciation is also extended to Drs. John H. Edgcomb, Frances N. Hamerstrom, Kevin L. Keim, Carl D. Marti, and Clayton M. White for reviewing various drafts of the paper. Robert Pitler provided encouragement and suggestions about the project. Dr. Arthur A. Levin assisted with graphics.

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Received 6 September 1984; Accepted 21 January 1985

FACTORS INFLUENCING DIFFERENTIAL PREDATION ON HOUSE MOUSE (*Mus musculus*) BY AMERICAN KESTREL (*Falco sparverius*)

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ABSTRACT - Due to the sexual size dimorphism of raptors, it was thought that a preference for different sized prey might be evidenced between male and female American Kestrel (*Falco sparverius*). A modified bal-chatri trap was used which gave kestrels a choice of 2 types of mice. In the first experiment, wild birds in the field were given a choice between a large mouse (35 - 40g) and a small mouse (22 - 27g). The results of the summer season were compared to those of the fall-winter season. The preferred prey size between the males and the females was not significantly different in fall-winter ($X^2 = 0.036$, $P > 0.05$). During breeding season, the preferred prey size shifted dramatically; males chose predominately small mice, females predominately large ones ($X^2 = 20.55$, $P < 0.001$). The second experiment showed the influence of hunger on preference for a particular sized mouse. The birds that were determined to have a higher hunger level chose predominately the large mice ($X^2 = 5.18$, $P < 0.025$). The third experiment showed the effect of a conspicuous, but odd, color of prey (white mouse) compared to that of the normal, agouti color. The agouti color was chosen by 82% of the birds. The difference between the actual preference and a random choice was highly significant ($X^2 = 18.85$, $P < 0.005$).

There are many aspects to the selection of prey by predators. Lack of protective coloration (Dice 1947; Kaufman 1974a), prey activity (Kaufman 1974b) and oddity (Mueller 1971) play important roles. The roles of predator experience (Mueller and Berger 1970), specific search image (Tinbergen 1960; Mueller 1971) and hunger (Mueller 1973) have also been demonstrated. Several authors have investigated the role of size in the selection of prey by storks (Ogden et al. 1976), shrikes (Slack 1975) and several species of raptors (Storer 1966; Mueller and Berger 1970; Synder and Wiley 1976; Marti and Hogue 1979).

The American Kestrel (*Falco sparverius*) shows only a slight size dimorphism with the male being, on the average, 8% smaller by weight than the female (Brown and Amadon 1968). The kestrel must select prey with an efficiency such that the energy expended to find, catch and kill the prey is less than the energy obtained. Predation efficiency is even more important during the breeding season when the male feeds the female and young, as well as himself. Certain prey must exist that are more efficiently found and subdued (Emlen 1968). One aspect of this efficiency is size of prey. This study attempts to show a preferred size of prey by kestrels which corresponds to the sex of the bird, hunger of the bird and color of the prey, as well as seasonal variation.

METHODS AND MATERIALS

A modified bal-chatri trap (Mueller and Berger 1959), consisting of 2 compartments (each 13 cm x 25 cm) separated by 15 cm and made of ½-in hardware cloth was used. Capture loops were made using 12# + cst monofilament line with approximately 20 loops attached to each compartment. Two size categories of the agouti colored House Mouse (*Mus musculus*) were used: large (35-40g) and small (22-27g). All agouti mice were inbred genetic

strain C2H. Small mice were randomly placed in 1 cell and large in the other. Whenever possible, the 2 mice used had a 15g weight difference. When a perched kestrel was sighted the trap was tossed to the ground from a slowly moving vehicle at a distance of 10-40 m from the bird. The trap was removed after 5 min unless some type of response from the kestrel was observed. When the bird was trapped, its sex was noted as well as which mouse (large or small) it attacked. Any time a bird switched from one side of the trap to the other, the trial was discounted. This happened on only 10 of 149 trials and only in the fall-winter season. The fall-winter season included the months September, October, November and December 1980 & 1981. No switches were made during the summer season of May, June and July, 1981, 1982, 1983 (see Tables 1 and 2). Males and females were compared for prey size preference as well as difference between the 2 seasons. Independent and semi-independent young birds were separated from adults on the basis of whether flight feather molt was occurring during the breeding season (see Table 2). During fall-winter season the immature birds were combined with the data for adults.

A second part of the study concerned the determination of hunger in birds which might have influenced preference for a particular sized mouse. Hunger was determined by computing ratio of average wing chord to the cube root of average body wt. Any bird with a ratio above the average was considered underweight and any bird with a below average ratio was considered overweight. Overweight and underweight kestrels were then sub-

Table 1. Comparison of the number of female and male kestrels that chose either the large or the small mouse during the fall-winter "season". The category "switched mice" denotes that the kestrel attacked one size mouse and then switched and attacked the other.

	LARGE MOUSE	SMALL MOUSE	SWITCHED MICE
Males	23	26	4
Females	41	49	6

Table 2. Comparison of the number of female and male kestrels that chose either the large or the small mouse during the "summer" season. The category "switched mice" denotes that the kestrel attacked one size mouse and then switched and attacked the other.

	LARGE MOUSE	SMALL MOUSE	SWITCHED MICE
Males	5	23	0
Females	21	4	0
Immature			
Females	3	10	
Immature			
Males	1	1	0

jected to Chi-square (X^2) analysis to determine if both preferred the same or different sized mice.

Finally, I determined if a conspicuous, but odd-colored, mouse (white) was preferred over the more natural color (agouti). The white mouse could be seen, when it moved, up to approximately 300 m away, whereas the agouti mouse could be seen up to approximately 200 m. These distances were determined by objective analysis by the author. The background did not appear to make much difference in discerning the white mouse unless the substrate was very light in color. The experiment was similar to the large and small mouse experiment, except the trap contained only 1 white and 1 agouti mouse with no more than 3 g difference in wt.

Comparison of wing chord was done between summer and fall-winter kestrels to determine if 2 populations of kestrels (migratory and non-migratory) were being sampled in fall-winter versus 1 population in summer (non-migratory). A t-Test was used to compare means and a F-test for variance.

RESULTS AND DISCUSSION

Fifty-three adult birds were trapped during the summer season when young were in the nest or still on the territory being fed. In the fall-winter season 1980 and 1981, 149 birds were trapped. Eighty-nine birds were trapped for the white mouse/agouti mouse experiment in the fall-winter season, 1982 and in January 1983. Kestrels were trapped in open habitat in Los Angeles, Orange, Riverside and Kern counties, southern California. During fall-winter, more females were trapped than males. This may have been due to sexual habitat preference (Koplin 1973). Females tend to prefer open habitat while males prefer woodland margins.

The data are shown in Tables 1-5. The preferred prey size between males and females was not significantly different in fall-winter ($X^2 = 0.036$, $P > 0.05$; see Table 1). During the breeding season, preferred prey size shifted dramatically; males

predominately chose small mice, females predominately chose large mice (see Table 2). This difference was highly significant ($X^2 = 20.55$, $P < 0.001$) and was reflected in seasonal comparisons within each sex. Males shifted from a random choice in fall-winter to a strong preference for small mice in the breeding season ($X^2 = 5.32$, $P < 0.025$). Females shifted from a random choice in fall-winter to a strong preference for large mice in the summer season ($X^2 = 10.14$, $P < 0.001$).

Table 3. The number of overweight and underweight females that chose either the large or small mouse during the fall-winter "season".

	LARGE MOUSE	SMALL MOUSE
Overweight	12	13
Underweight	11	13

Relationship of hunger to preferred prey size was apparent with females. During the fall-winter, underweight females predominately chose the large mouse while overweight females chose the small mouse (see Table 3). This difference in the preferred prey size was significant ($X^2 = 5.18$, $P < 0.025$). However, there seemed to be no relationship of hunger to preferred prey size in males ($X^2 = 0.018$, $P > 0.05$) (see Table 4). Average wing chord for 49 males and 90 females was 188 mm and 196 mm, respectively. Wing chord means and variance values did not differ significantly from summer to fall-winter seasons (t-Test, $P > 0.05$; F-test, $P > 0.05$). Average weight was 108 g for males and 122 g for females.

Table 4. The number of overweight and underweight males that chose either the large or small mouse during the fall-winter "season".

	LARGE MOUSE	SMALL MOUSE
Overweight	12	13
Underweight	11	13

Effect of a conspicuous, but odd, color of prey (white mouse) is seen in Table 5. There was no significant difference between male and female selection for color ($X^2 = 0.272$, $P > 0.05$), therefore they were combined. Eighty-two percent of kestrels chose agouti mice. The difference between the actual preference and a random choice was highly significant ($X^2 = 18.85$, $P < 0.005$).

Table 5. The number of males and females that chose either the white or agouti colored mouse during the fall-winter "season". The category "switched mice" denotes that the kestrel attacked one size mouse and then switched and attacked the other.

	WHITE	AGOUTI	SWITCHED MOUSE
Males	4	26	1
Females	12	47	2

Behavior of kestrels toward the trap led me to believe that each bird was preferentially selecting one of the mice. The kestrels exhibited several types of behavior. In one type the bird flew toward the trap and hovered over it for several seconds before attacking one side. In another pattern the kestrel flew to a position over the trap (telephone lines or poles, trees, etc.) and sat examining the trap for some time before attacking. In the third, and most convincing, type of behavior, the bird was not caught on initial attack, flew away, and consistently returned to attack the same mouse. This pattern continued until the kestrel either was caught or gave up. In the last, the bird attacked one side of the trap, then attacked the other or it attacked one side, flew away, and returned to attack the other. This was rare, occurring 6.7% of the time, during fall-winter and was excluded from data analysis.

The results clearly show a preference for size of prey in spring for kestrels. The reasons for this preference are not as clear. The first possible reason was advanced by Storer (1966). He hypothesized that due to sexual size dimorphism, sexes take different size prey serving to reduce competition between them so that the pair can feed in a smaller territory. This may work well when the prey is birds. Young birds (after fledging) are essentially

the same size as adults, so preying on different size birds means preying on different species. This would seem to reduce competition between sexes and increases the number of potential prey. However, in rodent species young are smaller than adults. Preying on different sizes (hence different ages) of the same species would not seem to increase available prey, although it would allow some reduction in competition between sexes. If male and female kestrels prey on different sizes of the same species, the prey population would be reduced as quickly as if both sexes preyed on both sizes equally. This hypothesis should not be quickly discarded, however, as even a subtle avoidance of competition is an advantage.

An alternative is that males chose the smaller mouse because there are simply more small mice at that time of the year. The males may have formed a specific search image (SSI) for smaller mice on the basis of availability. The females, on the other hand, do little hunting for much of the season and may not have a strong SSI formed and thus choose the larger mouse for a larger reward.

Another alternative deals with the energetics of carrying a mouse to the nest cavity. The female does little hunting for most of the breeding season while the male procures food for himself, the female and young. He must carry prey to the nest for distances up to 1 km (Balgooyen 1976). It may be less energetically demanding to carry more small mice to the nest than fewer large mice. The female, on the other hand, hunts infrequently near the nest, and does not have far to carry prey; therefore, it seems most advantageous for her to attack the largest prey possible. Studies of the energetics of flying with varying weights are needed to confirm this hypothesis.

During winter, the males and females are feeding only themselves and would not need to be as selective with the size of prey. The prey does not have to be carried far and both sexes should be able to kill the large category mouse with almost equal skill. Males do not have the same bulk as females, however males do have a lighter wingloading and feet and beaks which are not significantly different in size (Balgooyen 1976). The male should be able to transport prey as easily as the female due to lighter wingloading. The only advantage seems to be that females have more bulk to subdue larger prey. A flaw in this hypothesis is that it would seem most advantageous to prey on the largest mouse because

of the larger gain. This was not, however, indicated by the data. The birds selected a large proportion of small mice in winter. This may be explained by the hunger of the bird. A kestrel that is underweight might be more inclined to attack a larger mouse than a kestrel that is overweight.

The influence of hunger in predation was shown by Mueller and Berger (1970). They trapped Sharp-shinned Hawks (*Accipiter striatus*) in 2 manners. One in which the hawks actually struck lure birds [pigeons, starlings or House Sparrows (*Passer domesticus*)], and the other in which the hawks flew near, but did not attack, and were trapped in a net. Although the data were not statistically significant in all cases, a tendency existed in which lighter hawks actually struck prey more frequently. This suggested to them that hunger influences a hawk's tendency to kill. Mueller (1973) demonstrated the relationship of predatory behavior to hunger in American Kestrels. Kestrels were deprived of food for intervals of 1, 5, 10, 20, 25, 30 or 35 h. In his experiment on deprivation interval to food consumption the curve was almost linear. On the average, kestrels consumed 2% of their body wt after 1 h of deprivation and about 13% after 35 h. In the experiment on deprivation interval to killing tendency the curve was only a little less linear. After 1 h of deprivation kestrels killed mice 14% of the opportunities and 92% after 35 h. Mueller (1973:519) felt that all his data "indicate a complete correlation between food consumption and predatory behavior, suggesting that predation is a direct response to hunger."

In this paper it was assumed that an underweight bird is more hungry than an overweight bird. The effect of hunger is seen in Tables 3 and 4. Table 3 shows the effect of female hunger in which 32 of 48 (67%) of the overweight females chose the large mouse. Table 4 shows this not to be the case with males. There is no difference in preferred prey size from underweight to overweight males. There may be other factors that override the effect of hunger in males. The data for females suggest that hunger influences the selection for prey, which is contrary to Lorenz's (1966) generalization that killing instinct of predators is unitary and driven independently of hunger. However, my study supports the contention of Mueller (1973) and Mueller and Berger (1970) that hunger plays an important role in the tendency to kill.

The results of the white mouse/agouti mouse ex-

periment clearly show a preference for the natural agouti color although there is a definite selection for the odd color (white) at times. This was especially evident when kestrels attacked the white mouse, was not caught, and returned to the same mouse before getting caught. The selection of agouti mice seems to show an SSI for agouti color whereas the selection of white mice may show a tendency of a kestrel to vary its diet (Tinbergen 1960; Mueller 1974). I believe the existence of an SSI is supported by this study, although there appear to be many variables that can alter the SSI. Several authors believe that predators carefully evaluate their chances of success with each prospective prey (Cushing 1939; Errington 1967; Cade 1967). When this evaluation encompasses the SSI, the predator will decide whether to attack or not (e.g., if the mouse is the correct size, color and species but the distance to the prey is too far and the cover is too dense, the bird will not attack).

The selection of odd mice in my experiment is consistent with the results of Mueller (1974:716) in which "some birds showed a tendency to select a reasonably constant proportion of mice of a given color throughout a series regardless of the relative abundance of the mouse, suggesting that the bird seeks a fixed amount of novelty or variety." Mueller contended that in most prey populations odd prey is probably unfit and, therefore, would be actively selected from the environment (see Mueller 1974 for a listing of references to support the contention).

There are inherent problems in any study that attempts to relate an artificial situation to the real world, and this study is no exception. A choice between 2 mouse sizes probably rarely occurs in nature and it seems unlikely that the kestrel would not kill a mouse of the non-preferred size. However, the birds probably have an SSI for a preferred size and when all factors are considered (i.e., distance from prey, visibility of prey, etc.) they are more likely to attack the preferred size than another. This does not mean that either sex will not attack the non-preferred size mouse. The kestrel is an opportunistic predator and will attack anything within certain broad limits. It does mean that they have an SSI for a size prey that they will aggressively pursue over long distances and more adverse conditions than other size prey. Another problem to consider is the activity of the 2 mouse sizes, as Kaufman (1974b) showed that active rats were

preyed upon more than inactive rats. Marti and Hogue (1979) found that small mice may move faster than large mice, but they do not move longer distances in the same time period. If the kestrels preferred a faster (smaller) mouse or a slower (larger) mouse, it would not be expected that they would switch this preference seasonally as is the case in this study.

A third potential problem is with fall-winter data which dealt with hunger in females where 2 populations of females were sampled (migratory and non-migratory). Although wing chord analysis showed no difference in the size of these 2 populations, it may be that migratory females are, on the average, lighter in wt than non-migratory females. Migratory females may have a previous SSI formed for large mice. This would bias the data toward the results achieved based on hunger. In the fall-winter data, part of the population were immature birds which were not distinguished from adults. Mueller and Berger (1970) showed that inexperienced raptors tend to take inappropriate prey. However, I have a strong feeling that by winter young birds have formed an SSI.

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First Received 24 December 1983; Accepted 1 December 1984

HABITAT SELECTION BY THE AMERICAN KESTREL (*Falco sparverius*) AND RED-TAILED HAWK (*Buteo jamaicensis*) WINTERING IN MADISON COUNTY, KENTUCKY

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ABSTRACT - Habitat selection by the American Kestrel (*Falco sparverius*) and Red-tailed Hawk (*Buteo jamaicensis*) in Madison County, Kentucky, was determined for the winter of 1980-81. Results showed that there was significant non-random use of 6 habitat types (Kestrels: $\chi^2 = 629.5$, P < 0.05, d.f. = 5; Red-tailed Hawks: $\chi^2 = 124.8$, P < 0.05, d.f. = 5) with old field sites being used most frequently by both species.

The American Kestrel (*Falco sparverius*) and Red-tailed Hawk (*Buteo jamaicensis*) are the most numerous diurnal raptors wintering in Madison County (Sferra 1984). Mengel (1965) reported that, in Kentucky, kestrels preferred open areas. Along highways in West Virginia, kestrels most often hunted in pasturelands, or open areas planted with *Lespedeza* spp. (Ferris 1974). However, near highways in the Texas panhandle, kestrels frequented wooded areas (Allan and Sime 1943).

Red-tailed Hawks were most commonly associated with woodlots in Iowa and the Texas panhandle (Allan and Sime 1943; Weller 1964). Petersen (1979) reported that Red-tailed Hawks seldom used internal portions of woodlots, supporting Schnell's (1968) observation that the species preferred perching at woodlot edges. In Michigan, open areas were heavily utilized (Craighead and Craighead 1956), lone trees being favored as perch sites (Chamberlain 1974).

High winter densities of these raptors in Madison County (Sferra 1984) may result from the amount of open habitat available for hunting, as well as the presence of adjacent, heterogeneous edge habitat. Many open areas are bordered by fencerows of trees or are bisected by power lines, providing perching sites from which hawks can search for prey. The purpose of the present study was to determine the relative extent to which wintering kestrels and Red-tailed Hawks frequented various habitats found in Madison County.

STUDY AREA AND METHODS

Madison County encompasses parts of 4 physiographic regions in central Kentucky: the Hills of the Bluegrass, the Outer Bluegrass, the Knobs Section of the Cumberland Plateau, and the Mountains (Soil Conservation Service 1973). Terrain ranges from rolling, upland plains to long, narrow ridge tops separated by steep valleys with the maximum relief being 335 m (Jillson 1928). Madison County is composed predominantly of pastureland and hayfields with forest stands being confined mainly to stream margins, field edges, and rugged regions of the Cumberland Plateau and Mountains.

Birds were located by means of an automobile road count (Craighead and Craighead 1956) covering secondary roads of the county. The count routes were chosen so that each of the physiographic regions in the county were represented. One road count was run weekly from late December 1980 to March 1981 for a total of 10 counts. Each covered the same 235 km and were not run when visibility was hampered by snow, fog, or rain. A driver/observer and passenger/observer were present during each census. Routes were driven at speeds between 32-48 kph, and all raptor sightings on both sides of the road were recorded. The maximum distance of sightings on each side of the road was approximately 440 m.

Habitats directly beneath raptors in flight, and areas overlooked by perched birds formed the basis for determining species-specific habitat utilization. Six habitat categories were distinguished: pastureland (both grazed pasture and mowed hayfields), cropland, urban areas, old fields, woodlots and plowed fields. Actual habitat use was tested against their relative occurrence. Proportion of occurrence was quantified from randomly selected aerial photographs representing 10% of the entire county.

RESULTS AND DISCUSSION

The six habitat types occurred in the following proportions: 57% pastureland and hayfields, 33% woodlots, 3% cropland, 3% urban areas, 2% old fields and 2% plowed fields. Kestrels and Red-tailed Hawks utilized certain habitats to a greater extent than that predicted by their relative availability. Chi-square (χ^2) tests showed significant non-random habitat use by kestrels and Red-tailed Hawks wintering in Madison County (Table 1).

Table 1. Results of Chi-square (χ^2) analysis of habitat selection and utilization based on habitat availability in Madison county.

SPECIES	χ^2
American Kestrel	629.5 ^a
Red-tailed Hawk	124.8 ^a

^aP < 0.05; d.f. = 5

Table 2. Total number of American Kestrel and Red-tailed Hawk sightings and % deviation from expected Chi-square values for their occurrence in each of 6 habitat types. A positive sign indicates habitat use greater than expected and a negative sign indicates use less than expected.

HABITAT	AMERICAN KESTRELS		RED-TAILED HAWK	
	N	% DEVIATION	N	% DEVIATION
Pastureland	276	+ 38	117	+ 28
Old Field	66	+790	21	+525
Cropland	15	+ 76	1	- 59
Plowed Fields	5	- 31	1	- 70
Woodlots	3	- 98	28	- 65
Urban Areas	0	-100	0	-100

Kestrels habitat use was as follows: pastureland 76.9%, old field 18.4%, cropland (consisting mainly of corn stubble) 4.2%, plowed field 1.4%, woodlots 0.8% and urban areas 0%. Percent deviations from expected values of the chi-square test showed that kestrels utilized woodlots and urban areas less, and all other habitats more than expected. Selection of old fields was most pronounced (Table 2).

The nature and distribution of perching sites in a given surveyed area probably introduced bias into road count data. In the Texas panhandle, for instance, frequent utilization of woodlots by kestrels (Allan and Sime 1943) could have been directly related to lack of perching sites in open habitat. In Madison County, the majority of kestrels were seen perching on utility lines, many of which run parallel to the census route. On the other hand, birds hidden behind trees, buildings and signs may have resulted in low utilization estimates for woodlot and urban area use.

Winter habitat separation by sexes has been reported as common among kestrels in Texas, California, Arizona, Mexico (Mills 1976; Koplin 1973) and Georgia (Stinson et al. 1981). Chi-square test showed male kestrels were significantly more numerous than females (58% males, $P < 0.05$). However, sex-specific differences in habitat were not significant in Madison County ($P < 0.05$).

Habitat selection by Red-tailed Hawks was as follows: pastureland 69.9%, woodlots 16.7%, old field 12.5%, cropland 0.6%, plowed fields and urban areas 0%. Use of pastureland and old field sites was greater than expected; all other habitats

were frequented less than expected (Table 2). The majority of Red-tailed Hawks associated with woodlots were perched along margins overlooking open areas. Similarly, Petersen (1979), using a road count in Wisconsin, found that internal portions of woodlots were seldom used.

Of all habitat types, old field site use by hawks deviated the most from the expected values. Selection for old field sites by kestrels, and to a lesser degree by Red-tailed Hawks, may have been induced by higher prey populations, specifically Meadow Vole (*Microtus pennsylvanicus*). Austing (1964) found Meadow Voles to be staple prey for Red-tailed Hawks during winter months, and vole population density has been suggested as the major factor determining hawk distribution (Bart 1977). Kestrels also depend heavily upon Meadow Voles during winter (Craighead and Craighead 1956). In Madison County, matted vegetation used by voles for runways will not accumulate on intensively grazed pastureland and mowed hayfields, resulting in decreased population density. Old field sites, based on presumed prey density, have the greatest potential for supporting large numbers of wintering kestrels and Red-tailed Hawks.

Acknowledgments

Special thanks are extended to those who helped in obtaining field data: R. Altman, G. Barels, P. Mastrangelo, G. Murphy, J. Schafer, C. Schuler, T. Towles, and especially J. Colburn.

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Received 15 July 1984; Accepted 30 January 1985

SHORT COMMUNICATIONS

A Clutch Of Unusually Small Peregrine Falcon Eggs

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Unusually small (dwarf or runt) eggs are rare, occurring at a frequency of 0.05-0.09% in the Domestic Chicken (*Gallus gallus*) (Romanoff and Romanoff 1949), 0.08% in the Common Grackle (*Quiscalus quiscula*), and 0.18% in the Red-winged Blackbird (*Agelaius phoeniceus*) (Rothstein 1973). More than one small egg in a clutch is even rarer. Pearl and Curtis (1916 cited in Romanoff and Romanoff 1949) found only 11% of chickens that laid any small eggs laid more than one, i.e. about 0.0055-0.0099% over all.

Small Peregrine Falcon (*Falco peregrinus*) eggs, here defined as those less than 40 ml in estimated volume, are also rare (Table 1). Although accurate frequency data from the wild are not readily available, Burnham (pers. comm.) found only 1 small egg in about 350 (0.3%) he has handled. Most small eggs occur as runts, an odd egg in an otherwise normal clutch (Ratcliffe 1980). The 2 eggs of the clutch described here are smaller than any noted in the literature for North American peregrines. That both eggs were small suggests a "normal" egg size for this female rather than odd eggs. I found the clutch in a Sonoran eyrie on 8 May 1981. This site was first known to be occupied in 1978 when an adult was seen there in mid-March. A pair of adults vigorously defended this area in late April of 1980, but the exact eyrie location was not found. The eyrie site used in 1981 was a small cave (ca. 2 X 2 X 2 m in size and hemi-conical in shape) near the top of an igneous cliff. There were 2 eggs in a scrape near the back wall of the cave. The eggs were cool to the touch and their contents sloshed when gently shaken, indicating they were addled. On 8 May successful eyries in this area should have contained nestlings, as had 10 other eyries previously visited. The estimated mean hatching date for Gulf of California peregrines is 12 April (n=31), the latest known hatching date is 15 May (Porter et al. in prep.).

I measured the 2 eggs with a caliper having a Vernier scale marked in increments of 0.1 mm; the results are given in Table 1 as eggs A and B. Table 1 also compares the size of these 2 eggs with some published dimensions of small and average-sized Peregrine Falcon eggs.

Several factors have been given as causes for abnormally small bird eggs. Chickens may occasionally lay yolkless eggs which weigh only a few grams (Romanoff and Romanoff 1949). The only known yolkless peregrine egg from the wild, also from the Gulf of California, was noted by Risebrough (1971). This egg was small but its dimensions were not given. In captivity, yolkless eggs occur about once in 300 eggs; one measured 33.2 X 25.0 mm

(Burnham pers. comm.). The sizes of eggs laid by individual peregrines may also vary with age; small eggs are produced by young females laying for the first time (Blair 1967) but also by old females (Ratcliffe 1980). The eggs of one female reported by Ratcliffe (1980) from Britain decreased in size in an 8-y period from almost normal eggs averaging 50.0 X 39.5 mm (39.7 ml) to the smallest recorded size of 4 eggs averaging 46.5 X 32.5 mm (25.0 ml).

Racial differences in egg size occur but are not great (Brown and Amadon 1968). The small-bodied subspecies *babylonicus* (considered by some to be a separate species) has the smallest mean egg size according to Brown and Amadon (1968) and is similar in body and egg size to the small *F. p. minor* (Table 1). Egg size variation due to racial differences are probably related to female body weight differences. Romanoff and Romanoff (1949) state that the smallest chicken eggs are produced by the lightest females.

The first egg of a cycle (clutch) in the chicken is generally the heaviest, decreasing thereafter (Romanoff and Romanoff 1949). Physical condition, nutrition, and climatic conditions can also affect egg size (Romanoff and Romanoff 1949).

Olsen (1982) found that peregrine egg size increased with increasing latitude (in the southern hemisphere), use of tree hollows as nests, and decreasing temperatures. These relationships disappeared in certain areas after the 1940s, a period corresponding with the introduction of DDT and intensification of land use. Olsen (1982) found no significant difference in egg size between the first and replacement clutches from the same nest site, nor any correlation between clutch size and egg size.

Some of the above causes of small eggs can be eliminated as factors in the Gulf of California clutch. The female defending the nest was seen clearly at close range and was in full adult plumage with no immature feathers remaining. She probably was at least in her third calendar year of life and had probably laid other clutches. However, it is possible that she was a very old female. Racial differences in egg size can be eliminated because the eggs of this clutch are far smaller (ca. 35% less in estimated volume) than average eggs of the small subspecies *F. p. babylonicus*. The order of laying was not a factor because both eggs were unusually small. Whether or not the eggs were yolkless is not known, but it is unlikely that 2 such eggs would occur together. The effects of low latitude and warm temperatures as found by Olsen (1982), could be

Table 1. Dimensions of Peregrine Falcon eggs. Maximum length (L) and breadth (B) are in mm; estimated volume (V) was calculated according to Hoyt (1979) and is in ml.

LOCALITY	SMALL EGGS ^A OR MINIMUM MEASUREMENTS ^B			AVERAGE-SIZED EGGS			REFERENCE	
	N	L	B	V	N	L	B	V
<i>F.p. anatum:</i>								
Sonora (A)	1	44.2	34.3	26.5				This paper.
Sonora (B)	1	44.4	34.8	27.4				This paper.
Gulf of California					2	52.0	41.8	46.2
Baja California	2 ^C	49.4	39.2	38.6	17 ^C	53.2	41.3	46.2
North America	124 ^b	46.5	37.6	33.5	124	52.8	41.1	45.4
North America	1	48.5	38.5	36.6	61	52.0	41.0	44.5
<i>F.p. peregrinus:</i>								
Britain	3	48.6	37.2	34.2				Blair 1967.
Britain	1	46.0	38.2	34.2	100	51.8	41.0	44.3
Britain	4	46.5	32.5	25.0	2,253	51.5	40.8	43.6
Britain	1	32.2	27.3	12.2				Ratcliffe 1980.
Germany, Poland	165 ^b	46.2	39.1	36.0	165	51.5	40.5	43.0
<i>F.p. calidus:</i>								
Eurasian tundra	202 ^b	46.0	37.0	32.1	202	53.0	42.0	47.6
<i>F.p. babylonius:</i>								
Asian steppes, deserts								
<i>F.p. minor:</i>								
Africa south of Sahara	47.9	38.0	35.2		50.6	40.2	41.6	Brown and Amadon 1968.

^aSmall eggs are those less than 40 ml in estimated volume.

^bSome authors reported ranges of egg measurements. In these instances I used the smallest dimensions given even though the length and breadth may not have been from the same egg; here n = the total sample size.

^cMeasurements are of one egg each from 19 clutches.

important because the eyrie is near the southern limit of peregrine distribution for the northern hemisphere, and is in an area that has mild temperatures during the time peregrines nest. Nevertheless, it is unlikely that even both of these effects in combination could produce such a large reduction from the average.

Thanks are due to M.A. Bogan, W.A. Burnham, L.F. Kiff, R.L. Phillips, R.D. Porter, and D.Q. Thompson for review and suggestions on an earlier draft of the manuscript. S. Sumida measured eggs from Baja California, Mexico, in the Western Foundation of Vertebrate Zoology collection. The 1981 field work would not have been possible without the cooperation and help of R. A. Graham, R.S. Ogilvie, J.R. Swift, and Alfonso de Anda T. of the Dirección General de Fauna Silvestre of Mexico.

ADDENDUM

An additional record of a small peregrine egg was recently brought to my attention. Charles Bendire (Smith. Inst. Spec. Bull. No. 1, 1892) noted an egg with dimensions of 38.5 mm x 30 mm (L x B). This egg is smaller than any I could find recorded, but it was a single example (a runt) and not a clutch as in the case of the Sonoran eggs.

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Received 20 February 1983; Accepted 28 April 1984

Eyrie Aspect as a Compensator for Ambient Temperature Fluctuations: A Preliminary Investigation

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Raptor ecologists have long recognized that nest site characteristics may influence reproductive success for many birds of prey (Olendorff 1973; Porter and White 1973; Ogden and Hornocker 1977). However, few studies have demonstrated relationships between nest site characteristics and physical factors that may provide energetic or reproductive advantages.

It has been suggested that the Prairie Falcon (*Falco mexicanus*) prefers nest sites with a southerly exposure (Enderson 1964; Olendorff 1973; Porter and White 1973; Denton 1975; Ogden and Hornocker 1977). Additionally,

Leady (1972) and Williams (1981) noted a component of easterly-facing eyries. McGahan (1968) speculated that an easterly eyrie aspect in Golden Eagle (*Aquila chrysaetos*) in Montana may negate early morning chill and temper afternoon heat, however, he did not test this prediction.

In 1980, I studied the reproductive phenology of a local population of Prairie Falcons nesting at high elevations ($\bar{x} = 2720 \pm 199$ m) in central Colorado (Williams 1981). Of the 14 eyries examined, 7 had east or southeasterly aspects between 93-165°. I initiated a preliminary investigation using one of these eyries to estimate the relationship bet-

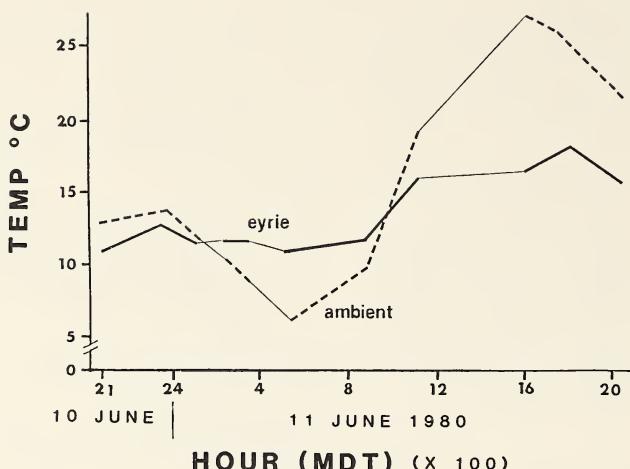


Figure 1. Eyrie and ambient temperatures for eyrie No. 2, 10-11 June 1980. Solid line denotes eyrie temp. Dashed line denotes ambient temp. Thin lines represent time periods when data were not collected.

between eyrie aspect, eyrie temperature and ambient temperature.

I collected eyrie and ambient temperatures over a 23 h period (2100 H MDT 10 June 1980 - 2000 H MDT 11 June 1980) from eyrie No. 2 (Williams 1981) in North Park, Colorado (eyrie aspect = 95°, cliff aspect = 80°, elevation = 2650 m). Temperatures were recorded using a Yellow Springs Thermistor Unit with wire temperature probes. Eyrie temp was monitored via a wire probe taped to the rear wall of the eyrie. The probe was in the shade at all times, placed 0.4 m above and behind the nestlings in the center rear portion of the eyrie. I do not believe the probe was close enough to the nestlings to have been influenced by their metabolic heat. The nestlings were 16 d old at this time. Ambient temperatures were collected in the shade at the cliff base. Temp was recorded at 15 min intervals from a secluded spot 30 m from the eyrie where my presence seemed to have no affect on the behavior of the adult birds. Weather during the 23 h period was clear with winds between 12-18 kph.

Minimum and maximum eyrie and ambient temp and ranges during the study period are shown in Figure 1. Eyrie temp was higher than ambient temp from 0100-0930 H, whereas ambient temp was higher than eyrie temp from 2115-0100 H and 0930-2000 H. Paired t-Tests were used to compare ambient temps higher and lower than eyrie temps. Both tests were significant: higher ($t = 7.07, df 31, P < 0.01$) and lower ($t = 10.9, df 17, P < 0.01$).

Ambient temp fluctuated 21.2° C, whereas eyrie temp fluctuated only 7.4° C during the 23 h sampling period (Fig. 1), suggesting that a microclimate exists within easterly-facing eyries which buffers nestlings from ambient temp extremes. This buffering is most readily seen where early morning and late afternoon ambient temps

varied greatly from eyrie temp. Eyrie and ambient temps were equal (13°C) at 1000 H. Eyrie temp increased only 4° C during the next 8 hours, whereas, ambient temp increased 14° C. Platt (1974) noticed a 5-8° C difference between ambient and eyrie temperatures, with the eyrie invariably cooler during the hottest time period of the day. Clayton M. White (pers. comm.) also noted clear differences between ambient and cliffside temperatures while entering Gyrfalcon (*Falco rusticolus*) and Peregrine Falcon (*Falco peregrinus*) eyries in Alaska.

In the cold climates of both Alaska and high elevation Colorado, environmental temperature fluctuations are apparently ameliorated by the action of solar radiation falling on the cliff surface. The cliff functions as a heat sink during the day, slowly absorbing heat from solar radiation and serves as a heat source at night, slowly losing the absorbed heat to the cooler night air. This keeps the cliff-face warmer than the minimum ambient temp at night and cooler than the maximum ambient temp during the day. Nesting falcons were able to utilize the moderated environment to initiate reproductive activities (courtship and egg-laying) while ambient conditions were still quite harsh. In both Alaska (C.M. White pers. comm.) and Colorado (Williams 1981), this was necessary so that nestling phenology was timed with peak abundances of prey species.

The relatively moderate microclimate of eyries should enhance nesting success. Adult falcons can devote less time to brooding and shading of young during daylight hours, thereby providing increased time for predator detection, eyrie defense and hunting. Increased prey deliveries would greatly benefit the youngest nestlings, who often do not survive the nestling period during times of food shortage. All of these factors could increase the

probability of nesting success and the number of young fledged by reducing nestling mortality.

Further studies are needed to define the role of eyrie aspect in nest site selection by Prairie Falcons. Data on eyrie and ambient temperatures from the courtship to fledging phases of nesting phenology should be collected from north, south, west, and east facing eyries across a spectrum of elevational and latitudinal locations. Such information could be coupled with existing data on nest site selection and productivity to identify general trends (and local patterns) in nest site selection of Prairie Falcons throughout their breeding range.

ACKNOWLEDGMENTS

I would like to thank C.M. White and J.R. Parrish for their input and encouragement during the preparation of this manuscript. Financial assistance was provided by the Frank M. Chapman Memorial Fund and the Colorado Division of Wildlife through Federal Aid in Wildlife Restoration Project W-124-R.

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Received 1 November 1984; Accepted 15 December 1984

Successful Breeding of a Pair of Sharp-shinned Hawks in Immature Plumage

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Adult plumage in *Accipiter* is usually acquired during an individual's second summer (1 year after hatching). Since this molt is not completed until the following fall, nesting accipiters can be easily identified as immature (yearling) or adult (2 or more years) on the basis of plumage. Although Bent (1937) stated that each of the three North American *Accipiter* species may breed as yearlings, published accounts of such breeding, particularly of yearling males, are uncommon. In the Northern Goshawk (*A. gentilis atricapillus*) and the Cooper's Hawk (*A. cooperii*), yearling females are known to occasionally pair with adult males and breed (Meng 1951; McGowan 1975; Reynolds and Wight 1978). I could find no published account of such pairing in the Sharp-shinned Hawk (*A. striatus*). However, K. Tuttle (pers. comm.) observed this at 1 of 26 nests found in Utah and Idaho during the 19-y period 1963-1981, and C.M. White (pers. comm.) saw this at another Utah nest in 1963. Breeding by yearling males is apparently a rare event. Two cases each of breeding by yearling male Cooper's Hawk (Kline 1975; Rosenfield and Wilde 1982) and European Goshawk (*A.g. gentilis*) (Glutz

von Blotzheim 1971) have been reported. R. Rosenfield (pers. comm.) has recently observed this at 2 additional Cooper's Hawk nests. To my knowledge, breeding by yearling male Sharp-shinned Hawks has not been documented. K. Tuttle (pers. comm.) observed this in 1973 at a Utah nest site at which an adult male had been shot and killed the previous year. This note documents the successful breeding of a pair of Sharp-shinned Hawks, both in immature plumage.

On 23 May 1983, while searching for nests as part of a breeding ecology study of accipiters in central Utah, I encountered an immature female Sharp-shinned Hawk in what later proved to be the nest stand. The male was first observed on 3 June and appeared virtually identical to the female in plumage and eye color. It was easily separable by its smaller size and higher pitched call.

The nest stand was at an elevation of @ 2000 m on a gentle, north-facing slope in the Uinta National Forest, 8 km northeast of Provo, Utah County. A partially constructed nest was found during the initial observation of the female. The nest was located 4 m above ground near

the trunk of a small white fir (*Abies concolor*) within a stand dominated by bigtooth maple (*Acer grandidentatum*) and Gambel oak (*Quercus gambelii*). No old nests were found in the stand. On 7 June the nest contained 3 eggs. All eggs hatched, but 1 chick disappeared the first wk after hatching. The 2 remaining young fledged by 15 August and were last seen in the nest stand on 23 August.

During incubation the female could be approached to within 3 m and could have been hand-netted on numerous occasions. With the exception of this extreme tolerance of the female to close approach, the behavior of the pair was similar to neighboring pairs. The immature female noted by White in 1963 could be touched while on the nest incubating.

Newton et al. (1981) reported that in a relatively stable population of the European Sparrowhawk (*A. nisus*), yearlings formed 17% of the breeding males and 16% of the breeding females. In *A. striatus* and *A. cooperii*, yearlings (especially males) appear to comprise a much smaller proportion of the breeding population than in *A. nisus*, though the reasons for this are not clear. Meng (1951), Hennessy (1978) and Reynolds and Wight (1978) reported that yearlings formed 6% (N=36), 20% (N = 15) and 6% (N = 34), respectively, of breeding females of Cooper's Hawk populations in New York, Utah and Oregon. Though males were not observed at every nest, all seen by these authors were adult. On the basis of examination of testes of 10 immature male Goshawks, Hoglund (1964) concluded that immature males are normally incapable of breeding. This may also be true of yearling males in *A. cooperii* and *A. striatus*, but to my knowledge, has not been studied. Reynolds (1972) discussed the general lack of nesting by yearling male Goshawks, Coopers Hawks and Sharp-shinned Hawks and hypothesized that since males are the principal food providers during the nesting season, foraging experience may be a prerequisite for successful nesting. Reynolds and Wight (1978) suggested that an immature male, lacking experience, may be subject to greater risk of predation or accident while foraging, and therefore, deferring the age of first breeding may increase its future fitness. A concomitant of deferred breeding is delayed sexual maturity. However, a similar argument should apply to the ecologically similar *A. nisus*, yet considerable numbers of European Sparrowhawks, and at least as many males as females, breed successfully their first year (Newton et al. 1981). Furthermore, the relatively larger proportion of yearling breeders is found in both stable and recovering populations, though it may be accentuated in the latter (Newton, pers. comm.). The breeding biology of the closely related Sharp-shinned Hawk has not been intensely studied, and breeding by yearlings, including males, may not be as rare as might be concluded from existing observations.

I thank R.L. Yergensen and K. Ellis for assistance in the field and Robert Redford and Brigham Young University for financial support. K. Tuttle, R. Rosenfield and I.

Newton graciously provided unpublished data. J.R. Murphy, C.M. White, R.T. Reynolds, R. Fitzner and D.H. Ellis reviewed the manuscript.

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Received 28 September 1984; Accepted 1 October 1984

Aegyptius Monachus Carrying Food In Its Claws

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On 24 September 1983, while taking a census of the Black Vulture (*Aegyptius monachus*) on the island of Mallorca (Balearic Islands) for ICONA (Ministerio de Agricultura), we observed an adult of this species flying with a relatively large, whitish object in its claws. The bird approached our observatory (Alfabia, 1,067 m above sea level) following the area's mountain crests at a height of approximately 30 - 50 m above the terrain. We could not determine where it came from — possibly from far away. After observing its flight — straight — for about 5 min, we saw it land on a rocky promontory 500 m from our position. It began to peck at the object in its claws. With the aid of binoculars (8 & 9x) we confirmed the fact that the bird was eating. With almost complete certainty the vulture had transported a part of a sheep (*Ovis aries*) which constitutes its basic diet on the island (70% according to Mayol (*Soc. Hist. Nat. Bal.*, 22:150-178, 1976.))

Our observation is of ethological interest, since no author cites this bird's ability to carry food in its claws (Bernis *Ardeola*, 12:45-99, 1966), Valverde (*Ardeola*, 12:101-115, 1966), Cramp and Simpson (Handbook of the Birds of Europe, the Middle East and North Africa, Vol II, Hawks to Bustards, R.S.P.B., Oxford University Press, 1980)). We must nevertheless mention the observation of Hiraldo (*Donana acta vertebrata* 3(1):19-31, 1976) referring to a Black Vulture presumably capturing a lizard (*Lacerta* sp.). These observations confirm the fact that the Black Vulture,

the only species of Palearctic vulture known to us to have this behavior, maintains the grasping capacity of its claws to a greater extent than other species of the group.

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Received 20 August, 1984; Accepted 1 September 1984

THESIS ABSTRACTS

Ecology of Breeding Burrowing Owls in the Columbia Basin, Oregon

The ecology of breeding Burrowing Owl (*Athene cunicularia*) was studied in northcentral Oregon during the spring and summer of 1980 and 1981. Pairs began arriving on the study areas as early as the first week of March; however, most arrivals were during April. Egg-laying began the first week of April and continued into the first week of May. Whole family groups left the nesting areas as early as the first week in July while members of other families remained until at least the end of September.

Nest success was 57% for 63 nests in 1980 and 50% for 76 nests in 1981. Desertion was the major reason for nest failure and may have been related to the proximity of other nesting pairs. Badgers (*Taxidea taxus*) were the major nest predators. Nests which were lined with cow or horse dung were significantly less prone to predation than nests not lined, suggesting dung masks odors of nest occupants.

Diets were determined by pellet analysis. Arthropods comprised 91.6% of the total prey by number; however, they contributed only 22.0% of the total biomass. Vertebrates, mostly small mammals, comprised the balance. *Perognathus parvus* (Great Basin Pocket Mouse) was the most important vertebrate prey and *Stenopelmatus fuscus* (Jerusalem Cricket; *Gryllacrididae*) was the most important arthropod. Coleoptera were preyed upon very heavily, but they were dominated by very small (< 10 mg) beetles and, therefore, contributed little to the total biomass. Burrowing Owls preyed on mammals during the spring then shifted to insects during the summer. Burrowing Owl diets were influenced by soil type, and owls selected mammals in proportion to their occurrence in the environment.

Burrowing Owls selected 3 of 5 habitats for nesting. Hole availability and possibly food availability as important prerequisites function analysis indicated variables responding to horizontal visibility and possibly food availability as important prerequisites for nest selection. Soil texture greatly influenced re-use and longevity of nest burrows. — Green, Gregory A. 1983. M.S. thesis, Oregon State Univ., Corvallis.

Reproductive Ecology and Habitat Utilization of Richardson's Merlins in Southeastern Montana

Reproductive ecology, food habits, habitat utilization, and eggshell quality of Richardson's Merlin (*Falco columbarius richardsonii*) in southeastern Montana were examined. Breeding activity spanned five months. Clutch size, brood size, and fledging success at active nests were similar ($P > 0.05\%$) among four years. Birds comprised >90% of individual prey items, and 61% of avian prey species were typically associated with predominantly open habitats. Horned Lark (*Eremophila alpestris*), Lark Bunting (*Calamospiza melanocorys*), and Vesper Sparrow (*Pooecetes gramineus*) collectively comprised 57% of all prey. Home ranges of three breeding male Merlins encompassed approximately 13, 23, and 28 km², and each male traveled a maximum of 8 to 9 km from his nest. These home ranges encompassed five physiognomic habitat types. Percentages of total observations by habitat type indicated greatest use of sagebrush and grassland habitats. Sagebrush, riparian, and ponderosa pine habitats were used more ($P < 0.05$) than expected, but grassland and agriculture habitats received less ($P < 0.05$) use than expected. Comparisons of Montana eggshells with pre-pesticide (pre-1946) eggshells indicated 12% and 20% reductions in eggshell weight and eggshell thickness indices, respectively. These reductions were significant ($P <$). Seven organochlorine compounds were detected in eggs collected on the study area. The overall management goal should be maintenance of a viable Merlin population and the habitat features essential for its continued existence. Management recommendations include limitation of alteration of ponderosa pine sideslope habitat, restriction of activities from 10 March through 20 July, rescheduling of activities, establishment of 400 m zones of no disturbance surrounding nests, limiting loss of prairie habitat and sagebrush removal, limiting use of organochlorine compounds, reviewing potential impacts of activities prior to their occurrence, and maintaining confidentiality of nest locations. — Becker, Dale M. 1984. M.S. Thesis, University of Montana, Missoula.

THE RAPTOR RESEARCH FOUNDATION, INC., YEAR-END REPORT

This was another year of firsts! We broke the 700 member number for starters and, for the first time distributed a comprehensive Membership Directory (named "The Kettle", of course). Dick Clark and his crew did an especially good job on that directory and we thank them for their efforts above and beyond the call of duty. As usual, the annual meeting (in Blacksburg, Virginia, this year) was the highlight of the year's activities. Roughly 300 raptor enthusiasts attended a very well-organized and smoothly-run conference held at the Donaldson Brown Center for Continuing Education at the Virginia Polytechnic Institute and State University. Papers ranged from topics on Condors to Screech Owls and the workshops provided valuable hands-on technique experience, e.g. transmitter attachment to eagles, etc.

The banquet was well-attended and lots of fun, with full credit going to Jim Fraser and his fellow organizers. A special thanks goes to Jim's wife for the music and dancing of an Appalachian fiddle-plucking and boot-stomping ensemble. The Andersen Award for Best Student Paper, again, went to the east Canadians working out of McGill University. Reed Bowman won the honor this year for his presentation of his M.Sc. results entitled "Behavior of Widow and Replacement Mates in Wild American Kestrels." Congratulations also go to the runners-up, Andre Lavigne ("Growth of Nestling Kestrels in Relation to Dietary Facts") and Nicole Vanderheyden ("Investigations into the Hematology of Captive American Kestrels"). And no, their major Professor, David Bird, wasn't on the selection committee!

Next year's RRF conference to be held in Sacramento, California promises to be one of the biggest ever. But don't let the length of the conference scare you. The program has been arranged in such a way as to allow participants to pick and choose the various symposia and meetings of particular interest. Frankly, sunny California at that time of year, i.e. November 2 - 10, 1985, is enough to entice most folks for the duration. It promises to be a momentous occasion in raptor conservation history. For more information, write to: Dr. Richard R. Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825.

The Conference Guidelines Committee composed of Toni and Dave Bird, myself, Ed and Judy Henckel, Butch Olendorff, Nancy Venizelous and Jim Fraser has been very active in promoting excellence in RRF meeting organizational efforts. A manual and questionnaire on this subject are now in rough draft format and we are very interested in your comments. Please send them to Dr. Bird (at Macdonald Raptor Research Centre, Macdonald Campus of McGill University, 21,111 Lakeshore Road, Ste-Anne-de-Bellevue, Quebec H9X 1CO). I am pleased to announce that the 1986 RRF meeting will be in Gainesville, Florida, under the direction of Dr. Michael Collopy. We are now looking for bids for the 1987 conference from places located in either the mid-west or far west. Applicants will need: a central meeting place capable of housing roughly 500 participants; easy access to major transportation centers, and; a good pool of hard-working volunteers. Send your bid to Dr. Bird at the above address.

One of the topics of intense discussions, especially among Board members was the journal, both as to format and timing. Specific changes have been implemented, including the formation of a working committee of associate editors, which will help with the manuscript review process. I am confident that by early 1985, *Raptor Research* will be going out on time. Furthermore, I personally like the new professional format, thanks to the efforts of our volunteer editor, Dr. Clayton White and his part-time Assistant Editor, Jimmie Parrish.

I am more than pleased to tell you that RRF memberships have reached 770, our highest ever, with more and more international members joining us each year. It is not just the journal publication you support with your annual dues, but also a strong voice in raptor conservation, encouragement of young scientists to pursue excellence in raptor research and management, and the establishment of research grants and awards for dedication to raptor conservation. Most important, your involvement supports a solid network of diverse individuals and organizations with identical objectives in mind and heart. Let's shoot for a thousand members for the end of 1985. Join (or rejoin) our swelling ranks!

As an update on Directors and Officers, the Board decided to keep me around for another year, as your President. Sadly, we could not cajole our hard-working, devoted Secretary for the past two years, Ed Henckel, to renew his post, but happily for RRF, Jim Fraser has consented to take on this tedious task. The results of your ballots are in: Jim Mosher and Martin Böttcher remain in their positions of Eastern and International Directors, respectively, and Rich Howard won his bid for the At-Large #3 Director's slot. Congratulations to all and a hearty thanks to our outgoing At-Large Director, Mark Fuller, for a job well-done and his encouragement for "new blood" in the organization.

Warmest wishes for success in the new year. See you in Sacramento next fall!

Jeff Lincer
PRESIDENT

MEMBERSHIP RECOGNITION

The Raptor Research Foundation, Inc., expresses sincere appreciation to the following individuals for their continued support of the Foundation and its objectives.

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THE RAPTOR RESEARCH FOUNDATION CONFERENCE — NOVEMBER 1985. The 1985 Raptor Research Foundation International Meeting and Symposium on the Management of Birds of Prey will be held at the capital Plaza Holiday Inn in Sacramento, California, November 2 - 10, 1985. Highlights of this 20th anniversary meeting of the Foundation will include 1) the Second RRF Conference on Raptor Conservation Techniques — Twelve Years of Progress, 1973-1985, 2) a Western Hemisphere Meeting of the World Working Group on Birds of Prey (ICBP), 3) the Second International Vulture Symposium, 4) a Western North America Osprey Symposium, 5) a Workshop on North American Candidate Endangered Raptors, 6) an International Symposium on Raptor Reintroduction, and 7) a Symposium on Raptor Rehabilitation, Captive Breeding and Public Education. For more information contact Dr. Richard R. Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825, or Nancy Venizelous, San Francisco Zoological Society, Stoat Boulevard at the Pacific Ocean, San Francisco, California 94132.

Reviewers for *Raptor Research*, 1984

The subject matter of manuscripts received for publication in *Raptor Research* is very diverse. Numerous individuals throughout the year have generously given of their time and expertise by acting as reviewers for manuscripts submitted for publication. The Editorial Staff expresses its sincere appreciation to the individuals listed below, who, through their efforts as reviewers, have helped to raise the standards and quality of the journal. Those individuals who have contributed reviews of two or more manuscripts are indicated by an asterisk.

David M. Bird*, Douglas A. Boyce, Tom J. Cade*, Richard Clark*, William S. Clark, Michael W. Collopy, Gary E. Duke*, James H. Enderson*, Philip K. Ensley*, David L. Fischer, Glen A. Fox, Mark R. Fuller*, James A. Gessaman, Frances Hamerstrom, Frederick Hamerstrom*, Al Harmata*, Steve Herman, Jerome A. Jackson, James R. Karr*, Lloyd Kiff, Michael N. Kochert*, Carl Marti*, David P. Mindell, James A. Mosher*, Helmut C. Mueller*, Joseph R. Murphy, Richard R. Olendorff*, Lynn W. Oliphant*, David B. Peakall, David T. Rogers, Jr., Steve K. Sherrod*, Joseph K. Scheiring, Gordon R. Ultsch, F. Prescott Ward, Robert C. Whitmore*, Stanley N. Weimeyer, E. William Wischusen*, Neil Woofinden.

ANDERSEN AWARD — The third annual William C. Andersen Memorial Award for the best student paper was presented at the Raptor Research Foundation Annual Meeting in Blacksburg, Virginia, on 27 October 1984. The winner was Mr. Reed Bowman of the Macdonald Raptor Research Centre of McGill University for his paper "Behavior of Widow and Replacement Mates in Wild American Kestrels."

Students wishing to be considered for the 1985 Andersen Award must indicate their eligibility when submitting abstracts. Eligibility criteria were published in *Raptor Research* 16(1):30-32. Questions regarding the 1985 award should be directed to: Dr. Robert Kennedy, Director, Raptor Information Center, National Wildlife Federation, 9412 16th Street, NW, Washington, D.C. 20036.

The Macdonald Raptor Research Centre of McGill University is offering 4 to 6 non-salaried summer student internships with free residence (not board). Internships provide experience in public education, care and rehabilitation of captive raptors as well as an opportunity to pursue personal research. Interested candidates should submit two letters of recommendation, a resumé of experience and interests, and an unofficial transcript of college academic records by April 1, 1985 to: Dr. David M. Bird, Director, Macdonald Raptor Research Centre, 21,111 Lakeshore Road, Ste-Anne de Bellevue, Québec H9X 1CO, Tel: 1-514-457-2000, ext. 345.

BIOLOGY OF THE PEREGRINE AND GYRFALCON IN GREENLAND. By William A. Burnham and William G. Mattox. Meddelelser om Gronland, Bioscience 14, 1984: 25 pp., 12 figs., 12 tables. Dkr. 46.75 excl. of VAT and postage. — This paper presents the results of 10 years of study (1972-1981) in western Greenland that took place primarily in the region of Sondre Stromfjord. The study is still ongoing. Much of the data were hard won, especially in the early years. Frequently the researchers had to make week long treks with 25-35 kilos of gear in back packs just to gather data on 2-3 eyries. I still have vivid memories of trudging over the landscape with the survey crew in 1975; backpack so heavy and feet so sore I could hardly walk after a one week trek. Over 40 researchers were involved in data gathering and 9 organizations provided some support. Within this report the bulk of the data deals with the Peregrine Falcon (*Falco peregrinus*). Of the 17 pages containing biological data 9 were devoted to peregrine biology, 3 to Gyrfalcon (*Falco rusticolus*) and the remaining 5 to such topics as migration, banding recoveries, chemical pollutants, and interspecific competition. The biologies presented are not unlike that of both species elsewhere in their circumpolar ranges with but a couple of exceptions. The 2 species were not found to occupy the same cliff simultaneously (although they did in 1984). Part of their discussion attempts to explain why this would have developed in the historical sense. They speculate that food densities as well as the distribution of nests of the Common Raven (*Corvus corax*), which Gyrfalcons usurp for nesting, have been important factors in the dispersion of the 2 species.

A second departure from general peregrine biology was the findings on food habits. While peregrines are noted for their catholic diets this was not the case in Greenland. Four species made up about 90% of the diet in 1973. This probably results from the fact that there just are not large populations of many species to prey on at inland localities. In some ways it is disappointing that so much data were lost by not checking food remains in eyries more thoroughly. For all years of the study productivity was recorded at each eyrie and in most cases young were banded. 1973 was the only year reported with food data. Why weren't food remains systematically collected while in the eyrie? Had such data been collected a better idea of regional food differences, yearly prey fluctuation and biomass consumption at each eyrie may have emerged. Overall, considering the physical and logistic restraints encountered by field parties, this study is a credit to the authors and an important addition to raptor biology. — Clayton M. White.

R A P T O R R E S E A R C H

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

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Raptor Research (ISSN 0099-9059) welcomes original manuscripts dealing with all aspects of general ecology, natural history, management and conservation of diurnal and nocturnal predatory birds. Send all manuscripts for consideration and books for review to the Editor. Contributions are welcomed from throughout the world, but must be written in English.

INSTRUCTIONS FOR CONTRIBUTORS: Submit a typewritten original and two copies of text, tables, figures and other pertinent material to the Editor. Two original copies of photographic illustrations are required. *Raptor Research* is published in a double-column format and authors should design tables and figures accordingly. **All submissions must be typewritten double-spaced** on one side of 8½ x 11-inch (21½ x 28cm) good quality, bond paper. Number pages through the Literature Cited section. The cover page should contain the full title and a shortened version of the title (not to exceed 30 characters in length) to be used as a running head. Author addresses are listed at the end of the Literature Cited section. Authors should indicate if present addresses are different from addresses at the time the research was conducted. When more than one author is listed, please indicate who should be contacted for necessary corrections and proof review. Provide an abstract for each manuscript more than 4 double-spaced typewritten pages in length. Abstracts are submitted as a separate section from the main body of the manuscript and should not exceed 5% of the length of the manuscript. Acknowledgements, when appropriate, should immediately follow the text and precede the Literature Cited. Both scientific and common names of all organisms are always given where first appearing in the text and should conform to the current checklists, or equivalent references, such as the A.O.U. Checklist of North American Birds (6th ed., 1983). Authors should ensure that all text citations are listed and checked for accuracy. If five or fewer citations appear in the text, place the complete citation in the text, following these examples: (Brown and Amadon, *Eagles, Hawks and Falcons of the World*. McGraw-Hill, New York, 1968), or Nelson (*Raptor Res.* 16(4):99, 1982)). If more than five citations are referenced, each should include author and year (e.g., Galushin 1981)), or in a citation with three or more authors, the first author and year (e.g., (Bruce et al. 1982)). Citations of two or more works on the same topic should appear in the text in chronological order (e.g., (Jones 1977, Johnson 1979 and Wilson 1980)). Unpublished material cited in the text as "pers. comm.," etc., should give the full name of the authority, but must not be listed in the Literature Cited section. If in doubt as to the correct form for a particular citation, it should be spelled out for the Editor to abbreviate.

Metric units should be used in all measurements. Abbreviations should conform with the Council of Biology Editors (CBE) Style Manual, 4th ed. Use the 24-hour clock (e.g., 0830 and 2030) and "continental" dating (e.g., 1 January 1984).

Tables should not duplicate material in either the text or illustrations. Tables are typewritten, **double-spaced throughout**, including title and column headings, should be separate from the text and be assigned consecutive Arabic numerals. Each table must contain a short, complete heading. Footnotes to tables should be concise and typed in lower-case letters. Illustrations (including coordinate labels) should be on 8½ x 11-inch (21½ x 28cm) paper and must be submitted flat. Copies accompanying the original should be good quality reproductions. The name of the author(s) and figure number should be penciled on the back of each illustration. All illustrations are numbered consecutively using Arabic numerals. Include all illustration legends together, typewritten **double-spaced**, on a single page whenever possible. Line illustrations (i.e., maps, graphs, drawings) should be accomplished using undiluted india ink and designed for reduction by 1/3 to ½. Drawings should be accomplished using heavy weight, smooth finish, drafting paper whenever possible. Use mechanical lettering devices, pressure transfer letters, or calligraphy. Typewritten or computer (dot matrix) lettering is **not** acceptable for illustrations. Use of photographic illustrations is possible but requires that prior arrangements be made with the Editor and the Treasurer.

A more detailed set of instructions for contributors appeared in *Raptor Research*, Vol. 18, No. 1, Spring 1984, and is available from the Editor.

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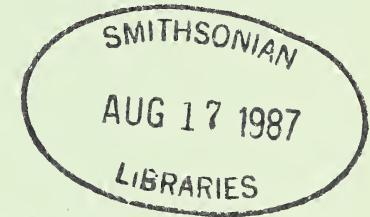
RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

VOLUME 19, NUMBER 1, SPRING 1985

(ISSN 0099-9059)

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Send requests for information concerning membership, subscriptions, special publications, or change of address to the Treasurer. Other communications may be routed through the appropriate Officer or Board member. All inquiries concerning the journal should be addressed to Clayton M. White, Editor, *Raptor Research*, Department of Zoology, 161 WIDB, Brigham Young University, Provo, Utah 84602, U.S.A.

Published quarterly by The Raptor Research Foundation, Inc. Business Office: Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 19

SPRING 1985

No. 1

HIGHWALL-TO-POLE GOLDEN EAGLE NEST SITE RELOCATIONS

ROBERT A. FALA, ARTHUR ANDERSON AND JOHN P. WARD

ABSTRACT - Golden Eagles (*Aquila chrysaetos*) constructed nests and produced young at 2 cliff-like mine highwalls at a southcentral Wyoming surface coal operation. The nests were in areas formerly unoccupied by nesting eagles, a result of the mining process creating suitable nesting habitat. Nest site availability is believed to be a local limiting factor on Golden Eagle productivity. Existing state and/or federal reclamation laws require the elimination of highwalls. Other laws, however, forbid the removal of Golden Eagle nests. To resolve this conflict and improve management of eagles, the nestling relocation technique was implemented to move nest sites to man-made nesting platforms mounted on poles. Behavioral responses of the adult eagles to the relocations indicated a high degree of parental attachment to young as well as nesting adaptability. Management implications of the technique are promising, particularly as they relate to mitigation for highwall nesting eagles and possibly other raptor species. However, further research is needed for this practice to be of predictive value for eagle behavior and response after relocation.

Golden Eagle (*Aquila chrysaetos*) nests are often threatened by surface coal mining operations in the western United States. Because Golden Eagles and their nests are also protected by the Bald Eagle Act, mining and reclamation are sometimes impeded.

Errington (1932) first indicated that certain raptor nestlings, tethered away from the nest, would be cared for and fed by adult birds. This technique was adapted by Postovit et al. (1982) to affect a successful tree-to-pole Golden Eagle nest site relocation in northeastern Wyoming by moving nestlings progressively further away from their original nest. Subsequent successful tree-to-pole Golden Eagle nest relocations were performed and reported for the same region (Phillips and Beske 1982, 1983). These authors stress the importance of locating artificial nesting structures within the home ranges of mated pairs while also taking into account the territories of adjacent nesting pairs. The demonstrated use of alternate nest sites (Lockie and Ratcliffe 1964; McGahan 1968; Boeker and Ray 1971; Call 1978) also indicates some flexibility by Golden Eagles in their adaptability to new nest locations. Postovit et al. (1982) and Phillips and Beske (1982, 1983) also report the use of artificial nesting structures by Golden Eagles in years subsequent to their initial relocation, indicating the potential long-term value of this technique.

The directed nest relocations performed in northeastern Wyoming were: from tree to pole, tree to tree, and pole to pole. Success in simulating tree nest sites suggests that the simulation of other types of nest sites may be successful, especially for highwall nesting eagles. A conflict with highwall nesting eagles arose in the Hanna Basin surface coal mining region of southcentral Wyoming. A highwall is the exposed face of rock or overburden, often nearly vertical, in an open cut of a surface mine; this substrate simulates cliff nesting raptor habitat (Figs. 1 and 2). Golden Eagles constructed nests and successfully fledged young on the highwalls of 2 mined-out pits: Bed 24 and Bed 51 East. Bed 24 highwall nest was first observed in 1979 and has fledged at least 1 eaglet during each of the past 4 yr (1979-1982). Bed 51 East nest was observed first in 1981 and has produced at least 1 eaglet in each of the past 2 yr (1981 and 1982).

Both nests were constructed beneath overhangs on highwalls with angles approximately 55° from the horizontal. Bed 24 nest faced SW and was 12 m below the top of the highwall, 60 m in height; Bed 51 East nest faced SSW and was 10 m below the top of a highwall, 40 m in height.

Unlike the situation in northeastern Wyoming where nests were impeding coal development, the 2 highwall nests in southcentral Wyoming were im-



Figure 1. Golden Eagle and nest (arrow) at Bed 51 East mine highwall. Note the cliff-like nesting habitat.



Figure 2. Close-up of Bed 51 East mine pit highwall nest with a nestling visible just below the adult eagle.



Figure 3. Bed 51 East pole nesting structure with 1 large nestling visible on the platform. Adult perch sites are indicated by arrows.

peding reclamation. State and/or federal laws require timely reclamation and the elimination of all mine highwalls for safety reasons. Regulations also forbid the disturbance of eagle nests. Therefore, reclamation in southcentral Wyoming could not occur within the legal time limit. To resolve the dilemma, state and federal agencies cooperatively developed a mitigation strategy using the research provisions of applicable laws. Citing tree-to-pole nest relocations as a precedent, relocation of the 2 highwall nests was made during the 1982 nesting season.

The intent of the highwall-to-pole strategy was to allow the pits and highwalls to be reclaimed while providing alternate nesting sites for the eagles. This paper describes the 2 highwall-to-pole relocations and some associated behavioral responses of the adult eagles.

STUDY AREA AND METHODS

This study was conducted in the Hanna Basin coal region, southcentral Wyoming. Vegetation is typical of semi-arid plains with sagebrush (*Artemesia* spp.) and grassland communities dominating, except for drainages that are ephemeral where greasewood (*Sarcobatus* spp.) prevails. Lack of trees of appreciable height precludes tree nesting by eagles. The topography is primarily gentle with dissection drainage patterns and numerous

minor rock outcrops. Nesting habitat is limited to a few rimrocks or cliff-like outcrops. These rimrocks contain the only other occupied or alternate Golden Eagle nests within the study area.

Beginning in September 1981, eagle pairs were monitored once a month to determine the approximate location of their home ranges. Home ranges were determined by direct observations of the eagles. Prospective locations of artificial nest structures were within the home ranges. Artificial nesting structures were constructed according to McEneaney and Phillips (1981) and erected with platform bases 7 m above ground level (Fig. 3). Platforms were installed in December 1981, to lure eagles into using the artificial structure over their actual nest site and to familiarize them with the structure. Leafless or dead sagebrush twigs and straw were then wired atop each artificial platform to construct a nest bowl.

Bed 24 artificial nesting structure was erected on a reclaimed area 575 m from the highwall nest (Fig. 4), and Bed 51 East artificial structure was placed in a sagebrush site 470 m from the highwall nest site (Fig. 5). The latter was later moved to within 100 m of the highwall nest. Both structures were in direct line of sight of their respective highwall nests.

The highwall nests were monitored bi-weekly beginning 1 March 1982, to document incubation, hatching, and number of nestlings. Monitoring was from 800 m with a 15 - 60X spotting scope to minimize disturbance during the sensitive incubation period (Fyfe and Olendorff 1976). Exact dates of nest events, such as hatching, were not determined since this was not critical. The main prerequisites for relocation was to do so when nestlings were present.

Golden Eagle nestlings developed the ability to fast when approximately 20 d old (Ellis 1979). To provide a margin of safety,

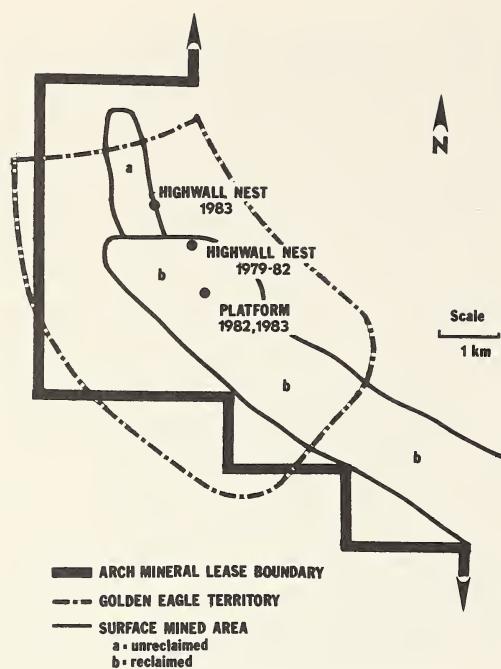


Figure 4. Location of Bed 24 highwall nest and artificial nesting platform.

attempts to move eaglets were made only after they were 4 to 5 wk old. On 8 June 1982 we removed 4 nestlings from the highwalls, 2 from each nest. They were fed about 0.3 kg of White-tailed Jackrabbit (*Lepus townsendii*) and placed on the platforms of the artificial structures. A jackrabbit carcass was provided on the platform as potential food for the adults to feed the young. Relocating and feeding of the young birds were accomplished within 2 h for each nest. Dawn to dusk monitoring of adults and nestlings resumed from 800 m distance as soon as relocations were completed. Nestlings were hand fed again on the platforms every 24 to 26 h until the adults began feeding them. Once the eaglets were accepted at the artificial structures, monitoring was reduced to 15 min observation periods every 1 - 2 d. Both highwalls were released for reclamation in August 1982 and eliminated before the 1983 breeding season.

RESULTS AND DISCUSSION

Bed 24 Nest. — Bed 24 artificial structure was utilized by perching eagles between erection in December 1981 and nestling relocation in June 1982, as indicated by actual observations of eagles and whitewash. Once the nestlings were placed on the artificial structure, the adult eagles were usually observed perched atop nearby spoil piles or along the Bed 24 highway, except for occasional hunting or soaring away from the site.

During the 50 h between relocation and accept-

ance of the nestlings, one adult flew in an anxious manner and alighted frequently at the highwall nest and at other perches along the highwall. The sex of this bird could not be determined at the time.

In the interim between adult acceptance of the Bed 24 nestlings and fledging of the eaglets (28 d), 24 observations (6 h total) were made on 21 different days. The adult female was very attentive to the artificial structure, as exhibited by her perching on the structure during 5 of the 24 observations (or 1.25 h). Attentiveness decreased as fledging approached. On 3 of the 5 occasions the female was observed on the platform feeding the young, but only during the first 5 d after acceptance of the nestlings at the artificial structure and not later than a nestling age of about 44 d. This is consistent with known natural eagle behavior (Ellis 1979). As was also noted by Postovit et al. (1982), no adult from the mated pair was ever observed at the former nest site once the new artificial site was accepted by both adults.

In addition to the recommendations of Postovit et al. (1982) concerning enhancing the success of Golden Eagle nest site relocations, we believe that other interrelated factors contributed to the Bed 24 relocation success: the relative serenity and lack of human related activities within 3 km of the reloca-

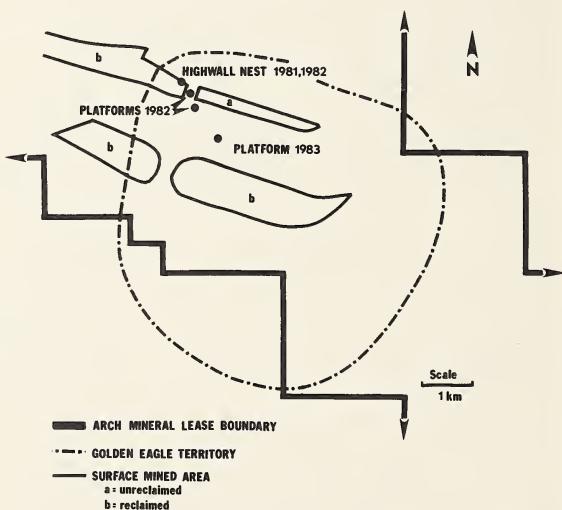


Figure 5. Location of Bed 51 East highwall nest and artificial nesting platforms.

tion site; familiarization with and use of the artificial structure during the period between erection and nestling relocation; and the amount of time the adult bird(s) spent in line of sight of the relocated nestlings at the relocation site; i.e., response time.

A few twigs were added to the platform nest by the adults in February 1983. Ultimately, this pair constructed a new nest 0.8 km to the NW at an adjacent mine property highwall. At the new highwall nest site the adults hatched 1 eaglet in 1983. This nest was relocated a distance of 1340 m SE to the existing platform on 31 May 1983. The adult male came to the platform 13 min prior to the female, about 26 h after relocation of the eaglets. It was felt that if intentional disturbance had occurred early on (under USFWS permission) at the highwall before incubation commenced, the adults may have been forced to use the artificial structure. Intentional disturbance was not used in this instance, because the nest was discovered late in the nesting cycle and disturbance may have resulted in nest failure.

Bed 51 East Nest. — The pair of adult eagles at Bed 51 East did not perch on the artificial structure in the interim between erection and nestling relocation. However, both adults were often seen flying in the general area. This relocation site was subject to reclamation disturbances involving use of heavy equipment within 0.8 km of the structure during the nestling relocation.

Once the Bed 51 nestlings were placed on the artificial structure, the adults spent considerable time away from the relocation site. Direct line of sight between adult perches and the relocated nestlings was broken at places by topographical relief and the close proximity (100 m) of spoil, thus response time of the adults was reduced.

After 54 h with little or no response by the adult eagles to the artificial structure, the nestlings were returned to their original highwall nest. No prey items had been placed at the artificial platform by the adult eagles, though a Desert Cottontail (*Sylvilagus auduboni*) and a Wyoming Ground Squirrel (*Spermophilus elegans*) had been delivered to the highwall nest during the eaglets' absence. Within 5 h after returning the nestlings to the Bed 51 highwall nest, the adult female alighted at this site.

One objective in this study was to habituate the mated pair to the artificial structure prior to reclamation of the Bed 51 East pit and highwall. The intention was to familiarize the pair with the plat-

form in hopes of encouraging them to nest there in succeeding years. With this in mind, we felt that the best course of action after returning the nestlings to their highwall nest was to wait a few days, then move the artificial structure closer to the highwall nest (from 470 m to 100 m) and make a second relocation attempt. The adult female responded to the new location and frequented the nearest perch atop a spoil pile (100 m distant) in direct line of sight of the platform for several hours at a time. This enhanced association with the platform resulted in acceptance of the platform by an adult 31 h after the second relocation of the nestlings.

In the interim between adult acceptance of the Bed 51 nestlings at the artificial structure and the last fledging date of the young (35 d), 31 observations (or 7.45 h) were conducted on 23 different days. An adult eagle was not sighted during 15 of these observations. However, 7 of these times an adult was observed perched atop the nearby spoil pile (100 m). Two sightings (30 min total) of adults on the artificial structure were made. One adult was observed atop the structure, and the other was of an adult on the platform with the young. These 2 observations were noted during the first 2 d after adult acceptance of the structure but not later than a nestling age of about 41 d.

In contrast to Postovit et al. (1982) and the Bed 24 case, we documented use of the former highwall nest site on 2 occasions. This occurred on the first 2 evenings after acceptance, when the adult female returned without prey and alighted at the highwall nest to roost. It was never positively determined that the adult male alighted on the artificial structure.

Because the adult female returned to the highwall nest, and seemed to lack attentiveness to the artificial structure after the apparent acceptance of the nestlings, there was concern over the seemingly tentative nature of the acceptance. Because we were not certain that the young were being fed, we climbed the platform structure and inspected the nest 20 h after acceptance. A Desert Cottontail had been delivered to the platform and picked clean by an adult. Despite the somewhat secretive and cautious acceptance of the artificial structure, there were no apparent ill effects to the eaglets, which developed normally and fledged.

Both adults added material to the artificial nest during the next nesting season (March 1983), and incubation began at this site on 26 March 1983. One eaglet was hatched at the platform nest site in May.

The original highwall was not available at this time, but there was an adjacent highwall 100 m to the west. Since the desired relocation site was not attained in 1982, a platform-to-platform relocation was preformed at a distance of 914 m on 31 May 1983. This relocation elicited an adult male response after 79.5 h, however the female did not accept the new platform. After 122.5 h the project was aborted due to concern for the nestling. The nestling was adopted out and fledged at a surrogate nest.

Both Nests. — As signified by the survival and ultimate fledging of the young at the respective artificial nest structures in 1982, the nestling relocation efforts at Bed 24 and Bed 51 East met with comparable results. However, the degree of difficulty in the relocation efforts and adult behavior after acceptance were distinctly different. We conclude that the differences in adult behavior were instigated primarily by the inherent behavioral or tolerance differences of the eagle pairs to man related manipulations. Also, Bed 51 East highwall nest site was located below ground level and not in view of mine related activities, whereas the artificial structure was located above ground level and in line of sight of mining activities. Conversely, the Bed 24 adults did not encounter human related disturbances to within about 3 km of the relocation area, and apparently the eagles responded favorably and fledged young.

We feel other possible explanations of the varied adult responses are related to the proximity of the artificial structure to suitable perches, the adults familiarity with and previous use of the platforms, and the amount of time the adults spent in direct line of sight of the structure once the nestlings were relocated (i.e., response time).

Management Implications. — As a result of the successful highwall-to-pole nestling relocations, the Bed 24 and Bed 51 East pits were released for reclamation grading activities in August 1982, soon after eaglets fledged. All reclamation activities were completed by 1 February 1983, so that spatial buffer zones around the platform could be honored, thereby increasing the likelihood of nesting by adult pairs at the respective structures in succeeding years.

Of paramount importance to nest manipulations of this type is whether the artificial structures will be used in subsequent years. Postovit et al. (1982) and Phillips and Beske (1982, 1983) reported use of

artificial structures in years following tree-to-pole, pole-to-pole, and tree-to-tree eaglet relocations. In the case of the Bed 51 East nest site in this study, and a Wyoming uranium mine highwall case (Beske, pers. comm.), it appears that the same is possible for highwall-to-pole or cliff-to-pole relocations. However, we recommend that this technique be utilized only on a temporary or emergency basis, or when other more permanent or natural nesting habitat cannot be created or enhanced (i.e., modification of natural cliff areas, preserving mine highwalls, tree planting, etc.).

In summary, the difference in response at the respective relocation sites for these 2 pairs of eagles represent some degree of adaptability for accepting and fledging young at an artificial, and drastically different, nest substrate under varying conditions. Due to the small sample size in this study, any generalizations about the nature of adaptability of Golden Eagle populations would be presumptuous. However, this study may be an indicator that relocation practices may prove beneficial in solving an important management dilemma currently faced by coal mine biologists and the USFWS.

ACKNOWLEDGMENTS

This project was funded primarily by Arch Mineral Corporation with assistance from the U.S. Fish and Wildlife Service, Wyoming Cooperative Fishery and Wildlife Research Unit, and the Wyoming Game and Fish Department. We thank M. Lockhart and R. Joseph for assisting with the field work and W. Dyer, U.S. Fish and Wildlife Service, for reviewing the manuscript. We thank S. Mikol-Ritter for assistance with the field work and L. Parker, Wyoming Game and Fish Department, for providing the photographs used in the figures. Pacific Power and Light, Inc., assembled, erected and relocated the artificial nesting structures. A. Beske, Wyoming Cooperative Fisheries and Wildlife Research Unit, aided with both the manuscript and field work.

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Received 8 March 1984; Accepted 30 January 1985

BIOLOGY OF ELEONORA'S FALCON (*Falco eleonorae*): 7. VARIABILITY OF CLUTCH SIZE, EGG DIMENSIONS AND EGG COLORING

MICHAEL WINK, DIETRICH RISTOW AND CORALIE WINK

ABSTRACT — The variation of egg size, egg coloring and clutch size was studied in an Aegean colony of Eleonora's Falcon (*Falco eleonorae*). Egg-laying occurs between mid-July and early August with laying intervals of 2.6 and 2.9 d between first and second, and second and third egg, respectively. Mean clutch size was about 2.28. Three-egg clutches are started earlier than 2-egg or 1-egg clutches, which results in a negative correlation between laying date and clutch size. Within a laying sequence, third eggs are significantly smaller than first and second eggs. Egg breadth has a higher interclutch variation than intraclutch variation. A positive correlation can be established between female weight and egg breadth. Egg color corresponds to laying order; the second and third eggs show many dark spots, the first egg is pale brown. Clutch size was correlated with the weight of the male falcon but not with female weight. A correlation between the hunting success of a male falcon and its weight is assumed. Food availability is a limiting factor in the colony studied, and since the female falcon relies entirely upon the food supplied by the male, a correlation between male hunting success and clutch size is suggested.

Variability in clutch size and egg parameters has been studied in many birds, especially in species breeding colonially (gulls, terns, swallows), or species using nest boxes (tits, flycatchers, sparrows) (Lack 1966; Klomp 1970; Drent 1975). Birds of prey, except for the European Kestrel (*Falco tinnunculus*) (Cave 1969), the Red-footed Falcon (*Falco vespertinus*) (Horváth 1955), and the European Sparrowhawk (*Accipiter nisus*) (Newton 1979), have not been studied extensively, probably because of difficulties in acquiring sufficiently homogeneous data.

Since the Eleonora's Falcon (*Falco eleonorae*) breeds colonially and shows rather synchronized breeding, studies on reproductive biology and ecology are facilitated. On the other hand, field work is difficult to carry out because breeding colonies are usually situated on rocky, uninhabited islands of the Mediterranean Sea.

We studied a large breeding colony of Eleonora's Falcon in the Aegean Sea for 8 seasons and report here on the variability of clutch size, egg dimensions and egg coloring with respect to laying sequence and weight of the corresponding parent falcons.

MATERIALS AND METHODS

The present study was carried out in July/August 1975 and in August/October 1977 near Crete in an Aegean colony of Eleonora's Falcon of about 250 breeding pairs. A few data were derived from a study in August/September 1979 (Ristow et al. 1980; Wink et al. 1980b). About 40 nests were monitored daily during the egg-laying period of 1975, and all eggs were marked individually with pencil so that the exact dates of laying and their sequence within a clutch were known.

Altogether, 240 eggs were measured. Egg weight was deter-

mined with a gauged spring balance to the nearest g. Egg length (L) and egg breadth (B) were measured with a micrometer to the nearest 0.1 mm. Egg volume was calculated as $V = (\pi \cdot L \cdot B^2)/6$, in analogy to the volume formula of a globe (Rheinwald, pers. comm.). The weight of captured adult falcons was measured with a spring balance to the nearest 5 g.

RESULTS

Egg Dimensions. — The measurements of 240 eggs made in 1975 and 1977 are summarized in Table 1. The data of both yrs are pooled, since the parameters L, B and volume did not differ significantly ($P > 0.05$, *t*-Test) between years. Third eggs are significantly smaller ($P < 0.02$, *t*-Test) than first or second eggs (Table 1), whereas first and second eggs cannot be distinguished by size. The mean egg shape index (L/B) decreases from first egg (1.29) to second egg (1.25) to third egg (1.23); third eggs sometimes give the impression of being spherical.

Relationship With Female Weight. — The range of B for 31 three-egg clutches was 5.6 mm, whereas the range was only 1.7 mm within the respective clutches themselves. To quantify the degree of intraclutch and interclutch variation (Väistönen et al. 1972), 30 sequenced three-egg clutches were subjected to a one-way analysis of variance (ANOVA) (Table 2). The proportion of interclutch variation was 15% higher in L and 52% higher in B than intraclutch variation. The strong interclutch variation of B suggests that the anatomy and physiology of the female might be of importance. Unfortunately, these factors are difficult to measure, and the only factor that could be determined for the incubating female was weight.

Table 1. Dimensions ($\bar{x} \pm S.D.$) of the first, second and third egg of Eleonora's Falcon. The third egg differs significantly in breadth ($P < 0.02$, *t*-Test), length, weight and volume ($P < 0.001$, *t*-Test) from the first and second egg.

PARAMETER	N	DIMENSIONS
Egg Length		
Total	240	42.14 ± 1.61
First Egg	23	42.63 ± 1.03
Second Egg	21	42.16 ± 1.40
Third Egg	23	40.41 ± 1.37
Egg Breadth		
Total	240	33.54 ± 1.01
First Egg	23	33.61 ± 0.98
Second Egg	21	33.80 ± 0.74
Third Egg	23	32.90 ± 0.72
Egg Weight		
Total	163	26.37 ± 2.32
First Egg	23	27.13 ± 1.89
Second Egg	21	26.57 ± 1.85
Third Egg	23	23.54 ± 1.74
Egg Volume		
Total	240	24.78 ± 2.56
First Egg	23	25.24 ± 1.62
Second Egg	21	25.26 ± 1.63
Third Egg	23	22.88 ± 1.40

The relationship between female weight and egg dimensions is illustrated in Figure 1. Breadth, volume, but not L, are the most influenced parameters, and in consequence, egg weight also. The heavier the female, the heavier the resulting eggs and probably the hatching young also.

Evaporative Water Loss. — Egg weight is subjected to a steady reduction during incubation due to H_2O evaporation and CO_2 production (Bezzel 1977). Sixty-four eggs weighed 22.8 ± 2.09 g ($\bar{x} \pm S.D.$) at the end of incubation in 1977. Taking 30 d as incubation period and 26.4 g as initial egg weight, a daily loss of 116 mg occurred. On this basis, a 13.3% total loss occurred which may be influenced by climatic conditions at the breeding site (Table 3) with its relatively high temp and low humidity during daytime.

Relationship With Laying Period. — Egg-laying

Table 2. Results of one-way analysis of variance (ANOVA) of inter- and intraclutch differences in egg breadth of 30 sequenced three-egg clutches of Eleonora's Falcon. The figures indicate percentage estimates of variance components. Significance of F-test is shown with stars (actual F-values not given).

VARIABLES	PERCENT OF VARIANCE	
	INTRACLUTCH	INTERCLUTCH
Egg Length	25.3***	39.8*
Egg Breadth	16.2***	68.5***

* - $P < 0.05$; *** - $P < 0.001$.

was rather synchronized and occurred between mid-July to early August with an interval of 2 or 3 d between each egg being laid (Table 4). The sizes of 54 eggs ordered by their date of laying show a negative correlation for L and weight, but not for B (Table 5). This effect can be easily explained by the fact that third eggs were smaller than preceding ones and laid about 5 to 6 d later than the first egg. Consequently, only slight negative correlations were established for first and third eggs analyzed separately.

Egg Coloring. — First eggs are pale brown with numerous small dots, whereas second or third eggs are dark brown with many dots, usually larger, which are concentrated at the blunt poles of the eggs (Table 6). Therefore, egg sequence of any clutch can be determined according to egg color

Table 3. Temperature and relative humidity ($\bar{x} \pm S.D.$) measured with a thermohygrograph at 15 Eleonora's Falcon nests in August/September 1977.

TIME	TEMP (°C)	REL. HUMID. (%)
Night	20.92 ± 2.5	85.00 ± 6.7
Midday ^a	32.00 ± 4.5	49.50 ± 9.2

^a 6 - 8 h after sunrise.

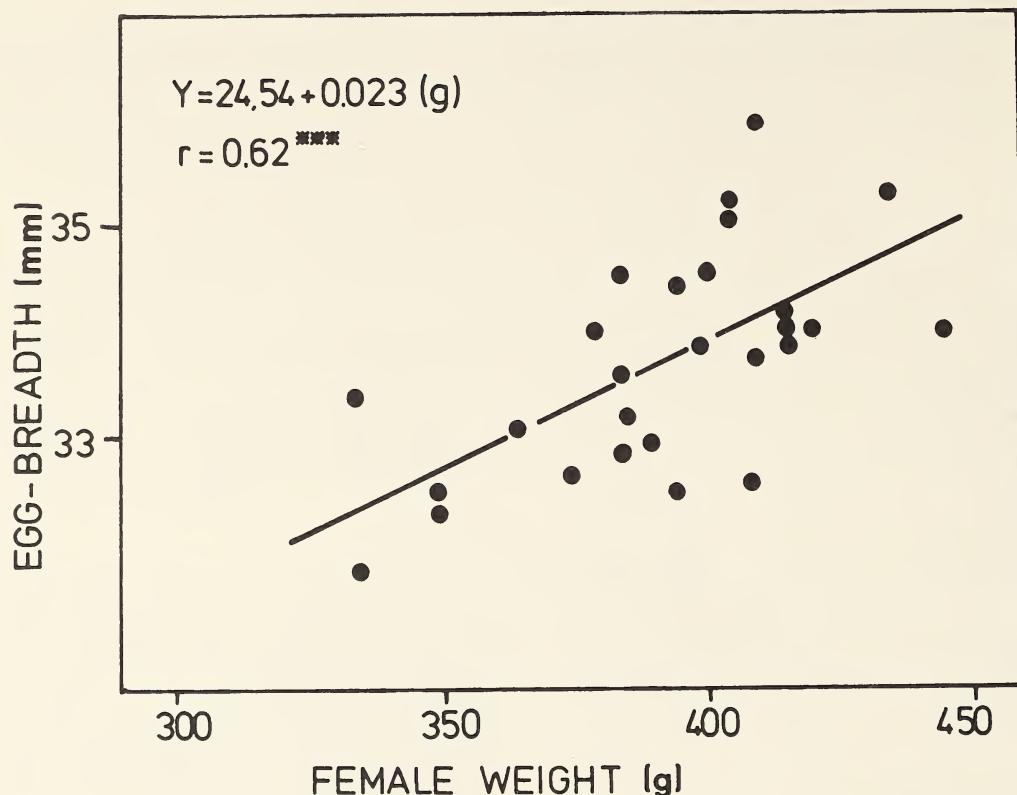


Figure 1. Linear regression analysis between weight of parent female Eleonora's Falcons and egg breadth (** - $P < 0.001$).

and egg size, as is also the case in eggs of the Red-footed Falcon (Horváth 1955).

Clutch Size. — Clutch size data are summarized in Table 7. Only data obtained at the beginning of

the incubation period (i.e., as soon as clutches are completed) were considered in order to avoid artifacts due to loss of eggs or clutches during incubation. A negative correlation ($P < 0.001$) existed

Table 4. Date of egg laying ($\bar{x} \pm S.D.$; Range) and interval ($\bar{x} \pm S.D.$) in days between laying of first and second egg and laying of second and third egg in an Aegean colony of Eleonora's Falcon.

EGG SEQUENCE	LAYING DATE	N	INTERVAL (D)
First Egg	24.5 July \pm 3.3 d 18 July - 27 July	21	
Second Egg	27.1 July \pm 3.3 d 21 July - 2 August	22	2.61 ± 0.92 (Between 1st & 2nd egg)
Third Egg	29.1 July \pm 3.3 d 24 July - 7 August	17	2.91 ± 2.12 (Between 2nd & 3rd egg)

Table 5. Correlation values resulting from a linear regression analysis between sequence of laying and egg size in Eleonora's Falcon.

PARAMETER	N	R	$Y = A - B(X)^*$
All Eggs			
Length	54	-0.43**	$Y = 46.15 - 0.16(d)$
Breadth	54	-0.11	
Weight	54	-0.36**	$Y = 31.54 - 0.21(d)$
First Eggs			
Length	21	-0.19	
Weight	21	-0.36	
Third Eggs			
Length	16	-0.06	
Weight	16	-0.17	

* - Sadis 1972; ** - $P < 0.01$.

between the date of laying and clutch size (i.e., 3-egg clutches were started earlier than 2-egg or 1-egg clutches).

Looking for an explanation, we studied the weight of the corresponding parent falcons. Clutch size was independent of female weight ($r = 0.53$, $P < 0.01$). The implication of this phenomenon was dealt with in detail in another paper (Wink et al. 1980a). We conclude that male weight and hunting efficiency are correlated; probably the mates of large males (which usually have 3-egg clutches) start laying at an earlier date than the mates of younger and smaller males.

DISCUSSION

In Eleonora's Falcon and all larids hitherto studied (Lundberg and Väistönen 1979) egg size decreases with laying sequence. The opposite has been found in several passerines (Svensson 1978) [e.g., the Song Thrush (*Turdus philomelos*) (Pitelka 1971), the Eastern Bluebird (*Sialis sialis*) (Pinkowski 1975)], as well as waders (Väistönen et al. 1972; Miller 1979), and the Red-footed Falcon (Horváth 1955) whose egg size increases with laying order. Passerines start incubation with the last egg and an adaptive value can be assumed for the observed egg size variation. Since the probability of predation is higher for the first than for the last egg, it is of advantage if the last eggs are bigger. The loss of a small first egg would be less costly than the loss of a large last egg (Miller 1979). This assumption de-

mands that in the opposite case (i.e., Eleonora's Falcon) the female should start incubation with the first egg in order to minimize the probability of a loss of the first and largest egg, and this is exactly what happens.

Is there any adaptive value of the third egg being the smallest and darkest? In order to answer this question it should be recalled that the interval between laying of the first and the third egg is about 5 to 6 d, but that incubation starts with the first egg. Hatching takes place within a 2 to 3 d (seldom 4 d)

Table 6. Observed numbers of eggs and color in relation to egg color and laying sequence in Eleonora's Falcon. A = all eggs individually known; B = includes data from eggs which were categorized by their size.

EGG COLOR	FIRST EGG	SECOND EGG	THIRD EGG
A. Pale Brown	21	1	1
	Dark Brown	17	18
B. Pale Brown	90	2	
	Dark Brown	91	36

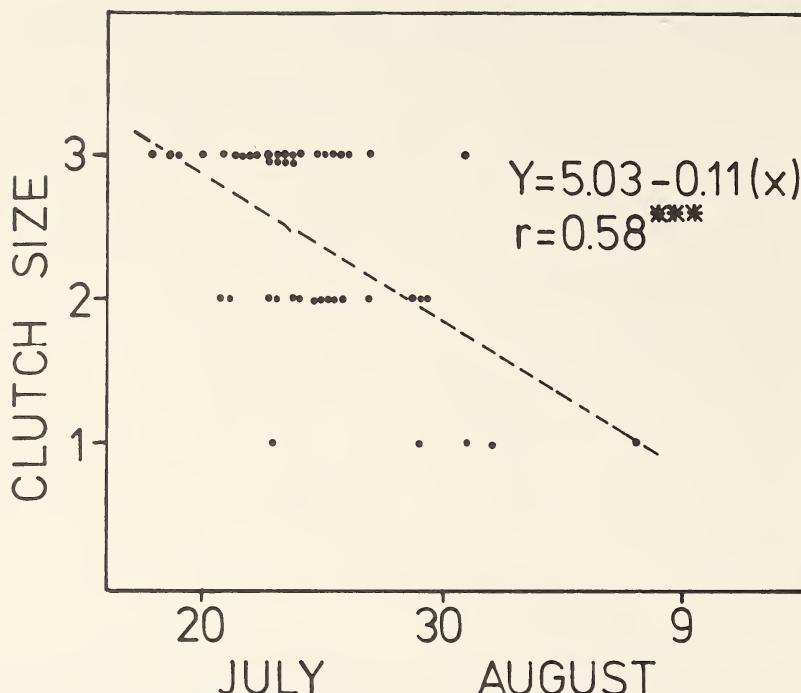


Figure 2. Linear regression analysis between laying dates of first egg and clutch size of Eleonora's Falcon (** - $P < 0.001$).

interval, however. To explain the gain of 2 to 3 d in laying time several factors have to be considered. The female may incubate the first egg less intensively during the first 3 days. "Clicking" calls of the young birds prior to hatching, which occurs in *Falco eleonorae*, can speed up hatching of an embryo to some extent (Drent 1975). Incubation time is positively correlated with egg weight and incubation

temp. According to basic physics, a dark body collects more radiation energy than a light one, thus we assume that a small and darker egg (i.e., the third egg in *Falco eleonorae*) would need a shorter incubation period. This would be of advantage, since the first young to hatch is the largest and the last young the smallest, which reduces the latter's chances of survival.

Table 7. Mean clutch size in an Aegean colony of Eleonora's Falcon. Initial clutch size data were derived from the beginning of the incubation period (July/August) in 1975.

PARAMETER	MEAN	CLUTCH SIZE (N)			
		1 EGG	2 EGGS	3 EGGS	4 EGGS
Initial Size	2.28	5	45	26	-
Post-Incubation Size ^b	1.97	21	76	18	(1) ^a

^aIn 1982 a 4-egg clutch was found, but according to egg size measurements it was derived from 2 females.

^bMost data were collected in 1977. If clutch size is determined at the end of the incubation period, clutch size is biased by egg loss due to predation.

Comparing the clutch size in different colonies of Eleonora's Falcon, the highest values are reached in the western Mediterranean: 2.55 eggs/clutch in the Balearic Islands (Mayol 1977), 2.85 - 3.05 eggs/clutch in Morocco (Conant and de Naurois 1958; Vaughan 1961; Walter 1968; Clark 1981) compared with 2.28 eggs/clutch in the Aegean region for our study period. Clutches of 4 eggs are more common in the Moroccan colonies (the mode being 3-egg clutches, Clark 1981) than in the eastern Mediterranean where 4-egg clutches are uncommon. It remains to be studied whether this gradient in clutch size from eastern to western Mediterranean regions is primarily due to a better food supply, or due to other factors such as climate, aridity, or genetic differences (Ojanen et al. 1979).

The clutch size within a colony seems to depend on the hunting success of the male, who supplies the female and the young with food during the breeding period. A larger falcon generally has a better hunting efficiency than a small one (Bezzel 1977; Newton 1979). Since food availability is a limiting factor for Eleonora's Falcon, it is not surprising that the clutch size is positively correlated with the weight of the male (Wink et al. 1980a). The physical condition of the female does not influence clutch size, but seems to be important for egg size and, in consequence, for the weight of the hatching young. The heavier a hatchling, the better its chances of survival (LeCroy and LeCroy 1974; Coulson and Thomas 1978; Lundberg and Väistönen 1979; Parsons 1970). Consequently, the offspring of a larger female may have an advantage over the young of a smaller female.

ACKNOWLEDGMENTS

We thank our friends in Germany and Greece for help and support, and the Studienstiftung des deutschen Volkes for grants (to MW and CW). We are thankful to Dr. R.A. Väistönen for critical comments on an earlier draft of this paper and to Dr. L. Kiff for refereeing and linguistic help.

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Received 18 April 1983; Accepted 27 September 1984.

THE RAPTOR RESEARCH FOUNDATION CONFERENCE — NOVEMBER 1985. The 1985 Raptor Research Foundation International Meeting and Symposium on the Management of Birds of Prey will be held at the capital Plaza Holiday Inn in Sacramento, California, November 2 - 10, 1985. Highlights of this 20th anniversary meeting of the Foundation will include 1) the Second RRF Conference on Raptor Conservation Techniques — Twelve Years of Progress, 1973-1985, 2) a Western Hemisphere Meeting of the World Working Group on Birds of Prey (ICBP), 3) the Second International Vulture Symposium, 4) a Western North America Osprey Symposium, 5) a Workshop on North American Candidate Endangered Raptors, 6) an International Symposium on Raptor Reintroduction, and 7) a Symposium on Raptor Rehabilitation, Captive Breeding and Public Education. For more information contact Dr. Richard R. Olendorff, U.S. Bureau of Land Management, 2800 Cottage Way, Sacramento, California 95825, or Nancy Venizelous, San Francisco Zoological Society, Stoat Boulevard at the Pacific Ocean, San Francisco, California 94132.

NESTING BEHAVIOR OF PEREGRINE FALCONS IN WEST GREENLAND DURING THE NESTLING PERIOD

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ABSTRACT - Time-lapse photography was used to study adult and nestling behavior at 2 Peregrine Falcon (*Falco peregrinus*) eyries in West Greenland during July and August 1974. During the first 10 d after hatching, nestlings at both eyries were brooded > 80% of the time. Brooding activity declined gradually during d 11-15 and was not recorded at either eyrie following d 20. The length of each feeding bout at 1 eyrie (Ringsø) diminished steadily throughout the nestling period. In contrast, the length of each feeding bout at the other eyrie (Lone Female) remained relatively constant. The rate of food delivery was consistently greater at Ringsø than at Lone Female. The Ringsø nestlings began to wander from the nest scrape on d 9-10, but spent most of their time on the scrape until d 24. The Lone Female nestlings also spent most of their time on the scrape during d 1-20, but they spent less time in bodily contact with one another than did the Ringsø nestlings.

Although the Peregrine Falcon (*Falco peregrinus*) has been the subject of numerous scientific investigations, few studies had been conducted in the Arctic prior to the 1970s. Following the reproductive decline of the peregrine throughout much of North America during the 1950s and 1960s (Hickey 1969), however, the need to evaluate the status of Arctic populations became apparent (Cade 1969).

In response, an intensive study was initiated in West Greenland in 1972. The primary focus of this long-term investigation was to determine the distribution, density and reproductive success of a nesting population of Peregrine Falcons (see Mattox et al. 1972; Walker et al. 1973; Burham et al. 1974; Mattox 1975; Mattox et al. 1980 and Burnham and Mattox 1984 for the results of this portion of the project). An additional effort was made to study the breeding behavior of the birds. Here, we present one aspect of that behavioral investigation: the use of time-lapse photography to record the activities of adult and nestling Peregrine Falcons at 2 eyries.

MATERIALS AND METHODS

The study was conducted on the west coast of Greenland at 2 cliffs located approximately 6 km WNW and 24 km WSW of Sondrestromfjord Air Force Base. The region ranges in elevation from sea level to 590 m, has a low-arctic climate, and is characterized by expanses of tundra interspersed with shallow ponds and lakes.

Two Peregrine Falcon eyries were studied intensively during July and August 1974 by T.D. Snowman and V.L. Cox, who established a base camp near the Ringsø eyrie. The Ringsø eyrie was two-thirds of the way up a 45-60 m cliff and overlooked 2 large and several smaller bodies of water to the SSE; there were 4 nestlings (2 ♂♂ and 2 ♀♀) at the eyrie. The Lone Female eyrie, 20 km to the WSW of Ringsø, was two-thirds of the way up a 24-30 m rock outcropping and overlooked a large lake to the S. On 23 July,

1 live (a ♂) and 2 dead nestlings were discovered at the latter eyrie. Because we believed there was little chance the single nestling would survive without the warmth of another bird, a second male nestling of about the same age was transplanted to the nest from a nearby eyrie on 29 July. At that time, both nestlings were approximately 12-13 d old.

Minolta super-8 movie cameras, housed within waterproof metal and Plexiglas cases, were secured with climbing pitons and slings 5 m from the nest scrape at Ringsø and 3-4 m from the nest scrape at Lone Female. Filming at Ringsø began 17 July, about 5 d after the eggs hatched, and continued through 6 August. During the first 17½ d, the camera exposed 1 frame/min; during the last 3½ d, the rate was increased to 1 frame/15 sec. From 13 July through 5 August, additional observations of adults and nestlings were made with an 8-25X spotting scope from a hidden location 140 m from the nest scrape. Filming at Lone Female began 23 July, about 6 d after the original clutch hatched, and ended 5 August. The camera exposed 1 frame/min throughout the period. The film at the Lone Female eyrie had to be changed every 60 h, requiring a 6-h, 20-km walk from Ringsø; incidental observations were made during these visits.

R. Fay, J.A. Hovis and K.L. Bildstein transcribed observations from the film using a film-editing machine and microfiche reader. Four adult behavioral patterns were recognized: 1) brooding, including close sitting or standing over the nestlings (Jenkins 1978); 2) feeding, including feeding bouts and food deliveries; 3) adult on eyrie but inattentive, including observations in which at least 1 adult was on or near the nest scrape but was not brooding or feeding the young; 4) adult not at eyrie, including observations in which neither adult was in view. We excluded from analysis adult behavioral patterns influenced by human activity when the film was changed.

We also recorded the absolute (on or off scrape) and relative (in contact with at least 1 other sibling or alone) location of nestlings.

RESULTS AND DISCUSSION

Adult Behavior. — Nestlings at the Ringsø eyrie were closely brooded during the first 10 d after hatching (Table 1). As the young began to acquire their second down at 10-14 d of age (Bent 1938), there was a gradual decline in brooding activity, with most brooding occurring at night or during

Table 1. Percent of time adult Peregrine Falcons engaged in various activities at 2 eyries in Greenland. Data were derived from 277 h and 199 h of film time at Ringsø and Lone Female eyries, respectively.

Activity	AGE OF NESTLINGS ^a				
	3-5	6-10	11-15	16-20	21-24
Brooding	86/ND ^{b,c}	80/86	13/37	0/0	0/ND
Feeding	9/ND	10/4	8/5	6/3	1/ND
On eyrie, inattentive	1/ND	2/5	3/36	1/68	<1/ND
Not on eyrie	4/ND	8/5	75/22	93/28	98/ND

^aDays since hatching.

^bRingsø Eyrie/Lone Female Eyrie.

^cND no data.

periods of extreme temp or rain. No daytime brooding was recorded following d 15 of the nestling period; brooding at night was last observed when the young were 19-20 d old and was associated with cold, rainy and windy weather.

Most brooding activity at the Lone Female eyrie also occurred when the nestlings were <10d old (Table 1). Thereafter, the young were left alone for increasing amounts of time; no brooding was recorded following d 14 of the nestling period.

A similar pattern in brooding activity was observed by Enderson et al. (1972) at 5 peregrine eyries along the Yukon River, Alaska. Nestlings were brooded >90% of the time during the first 6 d after hatching, approximately 88% of the time by d 10, and <10% of the time by d 20. The occurrence of increased brooding activity during periods of inclement weather has been reported for the peregrine (Nelson 1970; Enderson et al. 1972), the Gyrfalcon (*F. rusticolus*) (Jenkins 1978) and the Sparrowhawk (*Accipiter nisus*) (Newton 1978).

Although adult birds could not be sexed accurately from the film, observations made with a spotting scope suggested that all brooding at Ringsø was done by the female. Other studies also have found that males play a negligible role in brooding (Nelson 1970; Enderson et al. 1972; Harris and Clement 1975), a behavioral pattern that in part may be due to the difference in size between the sexes. Males apparently are too small to cover the nestlings properly and are probably less efficient brooders than are females (Nelson 1970), which are about one-third heavier.

The amount of time the Ringsø adults spent feeding their young remained relatively constant throughout the first 20 d of the nestling period (Table 1). However, average length of each feeding bout diminished steadily during the period (Table 2). As the nestlings began to tear and shred food on their own, they probably required decreasing amounts of time to consume small prey items such as the Lapland Longspur (*Calcarius lapponicus*) and the Snow Bunting (*Plectrophenax nivalis*), which comprise the major portion of their diet (Harris and Clement 1975; Burnham and Mattox 1984). Also, as the nestlings grew increasingly aggressive with age, it became difficult for the adults to feed them at the eyrie. By the fourth wk of the nestling period, the adults were dropping prey at the eyrie and allowing the young to feed themselves. The tendency to avoid the young during the later stages of the nestling period has been observed for both peregrines (Sherrod 1983) and Gyrfalcons (Jenkins 1978).

The rate of food delivery at the Ringsø eyrie was greatest when the nestlings were 6-20 d old (Table 2). At earlier ages, young took more time to consume lesser amounts of food (Enderson et al. 1972), were satiated more quickly (Newton 1979) and required fewer prey items. The limitations of time-lapse photography probably account for the low rate of food delivery recorded during the fourth wk of the nestling period. As the average length of each feeding bout decreased (Table 2), many food deliveries were too brief to be recorded on film (Jenkins 1978).

Table 2. Rate of food delivery and length of feeding bouts at 2 Peregrine Falcon eyries in Greenland.

	AGE OF NESTLINGS ^a				
	3-5	6-10	11-15	16-20	21-24
Rate of food delivery (prey/hr)					
Rings♂	0.8±0.1(2) ^b	1.3±0.2(5)	1.2±0.2(5)	1.4±0.3(5)	0.7±0.6(4)
Lone Female	ND ^c	0.9±0.1(3)	0.8±0.3(5)	0.6±0.1(5)	ND
Length of feeding bouts (min)					
Rings♂	6.7±5.0(21)	4.9±2.6(85)	3.7±2.0(95)	2.5±1.8(97)	1.4±0.9(22)
Lone Female	ND	2.8±2.3(40)	3.5±2.7(61)	3.0±2.2(47)	ND

^aDays since hatching.^bMean ± S.D.(N). N = number of days or number of feeding bouts.^cND = no data.

Feeding activity at the Lone Female eyrie remained relatively constant during d 6-20 of the nestling period (Tables 1 and 2). Both the percent of time the Lone Female adults spent feeding young (Table 1) and the rate at which they delivered food to the eyrie, however, were lower (Table 2) than at Rings♂. These findings most likely were related to differences in the number and sex of the nestlings at each eyrie. The 2 male and 2 female nestlings at Rings♂ undoubtedly required more food than the 2 males at Lone Female. That the average length of each feeding bout at Lone Female did not diminish as the nestlings matured (Table 2) is more difficult to interpret. Possible explanations include: 1) a greater parental diligence on the part of the Lone Female adults; 2) differences in the development and behavior of the nestlings at the 2 eyries; or 3) the failure of the cameras to record accurately the occurrence and duration of each feeding bout at the 2 eyries.

Nestlings at Rings♂ were fed almost entirely by the adult female. The male was the primary hunter and provider of food, but was observed feeding the young only once, when they were 12-13 d old. Harris and Clement (1975) observed a similar division of parental duties for peregrines, whereas Herbert and Herbert (1965) and Nelson (1970) found that the male undertook a greater portion of the feeding responsibilities as the nestlings matured.

The aversion that adult falcons have towards being on the nest scrape together (Enderson et al. 1972; Harris and Clement 1975; Jenkins 1978) was further evidenced at the 2 eyries. The Lone Female adults were never filmed together. All of the 7 instances were the adults at Rings♂ were filmed together occurred within the first 2 wks of the nestling period, all were associated with a food exchange or feeding bout and all lasted less than 1 min. Harris and Clement (1975) suggested that females may dominate males during the nestling period, tolerating their presence only in conjunction with the delivery of food. Neither of the females observed in this study appeared to be overtly aggressive towards their mate and the reason for each pair's general avoidance of one another remains unclear.

The Rings♂ adults were rarely inattentive while on the eyrie (Table 1). Until the young were 10-15 d old, periods of inattentiveness occurred primarily between periods of brooding and feeding. This behavioral sequence also has been recorded for nesting Gyrfalcons (Jenkins 1978). With the cessation of brooding, the amount of time the Rings♂ adults were on the eyrie and inattentive declined to < 1%, and they spent 90% of the time away from the eyrie. In contrast, the Lone Female adults spent an increasing amount of time inattentive on the eyrie as the nestlings matured (Table 1). This probably re-

flects the fact that one of the Lone Female adults frequently perched away from the nest scrape but within the field-of-view of the camera.

Nestling Behavior. — Peregrine Falcons are semi-altricial (Nice 1962). At hatching, young are sparsely covered with down, and their eyes, although usually open, are weak and relatively non-functional (Brown and Amadon 1968). The young are dependent on their parents for food throughout the nestling period and for at least 6 wks after their first flight (Nelson 1970; Sherrod 1983). Time of first flight varies, but usually occurs when the nestlings are approximately 30 (Herbert and Herbert 1965) to 43 d old (Nelson 1970).

The young at the Rings ϕ eyrie were relatively helpless and immobile during their first wk. They were not observed leaving the nest scrape until they were 9-10 d old (Table 3), at which time they could sit up and propel themselves short distances by hopping about on their wings. By the end of the second wk, the nestlings were actively shifting about as a group. They had begun to preen themselves and were able to grab food from the adult as often as it was offered to them. By d 15, the nestlings were tearing and shredding prey items and fighting aggressively over their food. They continued to spend most of the time in bodily contact with one another and on the nest scrape (Table 3). Vocalizations, identified as soft "kaks," were first heard at this time. During the fourth wk, the

nestlings became increasingly mobile as they began to stand and stay off their wings. Thereafter, the amount of time they spent on the nest scrape and in contact with one another decreased rapidly (Table 3). When last observed, mid-way through wk 4, the nestlings appeared healthy and likely to reach fledging age. They were extremely active and aggressive, were able to feed themselves and remained outside of the field-of-view of the camera for long periods of time.

Transferring the additional nestling to the Lone Female eyrie did not appear to affect the development or behavior of either young. The nestlings, like those at Rings ϕ , spent the majority of the time on the nest scrape during d 11-20 (Table 3). The amount of time the Lone Female young spent in bodily contact with one another during this period, however, was lower than at Rings ϕ . The presence of only 2 nestlings at Lone Female may explain this difference; at any point in time each of the 4 Rings ϕ nestlings had a greater probability of being in contact with at least 1 of its siblings than did either of the Lone Female nestlings.

In conclusion, time-lapse photography proved an effective means of monitoring the activities of adult and nestling Peregrine Falcons in West Greenland. First, the technique generated relatively large amounts of data with minimal disturbance of the birds (Enderson et al. 1972). Second, the information derived from the films

Table 3. Percent of time nestling Peregrine Falcons were on the nest scrape or were in bodily contact at 2 eyries in Greenland.

	AGE OF NESTLINGS ^a				
	3-5	6-10	11-15	16-20	21-24
On nest scrape					
Rings ϕ	100	95	94	90	36
Lone Female	ND ^b	ND	73	78	ND
In bodily contact					
Rings ϕ	90	80	91	85	28
Lone Female	ND	ND	46	54	ND

^aDays since hatching.

^bND = no data.

represents an important contribution to our knowledge and understanding of the Peregrine Falcon in the Arctic.

ACKNOWLEDGMENTS

We thank William G. Mattox and the rest of the 1974 Greenland Peregrine Falcon Survey Team for their help in the field and during the preparation of this manuscript; and Jim Weaver for assembling our cameras in watertight boxes. The Mellon Fund of Dartmouth College supported our research and the U.S. Air Force provided essential logistical support in Greenland. We thank them both. The Biomedical Laboratory of Edgewood Arsenal (U.S. Army) — currently the Chemical Research and Development Center, Aberdeen Proving Ground, MD, supplied essential funds for travel and field maintenance for the 1974 Greenland Peregrine Falcon Survey.

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Received 6 September 1984; Accepted 4 January 1985

THE HUNTING RANGES OF TWO FEMALE PEREGRINES TOWARDS THE END OF A BREEDING SEASON

RICHARD MEARS

ABSTRACT - Radio transmitters were fitted to two female Peregrine Falcon (*Falco peregrinus*) at adjacent territories in South Scotland, and each was tracked during the late nestling and early post-fledging period. Whilst the young were on the nest ledge, and for a week after leaving, both females remained close to the eyrie. Occasionally they left to hunt, probably within 5 km. Later the females began to range more widely. Eighteen days after the young had left the nest, one female regularly traveled 8-14 km, sometimes more, and once 18 km from the eyrie. The second female was not studied at this later stage. The territories of the two females did not apparently overlap. One female, next to a Golden Eagle (*Aquila chrysaetos*) territory, tended to avoid that area. Although birds hunted often over coniferous forest this was mainly for domestic pigeons and few 'woodland' species were recorded. One pair took a larger proportion of waders than the other and this was consistent with the observed ranges of the females, which included areas of low marshy ground for one, but not for the other.

During the breeding season, the male Peregrine Falcon (*Falco peregrinus*) is responsible for almost all the hunting for himself, the female and young nestlings. As the food demands of young increase, the female may have to take a more active hunting role. This may be especially so if the brood is large (Weir 1978).

For a pair of radio-tracked peregrines in California, the female made proportionately fewer hunting flights than the male, but when she did leave the vicinity of the eyrie, she appeared to go as far as the male and was tracked up to 8 km away (Enderson and Kirven 1983). Other peregrines, of undetermined sex, have been recorded hunting (not by radio telemetry) at 20 km and 27 km from their eyries (Porter and White 1973; Kumari 1974).

This study was an attempt to assess the foraging areas of two female peregrines with young.

STUDY AREA AND METHODS

The 2 eyries, A and B, were 4.5 km apart, about 300 m a.s.l., and had alternative cliffs 2.5 km and 3.0 km to the north, which had rarely been used. Eyrie A was easily observed from a road below; Eyrie B was 1 km from a road but was less easily observed because of trees close to the eyrie and beside the road. Both eyries were in areas planted with exotic conifers, mainly Sitka spruce (*Picea sitchensis*), Norway spruce (*Picea abies*) and larch (*Larix sp.*), but also various other tree species. Most of this new forest was 20-25 y old, but some small areas had trees over 50 y old (Fig. 1). Most of the remaining ground in the study area was open, mainly heather (*Calluna*) moorland or rough pasture, though some parts had recently been ploughed and planted with trees. To the east was a mixture of pasture, rough grazing and arable land, with scattered small clumps of coniferous or deciduous woodland. The valley bottoms had numerous small lochs and marshy areas.

Both eyries were on the edge of an upland area where several other peregrine pairs bred. Eyrie A had other pairs 9 km southwest and 9 km west, while eyrie B had other pairs 10 km south-west and 7 km west-northwest. There were none to the east or southeast within 30 km. A Golden Eagle (*Aquila chrysaetos*) reared 1 young

about 11 km southwest of eyrie A and an unsuccessful eagle pair nested 6 km southeast.

The 2 eyries were chosen because of their previous good breeding success and the good network of roads nearby. The females were trapped at the nest during incubation and 10 g radio-transmitters were fitted to their central tail feathers. On non-breeding Goshawks (*Accipiter gentilis*), transmitters of comparable weight and fitted in the same fashion did not interfere with prey capture, nutritional condition or tendency to leave an area (Kenward 1978). The transmitter signals could be detected from more than 10 km away when birds were soaring, but from much shorter distances when birds were perched. Reception was severely restricted by intervening hills.

Female A was monitored for a total of 178 h over 24 d, between 1 June and 25 July (Fig. 2). Female B was monitored for a total of 86 h over 16 d between 2 June and 30 June. Each was monitored until transmissions ceased to be heard, probably because of battery failure or because the central tail feathers were moulted. Both broods left the nest between 23 June and 27 June; 4 young (2 ♂♂, 2 ♀♀) at eyrie A, and 3 young (1 ♂, 2 ♀♀) at eyrie B.

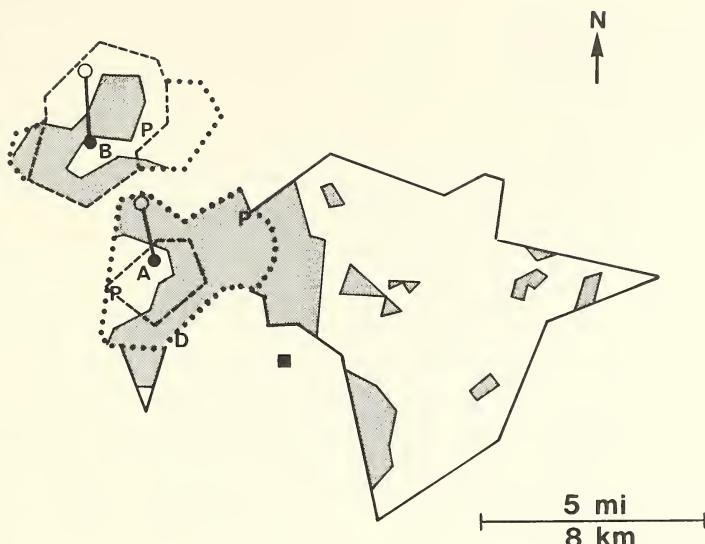
Both females were occasionally lost for up to 90 m (once 180 m); usually, I was away searching when a bird returned to the eyrie so exact times away were not known.

To begin with, I followed birds from the eyrie, but later it was more efficient to station myself at elevated points 5-10 km away and wait for the birds to appear. It was difficult to get cross bearings on a flying bird unless it was soaring, when precise location was usually possible.

Prey remains were collected after the young left the eyrie, as well as when eyries were visited to ring young. Additional data on prey were collected in other years, when these eyries were occupied by the same females.

RESULTS

Telemetry - Throughout the period when the young were on the nest ledge, female A spent 93% of the observed time at the cliff, either perched or feeding young (Table 1). She made several short flights and often soared above the eyrie. Longer trips were rare (only 1% of the time observed) but increased in number and duration after the young had left the nest (Table 2).



Hunting Ranges of Two Female Peregrines

Figure 1. Ranges of two female Peregrine Falcons in the British Isles. ● = Peregrine Falcon eyrie, occupied; ○ = Peregrine Falcon eyrie, unoccupied; ■ = Golden Eagle eyrie; □ = regular perch; ▲ = dispute with Golden Eagle; range limits: - - - = largely nestling period, = up to 18 d after fledging, — = over 18 days after fledging. □□ = open country. □□ = trees over 20 yr (within hunting range only).

When the young had been out of the nest a week, the female extended her range slightly to include two hills, one 2.5 km to the southwest, the other 3.8 km to the northeast of the eyrie (Fig. 1). The tops of the hills where she perched (once for 300 min) were mainly heather and boulders, but only one offered a view directly towards the eyrie. Also at this time the female was recorded on 4 occasions in the general area of the alternative nesting cliff, 2.4 km northward, and once was seen perched there, alone. Not until 18 d after the young left the nest was she recorded more than 8 km from the eyrie. She then travelled 8-18 km on each of the remaining 9 d that she was monitored; each day to the same general area to the southeast, usually between 8 km and 14 km, though twice when lost and relocated (after 40 min and 150 min) at about 14 km she may have been returning from a longer trip or she may have been perched on the ground (perhaps on a kill).

Female B also remained close to the eyrie when young were on the nest ledge but had a larger recorded range (22 km^2) than bird A (9 km^2), at this time (Fig 1). On 8 occasions the signal was lost for up to 90 min, during which time the bird could have

been on the hill opposite the eyrie on a perch that I later discovered, from which no signal could be heard on the road.

For 5 d after the young left the nest (the radio stopped working on the 5th day) the range of female B did not increase in size, though observation time was limited. The maximum recorded range of female B (23 km^2) did not overlap that of female A (117 km^2).

Activity - At all stages there was little activity for long periods and both females were often on their same perches for over 2 h at a time. After the young had left the nest, hunting trips by the females seemed to occur at any time of day, but were regular in the late afternoon to early evening period, and probably the early morning, because on 5 or 6 occasions female A was absent at about 0700 H when monitoring commenced (Fig. 2). This female was also often away from the eyrie at mid-day, but at this time was more usually perched elsewhere. Hunting flights varied in length; female A was 8 times away for 2-3 hrs, but may not have been actively hunting all of this time. She sometimes left the cliff and returned with prey in 20 min or less (Table 2). I had no information on the proportion of food brought

Table 1. Observed times spent (minutes) at nesting cliffs and away, in the later stages of breeding, by 2 female Peregrine Falcons.

		TIME SPENT NEAR EYRIE (WITHIN 2 KM)				TOTAL TRIPS > 2 KM FROM EYRIE				Lost	
TOTAL OBSERVATION TIME	TIME AT CLIFF	% OF OBSERVED TIME AT CLIFF		No. OF FLIGHTS NOT EXCEEDING 2 KM		No. OF TRIPS AWAY > 2 KM		No. OF TRIPS 2-5 KM		No. OF TRIPS 5-10 KM	
		WITHIN 2 KM	FROM EYRIE	NOT EXCEEDING 2 KM	FROM EYRIE	WITHIN 2 KM	AWAY > 2 KM	2-5 KM	5-10 KM	10+ KM	TOTAL TIME
BIRD A											
June 1 - June 24, large nestling	3250	3019	93	25	217	99		0	0	0	3
June 27 - July 3 up to 1 week after fledging	1370	1176	86	8	24	88	4	0	0	0	4
July 10 - July 16 2-3 weeks after fledging	3195	1565	49	210	56		14	920	340	0	5
July 17 - July 25 3-4 week after fledging	2670	1570*			59	10	290	220	255	4	335
BIRD B											
June 3 - June 22 large nestling	4140	3173	77	16	282	83	9	275	20	0	8
June 27 - June 30 up to 1 week after fledging	1050	855	81	3	55	87	3	90	0	0	1
											50

* Grouped together because observations were made by telemetry from 10 km away.

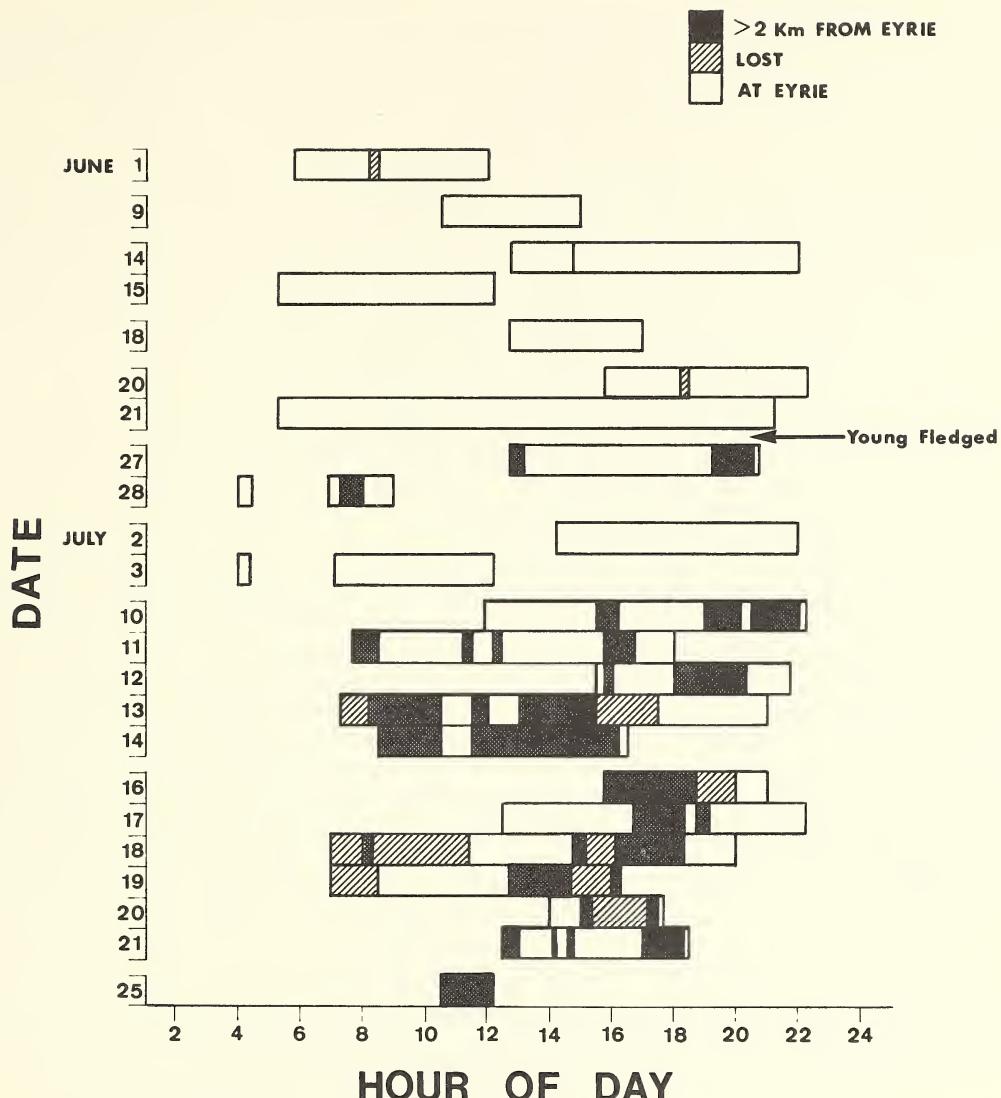


Figure 2. Peregrine Falcon nesting activity in the British Isles study area during continuous monitoring periods (Bird A only).

to the young by the two females.

There was little or no activity after 2000 H when continuous monitoring ceased; both females roosted on their cliffs close to their eyries.

Sight Observations - Despite radio-location, actual sightings of birds away from their eyries were few. On 6 occasions when female A was seen clearly, she was apparently alone, but once she was seen together with a male (probably her mate) 3 km from the eyrie. Bird B was seen 3 times alone and twice

with a male at 3 km and 4.5 km away from the eyrie. There was no indication of cooperative hunting in these instances.

At other times, I witnessed 5 attempts to catch prey, 4 of them above forest; twice this involved Domestic Pigeon (*Columba livia*) flocks, once a flock of unidentified birds and twice probably a small passerine. Each attempt was unsuccessful and was between 0.5 km and 4 km from the eyrie.

Adults were often pursued by their young beg-

Table 2. Length of time (min) spent > 2 km from eyries.*

	BIRD A TIME AWAY				BIRD B TIME AWAY			
	No	Av	Min	Max	No	Av	Min	Max
Nestling period	3	5	2	10	2	38	15	60
Young out of nest - 1 week	4	43	5	93	2	53	15	90
- 2-3 week	9	90	10	300	-	-	-	-
- 4 week	9	77	20	150	-	-	-	-

*Excludes trips when birds were lost, if birds returned to eyries while I was away searching.

ging for food even if not carrying prey; no young peregrines were seen more than 2 km from either eyrie.

Interactions with Other Birds - On 1 occasion female A was seen in aerial dispute with one of the neighboring Golden Eagles, together with a Merlin (*Falco columbarius*). The dispute continued for 6 min, after which the peregrine flew off towards her eyrie 3 km away. The Merlin pursued the eagle for 2 min longer, until the eagle moved south.

The general vicinity of the eagle eyrie to the southeast seemed to be avoided, and once when

returning to her eyrie from 15 km away the peregrine took a course that avoided flying directly over the eagle nest, even though this would have been the shortest route.

Bird A (and her mate) also briefly mobbed a Common Buzzard (*Buteo buteo*) when it was 3.5 km from the eyrie, and chased away a Carrion Crow (*Corvus corone*) from the front of the breeding cliff, though with no serious attempt to strike it.

Diet - The prey recorded at both eyries were predominantly Domestic Pigeons and few 'woodland' species were taken in 1978 or in other years;

Table 3. Proportion of main prey groups in the large nestling and early post fledgling periods.

	TERRITORY A		TERRITORY B	
	1978 (38 ITEMS)	1977-79 (66 ITEMS)	1978 (17 ITEMS)	1977-80 (76 ITEMS)
Game bird	3	1	0	3
Wader	31	26	12	13
Pigeon	47	53	53	49
Passerine*	16	17	35	34
Gulls, terns, ducks	3	3	0	1
'Woodland' species	5	4	12	8

*Including Cuckoo and Great Spotted Woodpecker.

most passerines were Meadow Pipit (*Anthus pratensis*) or Starling (*Sturnus vulgaris*). More waders were recorded for eyrie A than B (Table 3).

DISCUSSION

The activity of the adult peregrines clearly varied from day to day depending upon hunting conditions. It might also vary according to brood size, age and sex of young, success of prey capture and average weight of prey generally available. Even with 3 or 4 young, the adults did not appear hard-pressed to obtain food and much time was spent in leisurely soaring or perching. In southwest England, Treleaven (1977) also noted long periods of inactivity by both sexes, in all the later stages of breeding; birds would often remain perched for hours, and twice birds were on the same perches for over 6 h at a time.

During the nestling period both females remained within the general vicinity of their eyries almost all the time. This was consistent with observations by Parker (1979) at one Welsh coastal eyrie where the female spent 89% of the time observed at the nesting cliff. Occasionally she hunted pigeons out over the sea when she sometimes "could hardly be seen with binoculars". It is also consistent with the general observation that the female is almost invariably present when peregrine eyries are visited at this stage.

Adult peregrines elsewhere have been observed seeking out perches either not obvious to their young or away from the nesting cliff, in response to increased and persistent aggression by their young in demanding food (Sherrod 1983). This may partly explain the extension of range for female A which took place when young had been out of the eyrie for a week and the long periods she spent perched on nearby hills.

Ranges for all raptors are likely to be larger in the late nestling and post-fledgling periods than at other times in the breeding cycle, as food demands increase and the need to defend young decreases (see e.g. Marquiss and Newton 1982, for Sparrowhawks (*Accipiter nisus*)). In the breeding season the distances travelled must ultimately be limited by the need to return with heavy prey, itself a tiring feat. The maximum recorded distance from the eyrie of 18 km is intermediate between some other observations on peregrines. Outside the breeding season, when there is no need to return with prey,

the range could be larger still.

The 2 ranges did not apparently overlap, but they may have done so outside the breeding season. One adult female known to have been from the eyrie 7 km WNW of eyrie B was found dead, within the breeding season range recorded for bird B in 1978. This was in December 1980, when the bird flew into a stone wall. Other untagged peregrines breeding nearby could have hunted in the same areas or flown over them in order to get to low ground, though no intruding peregrines were seen during the telemetry work.

Golden Eagles are dominant over peregrines in choice of eyrie (Ratcliffe 1980) and probably over at least part of a hunting range. Flying around a Golden Eagle territory, rather than directly over it, would involve less expenditure of energy and time if it avoided a dispute with an eagle, especially when carrying prey. Meinertzhagen (1959) once saw a peregrine robbed of a grouse kill by a Golden Eagle.

Throughout, both females apparently hunted over all types of habitat within their recorded ranges, including both young and mature conifer plantations. Catching prey, such as Domestic Pigeons, above forest is unlikely to be a problem (Mearns 1983), but the trees offer immediate refuge for prey being chased and could reduce the success rate.

Some of the waders recorded as food could have been taken as they flew past on migration and some may have come from upland breeding areas, but most were probably from low ground. Even though there was less information on the range of female B, she (and her mate) did not apparently hunt over the lower ground as much as the birds at eyrie A, as fewer waders were recorded as prey.

ACKNOWLEDGMENTS

I thank the Forestry Commission for permission to work on their ground and various members of their staff for help that they gave, in particular the late Alec Marshall. I also thank A. Allison and Dr. M. Marquiss for help with identification of prey; and Dr. M. Marquiss and Dr. I. Newton for constructive comments on the original drafts of this paper.

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Received 28 January 1983; Accepted 15 April 1984

HOW EFFECTIVE ARE HUNTING PEREGRINES?

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ABSTRACT - Data on Peregrine Falcon (*Falco peregrinus*) hunting success are reviewed. Breeding adults have a mean success rate of 34.9%, significantly higher than adults in the non-breeding season which have a rate of 12.7%. Juveniles have a success rate of 7.3%, significantly lower than non-breeding adults. Factors affecting hunting success rates are discussed.

Since Rudebeck (1950-51) published his results on the hunting efficiency of some migrating raptors, the hunting abilities of the Peregrine Falcon (*Falco peregrinus*) have been widely discussed. I have analyzed available data on this subject in order to trace any differences in hunting success between different categories of peregrines.

RESULTS

Data on peregrine hunting efficiency are presented in Table 1. In addition, Monneret (1973) found a success rate of a. 10% (37 out of a. 400 attacks) for peregrines in a French mountain area.

The variation in hunting performance is enormous (7 - 83% success rate). Juveniles are significantly less successful than adults outside the breeding season, with success rates of 7.3 and 12.7%, respectively ($X^2 = 7.2$, $P < 0.01$, sources 1,7,12 and 3,5,7,15 (Table 1)). A few of Rudebeck's (1950-51) birds may be adults, so the difference is probably slightly greater.

Breeding adults are more successful (34.9%) than adults outside the breeding season (12.7%) ($X^2 = 149.1$, $P < 0.001$, sources 2,3,4,6,9,10,11,13,14 and 3,5,7,15 (Table 1)).

Data on sexual differences in hunting efficiency

Table 1. Studies on Peregrine Falcon hunting success

AUTHOR	HUNTING SUCCESS %	N	COMMENTS
1. Rudebeck 1950-51	7.3	260	Migration
2. Hantge 1968	17.0	69	Breeding ♀
"	11.0	121	Breeding ♂
3. Lindberg 1975	13.7	350	Winter, ad. ♀
4. "	13.7	51	Breeding
5. Clunie 1976	9.6	62	Winter, ad. ♀
6. Parker 1979	15.0	83	Breeding ♀
"	17.0	30	Breeding ♂
7. Dekker 1980	7.7	674	Migration
"	9.8	215	Adults
"	7.1	363	Juveniles
8. Hantge 1980	10.8	529	All year (only adults?)
9. Treleaven 1980	69.0	45	Breeding, "High Intensity"
"	30.0	10	Breeding, "Low Intensity"
10. Bird & Aubry 1982	35.0	197	Breeding pair
11. Cade 1982	83.2	183	Breeding ♂ ("Red Baron")
12. "	40.0	25	Subadults
13. "	31.0	32	Breeding
14. Thiollay 1982	25.4	318	Breeding Pair
"	16.5		♂
"	23.3		♀
"	37.8		Co-operative
15. Olsen & Roalkvam(unpub.)	13.7	453	Winter, ad. ♀

in breeding peregrines are too scarce to warrant an analysis, but Thiollay (1982) found that cooperative hunts were significantly more successful than when either bird hunted alone.

DISCUSSION

Although there is great variation in recorded hunting success, most studies reveal a success rate of 10 - 40%. This rather low rate is to be expected when predation is an important mortality factor for the prey species involved. The "life - dinner principle" has been put forward by Dawkins and Krebs (1979) to explain this: rabbits run faster than foxes because the rabbit runs for its life while the fox is only running for its dinner. Selection pressures are therefore stronger in improving the prey's anti-predator strategies than on the ability of predators to make successful hunting attempts. It is also to be expected that the success rate is lower for a predator (e.g. a peregrine) hunting evasive and agile prey than for a predator hunting less evasive prey, e.g. some fish species or insects (see Curio 1976: 193).

That juveniles are less able hunters than are adults is not surprising, as learning is very important in shaping hunting efficiency. Newly fledged peregrines often make attacks on flowers and insects as well as on more relevant prey. For a detailed account of the ontogeny of the behavior of young peregrines, see Sherrod (1983).

The higher hunting efficiency of breeding peregrines relative to birds outside the breeding season is interesting and has been noted by several authors, e.g. Dekker (1980) and Bird and Aubry (1982). This is often explained by a presumed higher motivation to make successful kills when hunting for young (Dekker 1980), resulting in more persistent pursuits by these birds than by non-breeding adults. There are other factors which may be equally important in explaining the difference: birds often form flocks in the non-breeding season, while they space out in the breeding season. Flocks are more vigilant and individuals harder to catch than lone birds (Kenward 1978). Further, there are large numbers of young, inexperienced birds during summer which should be easier to catch. It may also be that the difference in available prey species between seasons may affect the overall success rate. It is well documented that hunting success varies with prey species (Bird and Aubry

1982; Thiollay 1982). Finally, cooperative hunting which yields a higher success rate (Thiollay 1982) is restricted to the breeding season at least in areas where the peregrines are migratory.

Individual differences in hunting ability also occur. A notable exception in Table 1 is the "Red Baron", a released tiercel hunting from high perches over coastal marshes. In 1979 the Baron caught 95 birds in 102 hunts, a success rate of 93% (Cade 1982).

The availability of large open areas, e.g. coastal marshes, lakes or sea, is presumably favorable for hunting peregrines. Hunt et al. (1975) noted that peregrines sometimes missed intentionally and repeatedly in their stoops on released pigeons. When the pigeon took to the air, the falcon would guide it toward the ocean where escape possibilities were less. Also, the availability of suitable perches to hunt from is important. Treleaven (1980) observed that "still hunting" from a perch was more successful than when hunting "waiting on" on the wing.

Treleaven (1961, 1980), Hantge (1968), Dekker (1980) and Ratcliffe (1980) agree that a large portion of the peregrine's hunting attacks are not "serious". Hantge states that 20-40% of the attacks are of this category. Treleaven (1980) introduces the terms "Low Intensity" and "High Intensity" hunting to distinguish between the serious hunts and the others, with a success rate of 30% and 69%, respectively. The distinction between the two modes of hunting is however subjective and of little use in many situations. Even serious hunts may be given up long before contact is made. When the falcon is hunting from a perch, the hunt often lasts for only some seconds. In such instances it is virtually impossible to assess the "seriousness" of the hunt.

Playful hunting is well documented for young peregrines (Parker 1979; Sherrod 1983) where it occurs regularly when learning to hunt. In adults, "non-serious" attacks may be involved when 1) teaching the young to hunt, 2) chasing away intruders in the nesting area and mobbing birds, 3) testing a flock of birds before deciding to attack. Stoops meant to drive prey toward open areas, or to single out an individual from a flock should be considered part of the ordinary "serious" hunting process. The existence of "practice" attacks only meant to perfect hunting skills cannot be excluded, but it seems unlikely, especially in the breeding season, that a peregrine deliberately should avoid making a kill.

Food is a limiting factor that influences the breeding success (e.g. Thiollay 1982), and each extra prey (which can be cached for later use) reduces the possibility that the young may starve before fledging.

ACKNOWLEDGMENTS

I want to thank the reviewers for valuable comments on an earlier draft of this paper.

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Received 20 April 1983; Accepted 1 August 1984

POSITION ANNOUNCEMENT -- POSTDOCTORAL ASSOCIATE (70%) — Location: Department of Veterinary Biology, College of Veterinary Medicine, University of Minnesota. Requirements: Ph.D. in Physiology and one year of research experience working with avian species required. Two years research experience to include an interest and experience in fields of digestive function or avian energetics is desirable. Duties: The individual in this position would be expected to perform studies on neutral and/or hormonal regulation of avian GI motility and secretion. Salary: \$14,000/9 months (70% time). Application Deadline: 15 July 1985. Beginning Date: 1 September 1985.

Contact: Dr. Gary E. Duke, Department of Veterinary Biology, College of Veterinary Medicine, University of Minnesota, 295 AnSci/Vet Med Bldg., St. Paul, MN 55108.

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DISSERTATION ABSTRACTS

A STUDY OF THE BLACK-SHOULDERED KITE *Elanus caeruleus*

Colour-marked Black-shouldered Kites (*Elanus caeruleus*) were studied during 1977-1978 in a 6900 ha area near Settlers (24° 57' S; 28° 33' E) in the Springbok Flats, South Africa. Most of the annual rainfall of 601 mm fell during the summer months. About 75% of the area was cultivated. Results from ringing and moult studies during 1970-1976 in a wider area of the Transvaal Province were incorporated into the present work.

The study aimed to describe the basic biology of kites and to investigate the role of food supply in their behaviour and breeding. About 97% (n = 3408) of prey found in pellets were small mammals (Mendelsohn, J.M. 1982. *African J. Zool.* 17:197-210). Three rodents, *Otomys angoniensis*, *Rhabdomys pumilio* and *Praomys natalensis*, formed about 92% of the weight of the kites' prey. Regular trapping suggested that rodent densities changed substantially during the study. Measures of the food intake of kites showed changes that closely matched variation in rodent numbers (Mendelsohn, J.M. 1982. *Durban Mus. Novitates* 13:75-116).

The birds usually caught 1-3 prey items each day by hovering and perch-hunting. The proportions of hovering (about 30%), perch-hunting (70%) and the duration of hunting each day varied greatly. Non-breeders probably hunted for average periods of about 2 h each day while breeding males hunted for about 4 h. The 2 hunting methods differed in several ways; when hovering, prey was caught more rapidly than when perch-hunting, but hovering was energetically more expensive. Hovering was probably used to obtain prey as rapidly as possible, while perch-hunting helped minimize energy costs. It would be important to economize on daily energy expense since the unpredictability of prey capture means that excessive energy spent in hunting could not be replaced with certainty.

Individual kites showed a high degree of variability in their social behaviour and dispersion (Mendelsohn, J.M. 1983. *Ostrich* 54:1-18). Residents were unpaired, paired or breeding birds; unpaired kites experienced the poorest, and breeders the best, feeding conditions. Males usually established territories and remained resident as long as food supply allowed. Territories with good feeding conditions were at a premium and nomadic males probably spent long periods searching for suitable vacancies. Females seldom occupied territories alone but usually settled with territorial males. Most females settled to pair with males when most pairs were starting to breed. Females also deserted territories more readily than males and moved around probably in search of those males with territories holding the best breeding prospects. There were always more males than females in the study area and this could have allowed females to change territories often.

Many males and females were resident for short periods and, as a result, the average monthly turnover of residents was about 26%. These short-term residents and records of great concentrations of kites suggest that kites are often eruptive and nomadic, particularly when rodent densities vary erratically. Information concerning changes in food supply is probably exchanged at communal roosts; kites roosted communally when feeding conditions were poor. Such itinerant behaviour contrasts with the site-tenacity of some individuals that remained resident for most or all of the census period.

Residents bred repeatedly and opportunistically at any time of the year. Some males made up to 7 breeding attempts in 19 months but most failed, particularly at early stages of the cycle. The average duration of breeding was: pre-laying (24 d), incubation (31 d), nestling period (35 d) and post-nestling period (82 d). Most adult females deserted soon after the young left the nest and probably searched for unpaired males to attempt breeding again. The flying young were fed by adult males for the remaining part of the post-nestling period. For males, each successful breeding cycle lasted on average 172 d. Some males started breeding again immediately after the young became independent, and thereby breeding twice in one year. Females, with a shorter participation in each breeding cycle, could breed three times each year.

Breeding females seldom hunted. Males supplied them and the young with food. Many breeding attempts failed, probably because of frequent food shortages. Females accumulated energy reserves during the pre-laying period which helped them produce eggs and probably withstand food shortages later in the cycle. Other adaptations to future feeding conditions are indicated. Kites might stop breeding if poor feeding conditions early in the cycle indicate that greater food demands are unlikely to be met later during the nestling period. They may also time breeding on the basis of the amount of breeding activity in their rodent prey, again as an indication of expected food availability (Mendelsohn, J.M., In press. *Proc. 5th Pan-African Ornith. Congr.*).

It is suggested that breeding females do not hunt and remain largely inactive at the nest so that they can conserve energy reserves. Further, the fact that females are larger than males enables them to store proportionately greater reserves. Males probably do not store energy because the increased weight of reserves would hinder their flying ability in catching prey.

Residents in the study area defended territories (feeding and breeding) against all conspecific intruders. Tail wagging was probably an aggressive display to warn other kites away. The most violent conflicts, sometimes involving physical contact, were between neighbouring residents; intruding nomads were repulsed more readily.

Kites showed several responses to excessive heat and cold. They usually perched in the shade of trees during the hot, midday period, or soared sporadically if they were hunting. Most nests were built in the SW sectors of trees where incubating females and nestlings were protected from direct sun. In the early morning kites usually perched low above the ground where they were less exposed to cold wind. Similarly, they roosted within the foliage of trees during winter, where they were more protected from cold wind than on perches on the outermost branches of trees, their roost sites at other times.

Most kites moulted during summer and this seasonality contrasted with the variable timing of their breeding. Primary feathers moulted in a single sequence from the inner wing outwards, but sequences in the secondaries and rectrices were variable, as in many raptors.

Several size differences were found between males and females and between adults and 2 age groups of subadults. Changes in the weights of subadults during the year, and probably in those of adults, corresponded to changes in food supply. Males that remained resident for long periods were probably morphologically more 'typical' than short-term residents. The physical features of males may therefore in part determine their ability to catch prey and consequently to pair and breed successfully. The performance of females, however, may depend more on their ability to choose mates and territories which will provide the best feeding conditions.

In conclusion, I suggest that unpredicted fluctuations in feeding conditions play a central role in the biology of kites. Such fluctuations occur at 2 levels, one on an hourly or daily basis and the other on a weekly or monthly scale. The capture of large and irregularly spaced prey is an unpredictable event and several aspects of hunting behaviour and daily activity are geared to meeting the general requirement of obtaining prey as rapidly and at the least possible energy expense.

Many social, spatial and breeding strategies are probably adaptations to feeding conditions that fluctuate over longer periods. While kites often survive and occasionally breed in situations of moderate food supply, the 'slumps' and 'gluts' in prey numbers are the periods when selection is most severe. It is then that kites will either manage to survive or will so capitalize on a superabundant food supply that they leave great numbers of offspring. Mendelsohn, J.M. 1981. Ph.D. Dissertation. University of Natal, Pietermaritzburg, South Africa. 285 pp.

UNIFORMITY IN RELATIVE HABITAT SELECTION BY *Buteo lineatus* AND *B. platypterus* IN TWO TEMPERATE FOREST REGIONS

I have examined nest site habitat use and selection by 2 woodland hawk species, *Buteo platypterus* (Broad-winged Hawk, BWH), and *B. lineatus* (Red-shouldered Hawk, RSH). The hypothesis tested was that species select similar nesting habitat in dissimilar regions after accounting for differences in habitat availability.

Study sites were located in northeast Wisconsin (WI) and in western Maryland (MD). Twenty-seven characteristics were measured at active nest sites from 1978 through 1982. Also, random samples were collected to estimate habitat availability. Sample sizes were: 87 MD BWH, 34 WI BWH, 30 MD RSH, 22 WI RSH, 100 MD random, and 73 WI random. The two regions differed in structural features of the available habitat, and both species selected only portions of the available habitat within each region. Also, habitat use by BWH and RSH differed between regions.

To determine whether relative habitat selection differed between regions for each hawk species, I adjusted for regional differences using a series of 'Z' score rescalings of the availability data. Study area differences were eliminated by these transformations. The resultant data vectors were then applied to the specific hawk data sets for tests of habitat selection uniformity. Relative habitat selection was uniform between regions. For the BWH, only 2 of 18 rescaled variables were different between regions. Three of 18 rescaled variables were different between regions for RSH.

I contend that these two species have uniform patterns of habitat selection. Differences in habitat use between regions may merely reflect habitat availability related to differences in scale between regions. Titus, Kimberly. 1984. Ph.D. Dissertation, Univ. of Maryland, Cantonsville. Dissertation directed by James A. Mosher, Appalachian Environmental Laboratory.

NEWS AND REVIEWS

RESOLUTIONS

At the 1984 annual meeting held in Blacksburg, Virginia, the following resolutions were adopted by the Board of Directors of The Raptor Research Foundation, Inc.

RE: In Appreciation of the Hawk Mountain Sanctuary Association

WHEREAS, in 1934, the Hawk Mountain Sanctuary Association established the first formal sanctuary for birds of prey anywhere in the world; and

WHEREAS, the programs initiated by the Hawk Mountain Sanctuary Association 50 years ago have grown considerably, providing many educational and research opportunities; and

WHEREAS, the hard work of the people in the Hawk Mountain Sanctuary Association has facilitated the viewing and appreciation of raptors during migration and at other times by approximately 50,000 people annually; and

WHEREAS, the staff at the Hawk Mountain Sanctuary has taken an active role in many raptor conservation issues and programs outside the sanctuary;

NOW, THEREFORE, BE IT RESOLVED that The Raptor Research Foundation, Inc., commends the Hawk Mountain Sanctuary Association for its foresight in recognizing the importance of habitat preservation for birds of prey and for their ongoing efforts to provide educational and research opportunities for the public; and

BE IT FURTHER RESOLVED that The Raptor Research Foundation, Inc., encourages the Hawk Mountain Sanctuary Association to continue in its leadership role in raptor conservation.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeff Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 28th day of January, A.D. 1985

Ruth K. Trembath
Notary Public, State of Florida

RE: In Support of Steel Shot for Migratory Game Bird Hunting

WHEREAS, lead poisoning has been documented in waterfowl since 1900; and

WHEREAS, the U.S. Fish and Wildlife Service estimates that approximately 2 to 3 million waterfowl die annually from lead poisoning; and

WHEREAS, lead poisoning has been documented in our national symbol, the endangered Bald Eagle; and

WHEREAS, a growing body of evidence indicates that many Bald Eagles die annually from lead poisoning; and

WHEREAS, lead presence and/or poisoning has also been documented in a number of raptors, including Prairie Falcons, kestrels, Red-tailed Hawks, and California and Andean Condors; and

WHEREAS, steel shot is non-toxic when ingested and an acceptable substitute for toxic lead shot;

NOW, THEREFORE, BE IT RESOLVED that The Raptor Research Foundation, Inc., supports the complete conversion to steel shot for all migratory game bird hunting; and

BE IT FURTHER RESOLVED that The Raptor Research Foundation, Inc., requests that the Department of the Interior and the U.S. Fish and Wildlife Service establish nationwide non-toxic steel shot regulations for all migratory game bird hunting as soon as possible, but no later than 1989.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeff Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 28th day of January, A.D. 1985

Ruth K. Trembath
Notary Public, State of Florida

RE: Biological Survey of the United States

WHEREAS, there exists both scientific and public awareness of the effects of acid rain, pesticides, and industrial pollutants on the environment; and

WHEREAS, no systematic national survey has been conducted to collect basic information on the existing composition of our flora and fauna; and

WHEREAS, without more extensive knowledge of the various species of biota and their interaction, it is virtually impossible to understand and, effectively, mitigate human impacts on natural habitats; and

WHEREAS, several other countries, including Australia, Hungary, India, Israel, New Zealand, and the Soviet Union, have recognized the need and initiated comprehensive biological surveys to address similar issues;

NOW, THEREFORE, BE IT RESOLVED that The Raptor Research Foundation, Inc., supports the establishment of a comprehensive Biological Survey of the United States; and

BE IT FURTHER RESOLVED that this program be designed to (1) describe the plants and animals of the United States, (2) fund basic taxonomic research of the biota, and (3) produce needed publications including identification manuals, species catalogues, and atlases of biotic surveys.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeff Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 28th day of January, A.D. 1985

Ruth K. Trembath
Notary Public, State of Florida

Proceedings — Second Symposium On African Predatory Birds. — The proceedings of this symposium, held in August 1983 at Golden Gate National Park, South Africa, are now available. The volume contains 25 full papers and 18 abstracts, presenting a wealth of new information and several reviews. A limited edition of 200 copies is available for sale R22,00 (postage included). Orders should be sent to the Natal Bird Club, % Durban Natural History Museum, P.O. Box 4085, Durban 4000, South Africa.

Guide to Owl Watching in North America. Donald S. Heintzelman, 1984. Winchester Press, Piscataway, New Jersey. Xiii + 193 pp., 65 photos, 2 figures, 2 tables. Paperback: \$8.95. Geographic scope: North America south to Mexico. — The stated purpose of this book is to stimulate interest in owl study and conservation via recreational owl watching, and in this the author has succeeded. Functionally, the book consists of three parts. The first part is an owl watching primer containing species accounts, chapters on owl watching methods and equipment, pellets and food habits, migrations, survival adaptations and conservation. The second part contains lists of field marks and abundant photos as further aids in identification, while the final part comprises state by state (and province by province for Canada) accounts of where to go to observe owls. The text is well written with a timely conservation-minded undertone, which reflects the author's background.

The species accounts include information on size, field recognition, flight style, voice, nest and eggs, food, habitat and distribution presented in a clear, concise manner. Their brevity is desirable considering the intended audience and those desiring further details can consult any of a number of sources, some of which Heintzelman refers to in the suggested reading list. However, several of the range descriptions could be updated. For instance, no mention is made of the Boreal Owl in northern Wyoming and Colorado, where breeding populations are known to occur, and the range description for the Flammulated Owl leads one to believe it is absent from Colorado.

Heintzelman's discussion of owl watching methods is diverse, but too brief. In particular I thought the section on nocturnal owl watching could be expanded. Mention is made that tapes of owl calls should be played for at least 2 min for each species. This statement is open-ended and should be considered further. While censusing Eastern Screech Owls in Connecticut, my mean response time for 271 owls was slightly over 3 min, while thus far for Great Horned Owls in Utah it is over 6 min, with some birds not responding until several minutes after the tape is shut off. Siminski (unpublished M.S. Thesis, Bowling Green University, 1976) found mean responses in Ohio for male Great Horned Owls occurred after 25 played vocalizations and for females after 28 played vocalizations. These studies indicate that while some species and individuals respond quickly to the tape, others are

considerably slower and for these, 10 min of tape playback followed by a 5-10 min listening period might be appropriate. The author drives home a good point regarding police relations while observing owls at night, as any owl enthusiast can attest to the time he's been checked-out by the local Gendarmes for conducting suspicious activities.

In the section on owl pellets there is a guide to their identification that lists owl species, pellet size and pellet characteristics. The pellet descriptions range from quite detailed for the Great Horned Owl to extremely vague for the Barred Owl, whose pellets are characterized as "compact". I found some of the terminology ambiguous: large versus very large, gray versus dark gray, and I contend that use of this guide will result in a high proportion of misidentifications. To a great extent this ambiguity reflects the within species variability of pellets, with pellet shape, size, color and composition depending on diet, season and age of the bird. Perhaps photographs illustrating an assortment of pellets for each species would be more helpful, although identification of pellets from an unknown source is almost always questionable. Heintzelman's stand on taking detailed locality data at the pellet collection site and using a reference skull collection in identifying prey is to be commended. A table of nest box dimension, based primarily on the work of Hamerstrom (Birds of Prey of Wisconsin, Dept. of Natural Resources, Madison, 1972) is presented, but entrance width for the Saw-whet Owl is given as 2.75 in, which differs from Hamerstrom's value of 2.5 in.

Photographs are black and white and of adequate quality, but the lists of field marks opposite them are at times repetitive. The list of owl watching sites is extensive, containing 224 entries, each with a brief habitat description, access routes and list of species to be on the lookout for. State and national parks and wildlife areas are heavily represented. Finally, there are appendices of accidental occurrences of owl species, conservation organizations and an owl pellet data form. I question the appropriateness of the first of these because it contains only a single species entry which could have been included in the species accounts. Despite its shortcomings, this book presents a wide variety of information of definite value for the beginning owl student and I wish it had been available some years ago when I first began to observe owls. — D.T. Walsh.

INSTRUCTIONS FOR CONTRIBUTORS TO RAPTOR RESEARCH

Effective with Volume 19, 1985

The editorial office of the Raptor Research Foundation, Inc., welcomes original reports, short communications and reviews pertaining to the ecology and management of both diurnal and nocturnal predatory birds for publication in *Raptor Research*. Publication in the journal is open to anyone, regardless of current membership in the Raptor Research Foundation, Inc. Contributions are welcomed from throughout the world but must be written in English. **Submit all contributions to the Editor, Clayton M. White, Department of Zoology, 161 WIDB, Brigham Young University, Provo, Utah, 84602, USA.** Referees and associate editors review each manuscript submitted for originality of data, ideas or interpretation, for accuracy, conciseness, and clarity. With the exception of abstracts, **manuscripts submitted for consideration must not have been published or concurrently be under consideration for publication elsewhere.**

MANUSCRIPT PREPARATION

Submit a typewritten original and **four copies of the text, tables, figure headings and all other materials for use by the referees.** Submit four copies of all illustrations. All typewritten material must be **double-spaced** on one side of $8\frac{1}{2} \times 11$ -inch ($21\frac{1}{2} \times 28$ cm), good quality, bond paper, with at least 1 inch ($2\frac{1}{2}$ cm) margins. Do not use erasable, mimeo, or light-weight bond paper. Copies may be Xerox or carbon reproductions of good, clear quality. Number pages through the Literature Cited section of the manuscript. Type the author's name in the upper right-hand corner of every page. Submit each table on a separate unnumbered page; combine legends for illustrations on one unnumbered page whenever possible. Material submitted in tables or illustrations should not be repeated in the text of the manuscript. Write mathematical formulas on one line whenever possible. Each manuscript should include a cover page containing a concise, informative, full title, a shortened version of the title (not to exceed 35 characters in length) to be used as a running head, and the name(s) of the author(s) as it should appear in print. Avoid footnotes and hyphenation.

Address for each author at the time the research was conducted should be listed at the end of the manuscript following the Literature Cited section. Present address of author(s), if different, should be listed, as well as name and full address to whom proof is to be sent. If you are no longer associated with the institution where the research was conducted, but you wish to credit that institution, it may be mentioned first.

Provide an abstract for each manuscript more than four double-spaced typewritten pages in length. Abstracts are submitted as a separate section from the main body of the manuscript and should not exceed 5% of the length of the manuscript. The abstract should recapitulate the overall findings of the research and should be suitable for use by abstracting services.

Authors should cite the scientific and (if any) common names of all species at first mention in **both** the abstract and the main text of the manuscript. Names for birds should follow those in the A. O. U. Check-list of North American Birds (sixth ed., 1983), or an appropriate equivalent. Subspecific identification should only be cited when pertinent to material presented in the manuscript. In all cases where the scientific and common names are cited together, the common name should be placed first.

Metric units should be cited for **all** measurements in accordance with Système International D'Unité (SI) notation and conventions. Abbreviations of statistical terminology and mensural units should conform with the Council of Biology Editors (CBE) Style Manual (fourth ed., 1978, American Institute of Biological Sciences, 1401 Wilson Blvd., Arlington, Virginia, 22209, USA). Use the 24-hour

clock (e.g., 0830 and 2030) and "continental" dating (e.g., 1 January 1984). Consult the CBE Style Manual and current issues of *Raptor Research* on particular matters of style.

Raptor Research is published in a double-column format. Therefore, authors should consider whether a table or illustration can best be presented in a single-column, with the vertical axis of the table or illustration longer than the horizontal, or covering an entire page width.

Tables should not duplicate material in either the text or illustrations. Tables are typewritten, **double-spaced throughout**, including title and column headings, should be separate from the text and be assigned consecutive Arabic numerals. Each table must contain a short, complete heading. Footnotes to tables should be concise and typed in lower-case letters.

Illustrations (including coordinate labels) should be on $8\frac{1}{2} \times 11$ -inch ($21\frac{1}{2} \times 28$ cm) paper and must be submitted flat. Copies accompanying the original should be good quality reproductions. The name of the author(s) and figure number should be penciled on the back of each illustration. All illustrations are numbered consecutively using Arabic numerals. Include **all** illustration legends together, typewritten **double-spaced**, on a single page whenever possible.

Line illustrations (i.e., maps, graphs, drawings) should be accomplished using undiluted india ink and designed for reduction by $1/3$ to $\frac{1}{2}$. Drawings should be accomplished using heavy weight, smooth finish, drafting paper whenever possible. Use mechanical lettering devices, pressure transfer letters or calligraphy. Typewritten or computer (dot matrix) lettering is **not acceptable**. Lettering should be large enough when submitted that it will be as large as text type (7-10 point) when reduced by 50%. Avoid bold, heavy or ornate letters that would tend to distract from the illustration. Use a pattern of lines and dots for shading that will not appear as a solid tone when reduced. Include a key to symbols used within an illustration, unless the symbols are best explained in the legend. Measurement scales (e.g., distance) should be given in the illustration itself.

Some special symbols cannot be typeset by the printer. Therefore, if a magnification scale is needed in connection with a photomicrograph, for instance, the scale should be placed on the photo itself and not in the legend.

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three citations are referenced, each should include author and year (e.g., (Galushin 1981)), or, in a citation with three or more authors, the first author and year (e.g., (Bruce et al. 1982)). Citations of two or more works on the same topic should appear in the text in chronological order (e.g., (Jones 1977; Johnson 1979 and Wilson 1980)). Unpublished material cited in the text as "pers. comm.," etc., should give the full name of the authority, but must not be listed in the Literature Cited section. Authors should follow the BIOSIS List of Serials (1974, Biosciences Information Service of Biological Abstracts) as a guide for abbreviations and forms of titles of serial publications. If in doubt as to the correct form for a particular citation, it should be spelled out for the Editor to abbreviate.

Editorial review and revision processes will be conducted on manuscripts submitted for publication as regular articles or Short Communications. Manuscripts will be critically reviewed by referees selected for competency in the subject matter of the manuscript. Acceptance of a manuscript for publication will depend upon scientific merit, originality, timeliness, and suitability for the journal. The referee's comments and Editor's suggestions will be conveyed to the author. Manuscripts will generally be published in order of receipt, although publication may be advanced or delayed in order to maintain balance or to group manuscripts dealing with closely related subjects. Each published paper will show the date of receipt in the Editorial Offices and the date of acceptance of the final revision. Excessive time taken by authors in revising manuscripts will generally result in a delay in publication.

Proofs, typescript and reprint order forms will be sent to the senior author unless indicated otherwise. Please inform the Editor well in advance of any change in address or system for handling proofs. The corrected proofs and the original typescript should be returned to the Editor within 3 days of receipt. Corrections will be made without charge but revisions done by authors will be charged at the rate of \$20.00 per hour of additional typesetting.

Commentary on articles published in *Raptor Research* is invited by the Editor. Comments should be in letter form submitted in duplicate to allow one copy to be forwarded to the author whose work is being addressed. The recipient will be invited to reply. All submissions should be typed, double-spaced, signed, and be as brief as possible. Contributions to the Commentary section will be reviewed by the Editorial Board, which will select contributions for publication that are most pertinent to the interests of our readership.

Announcements of noncommercial raptor news, requests for assistance, etc., are invited by the Editor. Items submitted should be typed double-spaced in *Raptor Research* format. Announcements that carry a dead-line should be submitted at least six months in advance to allow enough time for publication and response. Advertisement notices will be published free of charge providing 15% of the proceeds requested are donated to The Raptor Research Foundation, Inc. All other advertisements will be charged at a rate consistent with current publication costs in effect at the time the ad request is received. The journal also publishes notices about selected new books, booklets, reports, etc., that are received in the editorial office. Authors and publishers are encouraged to submit a copy of their material for consideration and not just an announcement. Insure that price and source for all such material is given. A review of material when appropriate will be requested by the Editor and published in the journal.

PUBLICATION POLICY

The cost of producing an issue of *Raptor Research* is expensive, and membership dues alone do not meet the publication costs. In order to defray some of the costs of publishing the journal, it is the

policy of The Raptor Research Foundation, Inc., to expect authors of manuscripts accepted for publication to contribute to these costs through the use of institutional, grant or contract, or other funds available to them for this purpose. Those authors who are able to completely subsidize publication of their papers will be scheduled for publication in the earliest available issue of *Raptor Research* following approval of galley proofs. Authors who are members of The Raptor Research Foundation, Inc., but do not have access to institutional, grant or contract, or other funds may request a waiver of contributions toward publication costs. Authors of lengthy manuscripts are especially encouraged to help defray the costs of publication. It is unlikely that articles of more than 10 printed pages (i.e., 18 typewritten, double-spaced pages of manuscript including tables and illustrations) can be published without a significant contribution. The ability to contribute toward publication costs does not enter into the editorial decision regarding the acceptability of a manuscript.

There are some costs of publishing papers that are fixed and cannot be waived. These include costs of alterations or redrafting of figures, changes in proofs other than those correcting printing errors, and changes made necessary after type has been set as a result of excessively complicated text, or numerous tables or figures, or inclusion of color or black and white plates. Such charges will be billed to the author by the Treasurer.

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All funds should be made payable to The Raptor Research Foundation, Inc., and forwarded directly to the Treasurer: Dr. Gary E. Duke, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. All personal contributions towards publication costs, as well as other personal costs of preparing papers for publication, are tax-deductible.

Copies of these instructions are available upon request from the Editor, to whom correspondence regarding contributions to *Raptor Research* should be forwarded.

R A P T O R R E S E A R C H

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

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Raptor Research (ISSN 0099-9059) welcomes original manuscripts dealing with all aspects of general ecology, natural history, management and conservation of diurnal and nocturnal predatory birds. Send all manuscripts for consideration and books for review to the Editor. Contributions are welcomed from throughout the world, but must be written in English.

INSTRUCTIONS FOR CONTRIBUTORS: Submit a typewritten original and two copies of text, tables, figures and other pertinent material to the Editor. Two original copies of photographic illustrations are required. *Raptor Research* is published in a double-column format and authors should design tables and figures accordingly. All submissions must be typewritten double-spaced on one side of 8½ x 11-inch (21½ x 28cm) good quality, bond paper. Number pages through the Literature Cited section. The cover page should contain the full title and a shortened version of the title (not to exceed 30 characters in length) to be used as a running head. Author addresses are listed at the end of the Literature Cited section. Authors should indicate if present addresses are different from addresses at the time the research was conducted. When more than one author is listed, please indicate who should be contacted for necessary corrections and proof review. Provide an abstract for each manuscript more than 4 double-spaced typewritten pages in length. Abstracts are submitted as a separate section from the main body of the manuscript and should not exceed 5% of the length of the manuscript. Acknowledgements, when appropriate, should immediately follow the text and precede the Literature Cited. Both scientific and common names of all organisms are always given where first appearing in the text and should conform to the current checklists, or equivalent references, such as the A.O.U. Checklist of North American Birds (6th ed., 1983). Authors should ensure that all text citations are listed and checked for accuracy. If five or fewer citations appear in the text, place the complete citation in the text, following these examples: (Brown and Amadon, *Eagles, Hawks and Falcons of the World*. McGraw-Hill, New York, 1968), or Nelson (*Raptor Res.* 16(4):99, 1982)). If more than five citations are referenced, each should include author and year (e.g., Galushin 1981)), or in a citation with three or more authors, the first author and year (e.g., (Bruce et al. 1982)). Citations of two or more works on the same topic should appear in the text in chronological order (e.g., (Jones 1977, Johnson 1979 and Wilson 1980)). Unpublished material cited in the text as "pers. comm.", etc., should give the full name of the authority, but must not be listed in the Literature Cited section. If in doubt as to the correct form for a particular citation, it should be spelled out for the Editor to abbreviate.

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A more detailed set of instructions for contributors appeared in *Raptor Research*, Vol. 18, No. 1, Spring 1984, and is available from the Editor.

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RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

VOL. 19 NUMBER 2/3, SUMMER/FALL 1985

(ISSN 0099-9059)

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Provo, Utah

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

THE MERLIN

“THIS IS ONE OF THE MOST DASHING OF ALL BIRDS OF PREY, PURSUING ITS QUARRY WITH A SINGLE-MINDED TENACITY AND FEROCITY THAT CANNOT BE BETTERED BY MANY A LARGER AND MORE SPECTACULAR RAPTOR.”

L.H. BROWN, 1976.



Adult male Richardson's Merlin with House Sparrow — Saskatoon, Saskatchewan
Photo by L. W. Oliphant

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 19

SUMMER/FALL 1985

No. 2/3

NORTH AMERICAN MERLIN BREEDING SURVEY

LYNN W. OLIPHANT

ABSTRACT - A total of 864+ North American nestings of the Merlin (*Falco columbarius*) are summarized by state and province. Of these nestings, 812+ occurred since 1950. Productivity figures are presented for 526 successful nests. The number of nestings of the prairie race of Merlin (*F.c. richardsonii*) far outnumbered the other two subspecies and also exhibited the highest reproductive rate.

The Merlin (*Falco columbarius*) has been poorly studied in comparison to the other 4 species of falcons common to Canada and the United States. Trimble's (1975) review of the status of the Merlin concluded that "All North American Merlins have recently decreased in reproductive success". He also concluded that the great plains population (*F.c. richardsonii*) was "in the greatest trouble". Because the studies that led to these conclusions were based upon very limited sample sizes and more recent data on Merlins nesting in Saskatchewan indicated a rather healthy breeding population (Oliphant and Thompson 1978), I felt that an attempt to gather more information on the breeding status of this poorly studied falcon was in order.

METHODS

A "Merlin Working Group" was formed at the 1976 Raptor Research Meeting in Ithaca, New York, and a decision to summarize the breeding status of the Merlin was made at the 1977 meeting in Tempe, Arizona. Letters were mailed to over 60 persons known to have an interest in Merlins, soliciting information on the historic (pre-1950) and present (post-1950) breeding status of the Merlin. Summaries were made for each state or province with person(s) compiling the information indicated. The following criteria were used to edit submissions:

1. Minimum accepted evidence for a "nesting" was a defending pair seen during the breeding season.
2. Nestings at the same site in different years were counted as separate nestings (i.e. counted as a nesting for each year).
3. Only banding age nestlings or accurate counts of newly fledged young (branchers) were accepted for calculation of young/successful pair.
4. Published accounts of individual nestings (usually in local natural history journals) were included in the totals but not generally cited individually.

RESULTS AND DISCUSSION

Table 1 summarizes the results of the information submitted. Almost 75% of all recorded nestings since 1950 were Merlins (*F.c. richardsonii*) nesting on the northern great plains. Of these, approximately 85% were from the Canadian prairies. Reproductive success of this population was generally good (3-4 yg/successful nest) with the exception of the 7 nests reported for North Dakota that averaged only 2.0 yg/successful nest. Although no attempt was made to extract information from museum collections, a cursory examination of several large institutions confirmed that the majority of Merlin eggs collected during the late 1800's and early 1900's were also from the Canadian prairies. To what extent these data reflect the true distribution and breeding density of the Merlin or merely the relative ease of access to breeding areas by humans is difficult to assess. In any case, concern regarding the recent reproductive success of *F.c. richardsonii* (Fox 1971; Trimble 1975) can perhaps be allayed somewhat on the basis of the data presented here. Loss of suitable habitat is perhaps the most critical factor that is presently affecting Merlins on the prairies.

In comparison to the data on *F.c. richardsonii*, breeding information on the Merlins inhabiting the boreal forest (*F.c. columbarius*) is rather meager (Craighead and Craighead 1940; Lawrence 1946; Temple 1972). Recent reproductive success of this population is lower than that of *richardsonii* (2-3 yg /successful nests in most areas). Although there has been a decline in fall Merlin sightings at the

Table 1. Summary of Merlin nesting attempts and productivity.

AREA AND COMPILER	# NESTINGS	YOUNG/ SUCCESSFUL PAIR	DETAILS
1. Newfoundland (David Bird)	5 (pre-1950) 6 (1963-79) 20 (1969)	4/1 = 4.0 4/1 = 4.0 5/19 = 3.0	Includes 2 ground nests
2. Maritimes and adjacent islands (David Bird)	7 (1955-79)	7/3 - 2.3	Temple, 1972. (David Bird visited 6 of these sites in 1977 - none were occupied.)
3. Quebec (David Bird)	10 (1974-79) 1 (1965)		No breeding records for New Brunswick
4. Ontario (Gerry McKeating)	20 (pre-1950)		At least 5 of these nests hatched yg. and one fledged at least 4 yg. Fyfe (pers. comm.)
5. N.W.T. (Richard Fyfe)	11 (1950-78) 17 (1972-74)	16/6 = 2.7 26/6 = 4.3	Eggs or young noted at 16 of these sites.
6. Yukon (Dave Mossop)	No nesting records pre-1950 13 (1973-79)		8 possible additional nestings where only single adult observed; Nest sites new each year (not rechecks of old sites).
7. Manitoba (Bob Nero) (Dave Mossop)	2 (pre-1950) 5 (1954-77) 3 (1956-61)		Eggs at 3 of 4 sites where production not recorded; Casual observations of another estimated 5-6 pair in Northern Man. (1977-79). 3 fledged yg. at one site.
8. Saskatchewan (Lynn Oliphant) (Richard Fyfe)	27 (1958-65) 96 (1970-77) 70+ (1978-82) 14 (1967-76)	38/11 = 3.5 187/47 = 4.0 214/51 = 4.2 31/8 = 3.9	6 of the 27 known successful with unknown production and 1 known unsuccessful. Oliphant and Thompson, 1978. Urban Nestings Includes one nest in woodpecker hole.
9. Alberta (Alan Smith)	300+ (1968-79)	911/281 = 3.3	A single egg was taken from many of these nests for pesticide analysis. Productivity is reported without correction for this bias.
10. British Columbia (Keith Hodson)	4 (pre-1950) 11 (1969-1977)	-- 7/2 = 3.5	<i>F.c. suckleyi</i> 2 females collected, one with eggs; other 2 nests with unrecorded number of young. <i>F.c. suckleyi</i> At least 5 nests where production was not recorded were successful (fledged young seen)

(TABLE 1 CONTINUED)

(CONTINUATION OF TABLE 1)

AREA AND COMPILER	# NESTINGS	YOUNG/ SUCCESSFUL PAIR	DETAILS
11. Alaska (Doug Weir)	2 (1960's)	5/1 = 5.0	Other nest unsuccessful. Adolphson, 1969.
	21 (1974-79)	6/2 = 3.0	Several other probable nestings where only single bird was seen.
	5-6 (1980)	--	Fledged broods
12. Washington (Clifford Anderson)	1 (pre-1950)		<i>F.c. suckleyi</i>
	3 (1978-79)		Unconfirmed reports of <i>F.c. suckleyi</i> . One nest with a minimum of 3 fledged yg.
13. Idaho (Timothy Craig)	3 (pre 1950)		Craig and Renn, 1977
	1 (1973)	--	
	1 (1975)	3/1 = 3.0	4 eggs June 1 5 eggs June 5 All hatched, 2 died
	1 (1977)	--	Same site as 1975 - unsuccessful
14. California (Jim Adamson)	--	--	No known historical records - All "Merlin eggs" are American Kestrel. Recent - Merlins observed in N. Calif. in June and July; no nests found.
15. Nevada (Bob Oakleaf)	--	--	No confirmed nestings.
16. Wyoming (Bob Oakleaf)	1 (pre-1950)		Bent (1938)
	21 (1961-79)	20/7 = 2.9	2 nests known to have failed
17. Montana (David Ellis)	8 (1970-74)	15/5 = 3.0	Ellis (1976)
	10 (1977)	4/1 = 4.0	3 nests known to be unsuccessful although 5 young hatched at one site and died subsequently
(Dale Becker)	8 (1978)	24/7 = 3.4	Only one nest located, other sites (9) had active pairs
	18 (1979)	60/17 = 3.5	
	15 (1980)	49/14 = 3.5	All sites successful
	16 (1981)	38/10 = 3.8	
18. Colorado (Alan Jenkins)	2 (pre 1950)		1877 and 1887
19. Utah (Alan Jenkins)	2 (pre-1950)		Eggs collected in 1868 and 1869
20. North Dakota (Howard Postovit)	5 (1977-78)	9/5 = 1.8	2 yg. killed by Weasel at one nest; 2 other nests with addled eggs (1 yg. and 4 addled eggs and 2 yg. and 2 addled eggs).
(Bill Cornatzer)	5+(pre-1950)	5/2 = 2.5	
	2 (1977)		

(TABLE 1 CONTINUED)

(CONTINUATION OF TABLE 1)

AREA AND COMPILER	# NESTINGS	YOUNG/ SUCCESSFUL PAIR	DETAILS
21. South Dakota (Steve Duecker)	7 (1970) 3 (1971)	15/4 = 3.8	Unknown # yg. fledged in re-maintaining 3 sites. 2 nests checked had 2 and 4 small downies.
22. Nebraska (Ross Lock)	No historical records 5 (1975-78) 3 (1980)	-- --	One additional site with male only. 1 nest with 4 newly hatched young and 1 egg. 2 nests with 5 yg. each (less than 1 week old).
23. Wisconsin	3 (1966-68)	2/1 = 2	Sindelar and Jacobson 1981.
24. Michigan (Sergej Postupalsky)	3 (pre 1950) 19 (1955-67) 1 (1979)	-- 24/8 = 3.0 --	All 3 successful
25. New York, Penn. New England (Mark Fuller and Janet Partelow)	--	--	No authenticated records although some recent and historic sightings during the breeding season.
26. Minnesota (P.B. Hofslund)	4+(pre-1950) 13(1950-64) 4 (1952-81) 6+(1951-60)	4/1 = 4.0 5/1 = 5.0	Johnson 1982 - 3 nests contained 4, 4 and 2 yg. less than 1 week old. Beer, 1966 Johnson, 1982

Cedar Grove Ornithological Station in Wisconsin (D.D. Berger, unpub. obs.) the Merlins migrating along the east coast have increased over the past 10-15 years (W.S. Clark, F.P. Ward pers. comm.) despite the rather low productivity figures presented here. This discrepancy between the recent migration data and reproductive data is also true of the Peregrine Falcon (*Falco peregrinus*) and needs to be addressed.

The darkest Merlin (*F.c. suckleyi*) remains the least well studied of the three North American subspecies. Only 14 nestings potentially attributable to this subspecies since 1950 are reported here and production figures were available for only 2 nests (3.5 yg./successful nest). Conclusions as to the status of this population must await further study.

ACKNOWLEDGMENTS

The enthusiasm and work of Bud Anderson, Chris Servheen and Dale Becker was largely responsible for the initiation of the "Merlin Working Group" and the publication of this special Mer-

lin issue and is gratefully acknowledged. The effort of all those making contributions to this survey is greatly appreciated. The author takes full responsibility for any residual errors in the report.

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FOOD HABITS AND BREEDING BIOLOGY OF MERLINS IN DENALI NATIONAL PARK, ALASKA

KAREN LAING

ABSTRACT - Four pairs of the Merlin (*Falco columbarius*) were studied during the 1983 breeding season in Denali National Park, Alaska. Additional observations were made of a fifth pair and a family discovered after young hatched. Observations began 30 April, during the courtship period, and ended 1 September, when Merlins had dispersed from nesting territories. To determine food habits, prey remains were collected and identified, and prey delivery behavior was recorded. Productivity was determined by checking nests during incubation and after young hatched. Breeding behavior, including sex roles and nest defense, was also documented during 125 h of observation.

Little is known about the status of the Merlin (*Falco columbarius*) in Alaska. During the past 2 decades some attention was given the decline of breeding populations in other parts of the range (Fox 1971; Hodson 1976; Newton et al. 1978; Oliphant and Thompson 1978; Newton et al. 1981; Williams 1981; Roberts and Green 1983). In contrast, information on Merlins in Alaska is limited to general surveys (Gabrielson 1944; Kessel and Cade 1958; Gabrielson and Lincoln 1959; Murie 1963; White et al. 1977; Ritchie 1982, 1983; Mindell 1983). The objective of this study was to gather preliminary information on their productivity, food habits, and breeding behavior in Alaska.

STUDY AREA AND METHODS

Merlin nests were studied in the Alaska Range, Denali National Park, Alaska, at 63°N. All nests were within 200 m of the park's only road, at elevations ranging from 770 m to 1230 m.

Merlins often nest in strips of white spruce (*Picea glauca*) woodland at treeline, (Figure 1). Below 770 m, spruce forest dominates, while above treeline willow (*Salix* spp.) and dwarf birch (*Betula nana* and *B. glandulosa*) give way to alpine tundra at about 1230 m. Between April and September the park receives most of its 37 cm annual precipitation. Rain accounts for most precipitation, but occasional snowfall may also occur in summer. Temperature ranges from 0° to 20°C. Daylength varies from 12 h in late March and September to 22 h in late June.

Field Observations - Four nest sites were located in April and May 1983. A fifth pair was observed in May, but a nest was not located. An additional family was observed in late July and early August.

One hundred twenty-five h were spent observing Merlins between 30 April and 1 September, when they are in the park. Approximately half the observation time was spent at 1 nest. Between 15 and 20 h were spent at each of the other 3 nests, and 9 h were spent observing other Merlins. Observations were made using 7 x 35 binoculars and a 20-45x zoom spotting scope. Observations at 2 nests were made from the road. The third nest was observed from atop a human food cache located 60 m from the nest, while the fourth was observed from the ground.

Nest trees were climbed once during the third week of incubation and twice after young hatched. On the third visit, young birds at 3 nests were banded.

Food Habits - Information on food habits was obtained largely from discarded prey remains found at plucking perches near nests. Remains were collected at least weekly at 2 nests, and at least bi-weekly at other sites.

Prey remains were identified by comparing prey items with study skins in the University of Alaska Museum. Mean prey weights were obtained from museum specimens and records. If remains of the same species were found at several locations near 1 nest on the same day, they were considered to be from a single individual except when feathers of juveniles could be differentiated from those of adults.

Aging Merlins - Dorsal plumage of juveniles closely resembled that of adult females, varying in color from medium brown to dark brownish gray. At close range, juveniles were identified by the upper tail coverts and rump feathers, which were the same color as the back. In contrast, the upper tail coverts and rump feathers of females were slate brown against the darker back (Temple 1972). The color of the cere, eyelids, legs and feet proved a more useful field character. In adults all were bright yellow. Ceres and eyelids of juveniles were pale blue-gray to pale yellow, and legs and feet were pale yellow.

Sexing Merlins - Adults were usually separated in the field by their marked sexual dichromatism. Dorsal plumage in males was slate blue, and in females, brownish gray. In some males the buffy background color of the breast and belly gave way to orange at the throat and flanks, a character never observed in females. Adults perching together were more easily sexed since males were smaller than females. In some pairs vocalizations helped distinguish between sexes.

Juveniles were difficult to sex. When perched together, they could usually be sexed by size as in adults. At close range, they were sexed by the color of their light tail bands, which are gray in males, and buffy in females (Temple 1972).

RESULTS AND DISCUSSION

Food Habits — **Prey** - Bird prey remains were the only remains found near nests (Table 1). Although Merlins were observed to bite at insects near perches, predation on insects could not be confirmed since pellets were not analyzed. Snyder and Wiley (1976) note that studies of prey remains and pellets often give biased estimates of diets for raptors. Their data from stomach analyses, based on the number of prey items found, indicate that Mer-



Figure 1. Typical habitat occupied by the Merlin in Denali National Park, Alaska.

lins take 74.1% insects, 25.2% birds, 0.5% mammals and 0.2% lower vertebrates. However, most of their data were from migrants. Brown and Amadon (1968) estimate that, by weight, Merlins take 80% birds, 15% insects and 5% mammals.

Merlins preyed on 22 species of birds (Table 1). The main species were the American Tree Sparrow (*Spizella arborea*), Dark-eyed Junco (*Junco hyemalis*), Lapland Longspur (*Calcarius lapponicus*), Fox Sparrow (*Passerella iliaca*) and White-crowned Sparrow (*Zonotrichia leucophrys*), in decreasing order of occurrence. These 5 species formed approximately 49% of the numerical total remains collected.

The 5 species also made up 48% of the prey biomass, with the Fox Sparrow contributing most substantially (13.3%, Table 1). The Varied Thrush (*Ixoreus naevius*), Snow Bunting (*Plectrophenax nivalis*), and *Catharus* thrushes were not numerically important prey species, but did contribute substantially to total prey biomass (Table 1).

By contrast, the variety of major prey species taken by breeding Merlins elsewhere is much smaller. The Horned Lark (*Eremophila alpestris*) alone formed approximately 50% of the numerical prey

remains collected on the Canadian prairies by both Fox (1964) and Hodson (1976). Newton et al. (1978) in Northumberland, Great Britain, found the Meadow Pipit (*Anthus pratensis*) comprised 48% of numerical remains collected. Finally, Merlins at an urban site in Saskatoon, Saskatchewan, took an estimated 90% House Sparrows (*Passer domesticus*) (Oliphant 1974).

Habitat preferences of major prey species at Denali Park indicate that Merlins do not confine hunting to a particular habitat. Juncos are found primarily in spruce forest, while Tree, Fox and White-crowned Sparrows are common in willow and birch shrubland and spruce woodland, and Lapland Longspurs are found in alpine tundra.

Forty-five percent of prey items collected between 10 July and 6 August were identified as juveniles. Juveniles taken included the American Tree Sparrow, Lapland Longspur, White-crowned Sparrow, Dark-eyed Junco, Snow Bunting, Savannah Sparrow (*Passerculus sandwichensis*), Rosy Finch (*Leucosticte arctoa*) and Ptarmigan (*Lagopus* sp.).

Frequency of Prey Delivery - According to Krull (1976) and Daniel Gibson (pers. comm.), northern

Table 1. Prey remains found at 4 Merlin nests in Denali National Park, Alaska.

SPECIES	% ^a	% BIOMASS ^b
Ptarmigan (<i>Lagopus</i> sp.)	0.9	-
Semipalmated Plover (<i>Charadrius semipalmatus</i>)	1.8	3.4
Least Sandpiper (<i>Calidris minutilla</i>)	0.9	0.9
Horned Lark (<i>Eremophila alpestris</i>)	1.8	2.7
Tree Swallow (<i>Tachycineta bicolor</i>)	0.9	0.7
Catharus thrushes (<i>C. ustulatus</i> , <i>C. guttatus</i> , <i>C. minimus</i>)	0.8	9.0
Varied Thrush (<i>Ixoreus naevius</i>)	2.8	8.6
Water Pipit (<i>Anthus spinoletta</i>)	6.2	5.4
Orange-crowned Warbler (<i>Vermivora celata</i>)	2.8	1.0
Yellow Warbler (<i>Dendroica petechia</i>)	1.8	0.7
Northern Waterthrush (<i>Seiurus noveboracensis</i>)	0.9	0.6
Wilson's Warbler (<i>Wilsonia pusilla</i>)	1.8	0.6
American Tree Sparrow (<i>Spizella arborea</i>)	11.5	8.5
Savannah Sparrow (<i>Passerculus sandwichensis</i>)	3.6	2.6
Fox Sparrow (<i>Passerella iliaca</i>)	8.9	13.3
Golden-crowned Sparrow (<i>Zonotrichia atricapilla</i>)	1.8	2.4
White-crowned Sparrow (<i>Zonotrichia leucophrys</i>)	8.0	7.9
<i>Zonotrichia</i> sp.	0.9	1.0
Dark-eyed Junco (<i>Junco hyemalis</i>)	10.6	8.1
Lapland Longspur (<i>Calcarius lapponicus</i>)	9.8	10.7
Snow Bunting (<i>Plectrophenax nivalis</i>)	5.3	8.3
Rosy Finch (<i>Leucosticte arctoa</i>)	2.8	3.1
Common Redpoll (<i>Carduelis flammea</i>)	0.9	0.5
Unidentified small bird	5.3	-
Total	100.0	100.0

^aTotal prey items = 113.^bTotal calculated prey biomass = 2748 g; mean weights could not be determined for unidentifiable prey remains and Ptarmigan of unknown species and age.

Frequency of Prey Delivery - According to Krull (1976) and Daniel Gibson (pers. comm.), northern passernines rest 3 to 4 H daily, usually between 2300 H and 0300 H, despite long summer photoperiods. Since Merlins were observed hunting between 0400 H and 2330 H, a 20-H day was assumed for the purpose of estimating frequency of prey delivery.

During incubation, 18 May to 19 June, males delivered prey to females at a rate of 0.15 birds/h (3.0 birds/d). Between 19 June and 25 July, when young were being fed, males delivered prey to females at a rate of 0.48 birds/h (9.6 birds/d). Prey capture by females during breeding was not documented. In a study of a wintering female Merlin, Page and Whitacre (1975) estimated prey consumption at 2.2 birds/d. The Dunlin (*Calidris al-*

pina), the major prey species in that study, weighs approximately twice as much as major Denali Park prey species.

Hunting Behavior - Fast, low, horizontal flight from a perch has been described previously for Merlins (Bent 1938; Page and Whitacre 1975; Cade 1982). On 5 June a male departed its nest area and flew to an adjacent shrub-covered slope. He flew rapidly and close to the vegetation, gaining altitude only when he approached a rise, where he turned and swept back over the brush. He then perched without prey. Frederick Dean (pers. comm.) observed a similar low, fast flight along a ditch parallel to the park road. In this case the bird flew so low that it was level with the road bed. In another observation a male left his perch, flying fast over an

adjacent river valley. When he was about 1 km from the nest he began to dive at several small birds. Both the falcon and the pursued birds dipped and rose several times. Within 2 min, the falcon returned to the nest area with prey.

On several occasions females were observed to dive at a steep angle into brush below their perches near nests. Whether they were hunting or collecting cached prey could not be determined.

Feeding and Caching Behavior - Merlins removed the head and wings of prey and plucked most of the feathers before eating. Merlins usually prepared prey on snags, stumps or fallen logs within 150 m of the nest, using favorite perches repeatedly throughout the season.

Merlins sometimes cached prey in the vicinity of plucking perches. One Rosy Finch was found entire and unplucked. Four other birds were found partially plucked, with heads and wings removed. In 1 instance, following a food transfer, a female flew low toward an unseen perch for 10 sec, then appeared on a perch without prey. On another occasion, a female flew toward an unseen perch and then returned to the nestlings with prey. In this instance, the male had been absent from the area for 2 h.

Habitat and Nest Sites - Breeding Merlins at Denali Park favored sloping white spruce forest within 1 km of treeline. All 4 nests were in white spruce trees (Tables 2,3). One nest tree was living and undamaged, while a second had little green foliage. A third was living but was missing many branches on one side, where an old telephone cable was attached to the trunk with a glass insulator (Figure 2). The fourth nest was in a snag (Figure 3). Merlins nested only in abandoned nests of Black-billed Magpies (*Pica pica*) (Table 4). There was no evidence that Merlins altered the structure of Magpie nests.

Nesting habits vary throughout the Merlin's range. All nests recorded in Denali Park were in trees, and most Merlins in Norway and North America nest in trees (Fox 1964; Oliphant 1974; Oliphant and Thompson 1976; Hodson 1976; Cramp and Simmons 1980; Evans 1982). Near Arctic treeline in Alaska and Canada, Merlins nest on the ground (Bent 1938, Ritchie 1983, Clayton White, pers. comm.). Ground nesting is the norm in Great Britain. Seventy-seven percent of 96 nests in Northumberland (Newton et al. 1978), and 64% of 90 nests in Wales (Williams 1981) were on the ground.

Table 2. Description of 4 Merlin nest sites in Denali National Park, Alaska.

NEST	VEGETATION TYPE ^a	DESCRIPTION
1	Open needleleaf forest; white spruce	Nest tree was on a slope in open forest with a low, closed understory. Tree was located about 100 m from low, closed shrub scrub and 120 m from the road.
2	Open needleleaf forest: white spruce	Nest tree was in flat forest with low, open understory. Tree was located 50 m from low, closed shrub scrub and about 150 m from the road.
3	Closed tall shrub scrub: willow	Nest tree was on a slope dominated by tall willows (> 1.5 m). Area was formerly open spruce forest; almost all mature spruce trees were destroyed by porcupines during the 1950s, leaving many snags. Tree was 10 m from the road.
4	Open needleleaf forest: white spruce	Nest tree was on a slope in spruce forest with a tall, open understory. Tree was 500 m from shrub, 100 m from a river, and 90 m from the road.

^aVegetation nomenclature and classification follows Viereck et al. (1982).

Table 3. Measurements of white spruce nest trees used by Merlins in Denali National Park, Alaska during 1983.

NEST	TREE HEIGHT (m)	TREE DIAMETER AT NEST HEIGHT (cm)	TREE DIAMETER AT BREAST HEIGHT (cm)	HEIGHT OF NEST ABOVE GROUND (m)
1	9.3	18.8	37.6	5.5
2	7.5	12.9	22.2	5.5
3	9.0	18.8	26.9	4.1
4	10.0	21.8	28.3	4.1
\bar{x}	8.9	18.1	28.8	4.8
S.D.	1.1	3.7	6.5	0.8

Nesting Chronology - Spring arrival dates have not been documented for the Alaska Range, but records for interior Alaska indicate arrivals during the last 2 weeks of April. Occasionally individuals arrive in Fairbanks as early as late March (Brina Kessel, unpubl. data).

Merlins were first observed in Denali Park on 30 April, and engaged in breeding activity between that date and 15 May. During this period Merlins were extremely vocal. They were observed investigating Magpie nests, and on 10 May a female was flushed off a nest in which she later laid eggs. Harassment of other bird species near nests was first observed 7 May. All observed copulation attempts occurred between 30 April and 15 May. After 15 May females at all nests were observed only when they left nests to take prey from males, indicating that they began incubating during the third week of May.

Since Merlins incubate for 28-32 d (Cramp and Simmons 1980), it was assumed that Merlins in Denali Park hatched during the third and fourth weeks of June. On 29 June, nestlings at all nests were downy white, and were unable to grasp with their feet. On 10 July all young were able to grasp well. Nestlings at 1 nest had remiges over 6 cm long on this date. Their backs, wings and heads were well feathered, although down still projected through the plumage in tufts (Figure 4). Nestlings at 2 other nests visited on 10 July were still downy, with remiges 2-4 cm long (Figure 5).

The fourth nest visited 10 July was empty. The young left sometime after 5 July, when the adult female was last seen carrying prey to the nest. Mer-

lins at the other 3 nests fledged between 11 and 19 July. Merlins fledged about 32 d after hatching (Fox 1964; Newton et al. 1978).

After 20 July adults were only occasionally seen in nest areas, the last being a male on 16 August. Juveniles were first observed away from nest areas on 7 August. Merlins continued to be observed throughout the park until the first week of September.

Nest Success - All 4 nests contained 5 eggs, which compared to mean clutch sizes in Canada and Wales of 4.1 to 4.7 eggs (Fox 1971; Hodson 1976; Roberts and Green 1983). Fifteen of 20 eggs produced hatched, 2 did not hatch, and 3 were not accounted for, yielding a mean of 3.75 hatchlings/nest (range 2-5). A minimum hatching success of 75% was obtained on this basis. By contrast, Fox (1971) recorded 49% success in a Canadian population apparently affected by pesticide contamination, and 92-98% success in unaffected populations there.

Successful nests at Denali Park appear to be producing as many fledglings as reported for other areas. One nestling died soon after hatching, but all others fledged, giving a mean of 3.5 fledglings/nest. Hodson (1976) reported a mean of 3.2 fledglings/nest with young, while Oliphant and Thompson (1978) reported a mean of 4.0 fledglings/nest.

Courtship and Copulation Behavior - Merlins were observed investigating potential nests on 3 occasions. On 7 May, a female called "ki-ki-ki-keee" as she flew around the perched male. While the male remained perched, the female disappeared among the boughs of a spruce tree, where she uttered a "tick" call, and remained for 2 min. On 10



Figure 2. Magpie nest in White Spruce tree used by Merlins in 1983.



Figure 3. Magpie nest in dead spruce used by Merlins in 1983.

May, a female entered a Magpie nest and uttered "ki-ki-ki-kee", while a male flew in circles nearby, also calling. The female walked back and forth through the nest, then flew to an unseen perch and uttered a "chrrr" call, which often preceded copulation. The male flew toward her, also out of sight.

Food exchanges during courtship were usually slow and tentative. On 10 May, a paired male brought an unplucked Snow Bunting to the female

and perched beside her. The male transferred the bird to his bill as the female bit at it with her bill. The male then allowed the female to take the bunting, and she left the perch. The male remained on the perch an additional 5 min, gave a "tick" call twice, then flew in the same direction as the female. On 19 May, the male at another nest brought a bird to the nest area and perched. He uttered the "ki-ki-ki-kee" and "tick" calls, and bit at the prey. After 5 min

Table 4. Measurements (cm) of magpie nests occupied by Merlins in Denali National Park, Alaska during 1983.

NEST	NEST DIAMETER	BOWL DIAMETER	BOWL DEPTH	CAVITY HEIGHT
1	64.0	30.0	8.0	50.0
2	61.0	25.0	10.0	37.0
3	46.0	25.0	8.0	55.0
4	44.0	20.0	9.0	40.0
\bar{x}	44.0	20.0	9.0	40.0
S.D.	10.2	4.1	1.0	8.4



Figure 4. Nestling merlin in Alaska, age \pm 21 d.



Figure 5. Nestling merlin in Alaska, age 10 - 14 d.

the female perched on the same snag. The male crouched, transferring the prey to his bill, while the female stepped slowly down the branch toward the male. When she was close enough, the male allowed her to take the prey. The pair appeared to tug at the prey a moment before the male relinquished it. The female remained on the perch as the male flew to the nest tree and called.

Copulation attempts were observed 11 times during 16.3 h of observation between 30 April and 12 May. In one instance, Merlins attempted copulation twice in a 2 min period. One male mounted 3 times in a 2½ h period. Females often appeared to solicit copulation. Typically, a female called "ki-ki-ki-keee", flew low through the forest and perched near the male. The female then crouched on the perch and leaned forward so that her body was horizontal. While in this position, the female spread and lifted her tail to one side. The male then flew to the female, hovered momentarily above her, and uttered the "chrrr" call. In 2 instances a male approached a perched female and uttered the "chrrr" call before the female assumed the crouch position.

Sex Roles During Incubation - Females performed the majority of incubation. During 30 h of observation during incubation, males incubated approximately 15% of the time. This estimate is based on direct observation of undisturbed males entering and leaving nests. Both Temple (1972) and Newton et al. (1978) estimated that males incubate 33% of the time. However, their estimates were obtained by flushing birds from nests and then sexing them.

Males generally took over incubation for periods of 10 min to 1 h after bringing food to females. Females indicated readiness to resume incubation by calling and flying to perches near nests, at which time males vacated the nests. While 1 bird incubated the other often remained perched within 150 m. Perched males usually dozed or looked about, while perched females stretched and preened actively.

Males apparently did all hunting during the incubation period. Food transfer was accomplished in a more rapid and aggressive manner than was usually observed during courtship. When a male en-

tered the nest area and called, the incubating female left the nest. She quickly took the prey from the male and flew to a perch to feed. On only 1 occasion did a male appear reluctant to relinquish prey.

Sex Roles During the Nestling Period - Merlins apparently removed or ate eggshells and dead nestlings. When all nests were checked after hatching, 2 entire eggs were found, while 3 others were unaccounted for. No eggshells were found. Cramp and Simmons (1980) state that eggshells are removed or eaten by females. On 18 June, a dead nestling was found atop a 2 m stump commonly used as a plucking perch.

My observations indicate that females brood young only during the first week after hatching. Even then females were observed off nests for progressively longer periods. Feeding young, which generally required 10-20 min, was accomplished only by females. When the nestlings at 1 nest fledged at approximately 2 wk old, the female continued to feed them on the ground.

During the nestling period, males were away from nests more often, yet delivered food to females more frequently than during courtship or incubation. While females may have taken prey near nests, they did not appear to make a major contribution to food collection. This finding is consistent with studies by Rowan (1921) and Oliphant (1974). However, Temple (1972) found evidence suggesting that females do hunt soon after brooding.

Behavior of Young Merlins - On 29 June, nestlings called weakly, and did not react to an approaching hand. By 10 July, all young were alert and active. For example, 1 nestling perched at a nest entrance for 30 min, preened, watched passing vehicles, bobbed its head and snapped at insects.

During the first week after fledging, young did not fly often. When they did, flights were low and of short duration. After the first week, fledglings became more active. They called frequently, and often in unison. They chased each other, and mobbed adults returning to the nest area with prey.

By early August, juveniles were observed chasing other birds. While not observed hunting successfully, they were seen pursuing small birds. More often, they chased other raptors. On 16 August, 3 juveniles were observed chasing 2 American Kestrels (*Falco sparverius*) and 2 juvenile Northern Harriers (*Circus cyaneus*) simultaneously. On other occa-

sions, these same juveniles chased a Golden Eagle (*Aquila chrysaetos*), a Sharp-shinned Hawk (*Accipiter striatus*) and 2 Black-billed Magpies. All these chases appeared playful. Pursued birds, particularly kestrels and Sharp-shinned Hawks, sometimes turned and chased Merlins, and frequently remained in the area following a chase. Kestrels and Merlins sometimes perched together in the same tree. Cade (1982) has observed similar associations of juvenile Merlins and Sharp-shinned Hawks in interior Alaska.

Territorial and Nest Defense - Merlins at Denali Park generally chased intruders when found within 150 m of nests, females behaving more aggressively than males. Merlins were particularly aggressive toward raptors and other large birds. Golden Eagles, Northern Harriers, Common Ravens (*Corvus corax*) and a Gyrfalcon (*Falco rusticolus*) were chased on different occasions. Merlins were also observed diving at Black-billed Magpies and Willow Ptarmigan (*Lagopus lagopus*). In one instance, a female called vigorously for 10 min after a small airplane passed low over the area.

During courtship, Merlins were chased by birds already present in nest areas. On 1 occasion, a Mew Gull (*Larus canus*) chased a female Merlin just after the Merlin dove at a magpie. Gray Jays (*Perisoreus canadensis*) displayed aggression toward Merlins in early May, but were ignored.

Red Squirrels (*Tamiasciurus hudsonicus*) may pose a threat to nestlings. The nest vacated by young Merlins between 5 and 10 July contained spruce cones and scales in mid-July, indicating that squirrels were using it. Squirrels may have displaced the Merlins. Red Squirrels at Denali Park have been observed to feed on American Robin (*Turdus migratorius*) nestlings.

While they ignored Moose (*Alces alces*) and Grizzly Bear (*Ursus arctos*), Merlins were intolerant of human presence near nests. My searches for prey remains were commonly interrupted by a Merlin calling and diving at me, and this harassment continued until I moved at least 100 m from the nest. Perched males sometimes allowed me to pass without disturbance, but when visible to a female, I was always pursued.

The proximity of the park road to all 4 nests required Merlins to adjust to human activity. In 3 cases, nests were between 90 and 150 m from the road. Merlins at these nests appeared to regard the road as a territorial boundary, ignoring vehicles

and pedestrians on the road, but diving and calling at pedestrians off the road in the direction of nests. The fourth nest was located 10 m from the road. Plucking perches were located across the road, so the road bisected the nest territory. In May, adults called at any human activity on the road. By June, they ignored road activity, but pursued pedestrians off the road in either direction.

Nest checks elicited a strong response. Merlins often flushed from nests when humans approached to within 5 m of nest trees, and always flushed when nest trees were climbed. They called from nearby perches, diving frequently to within 2 m of the intruder, and were joined by their mates, when present.

ACKNOWLEDGMENTS

Permission to study Merlins in Denali National Park was granted by John Dalle-Molle of the U.S. National Park Service, which also provided equipment. Philip S. Niempf and Robin Hunter, U.S. Fish and Wildlife Service suggested the study and provided banding assistance. Kenneth Kertell, Michael Britten, Joseph Van Horn, Barbara O'Donnell, Marti Loew and Gary Lester assisted in the field. Stephen Herman, The Evergreen State College, provided guidance throughout the study, and Kenneth Kertell and Francis Singer reviewed earlier drafts. Daniel Gibson, University of Alaska Museum, identified many prey remains. I am grateful to these people, as well as to the many residents of McKinley Park, Alaska, who provided me with Merlin sightings.

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BREEDING CHRONOLOGY AND REPRODUCTIVE SUCCESS OF RICHARDSON'S MERLINS IN SOUTHEASTERN MONTANA

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ABSTRACT - Breeding chronology and reproductive success of the Merlin (*Falco columbarius richardsonii*) were studied in southeastern Montana from 1978-1981. Breeding activity spanned 5 mo from the earliest observation of adults to the latest dispersal of adults and young from nesting areas. Clutch size, brood size and fledgling success at active nests were similar ($P > 0.05$) among the 4 yrs. Mortality tended to be highest before the hatching stage. Breeding chronology and reproductive success were similar to results of studies in Canada.

The Merlin (*Falco columbarius*) is 1 of 6 species of falcons that occur in North America. Three subspecies of the Merlin in North America are recognized (Temple 1972). *F.c. richardsonii*, the subspecies of interest in this study, occurs in the prairie parklands of the Northern Great Plains.

Data pertaining to the ecology of *F.c. richardsonii* have been generated primarily from studies in the prairie provinces of Canada. The life history of Canadian Merlins, including breeding chronology and reproductive success, was documented by Fox (1964, 1971). In Alberta and Saskatchewan, Hodson (1976) reported that reproductive success at Merlin nests that fledged young was high, but net productivity was variable. An apparent increase in reproductive success over that reported by previous studies was discussed for Merlins in Saskatchewan by Oliphant and Thomson (1978).

Information on *F.c. richardsonii* in the United States is lacking, although local populations or scattered breeding pairs occur in several western states (Oliphant, this issue). This study was initiated to document the reproductive ecology of a population of *richardsonii* in Montana.

STUDY AREA AND METHODS

Breeding chronology and reproductive success were examined on a 39,448-ha study area in southeastern Montana. Sandstone buttes and hills ranging to 300 m above the adjacent prairies and farmlands are common on the study area. Maximum elevation is 1,282 m above sea level. Vegetation consists of approximately 27% forest cover and 67% grassland. The dominant forest species is ponderosa pine (*Pinus ponderosa*). Aspen (*Populus tremuloides*), box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), and a variety of shrubs grow in more mesic sites. Major grassland species are western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), prairie junegrass (*Koeleria cristata*), and needle-and-thread grass (*Stipa comata*).

The climate in southeastern Montana is characterized by frequent winds, hot summers, cold winters, and a semi-arid moisture regime. Annual precipitation averages 39 cm, of which 70% falls from May - September. Monthly mean temp during the Merlin breeding season range from -8°C in March to 33°C in July.

Breeding chronology and reproductive success were studied from March - September, 1978-1981. Breeding territories were located by traversing potential breeding habitat (i.e., ponderosa pine stands) during April and May. Nest sites were detected when adults were flushed or exhibited aerial and vocal defense behavior. When flushing was not observed but defensive adult Merlins were present, Black-billed Magpie (*Pica pica*) nests in the vicinity were examined.

Timing and duration of breeding activities were determined by observing Merlins from early spring through late autumn. Observations of courtship, hatching, growth of young, fledging, and dispersal were documented at all active nests. Number of eggs, young and fledglings were recorded during 3 visits to each nest: during incubation, shortly after hatching, and just prior to fledging. Precautions were taken to avoid disturbance of adults and young (Fyfe and Olendorff 1976).

Data collected during nest visits were used to calculate percentages of eggs hatched, young fledged, and eggs resulting in fledglings. Fledgling success was calculated for active nests ("nests in which eggs have been laid") and successful nests ("occupied nests from which at least 1 young fledged during the breeding season under consideration") (Postupalsky 1974). Sex of nestlings was determined at approximately 2 weeks of age. Larger foot size and larger, less fully developed bodies (Fox 1964), along with greater tarsal diameter were generally reliable characteristics of females.

Student t-Tests were used to compare reproductive success among years. Paired t-Tests were used to compare average clutch size, brood size and number of fledglings/active nest within yrs. Clutch size, brood size and number of fledglings/active nest for the 4 yrs combined were compared using combination of probabilities from tests of significance (Fisher 1950). Unless otherwise noted, differences were considered significant at $\alpha = 0.05$.

RESULTS

Breeding Chronology. — The earliest observation of an adult Merlin on the study area was 11 March 1978. Breeding activities spanned approximately 5 mo from the earliest observation of an adult until the latest dispersal of adults and young (Fig. 1).

Males were observed at breeding territories before females. Courtship began shortly after the arrival of the females in early April and continued until late-May (Fig. 1). Eggs were laid from mid-April through mid-June. Females usually incu-

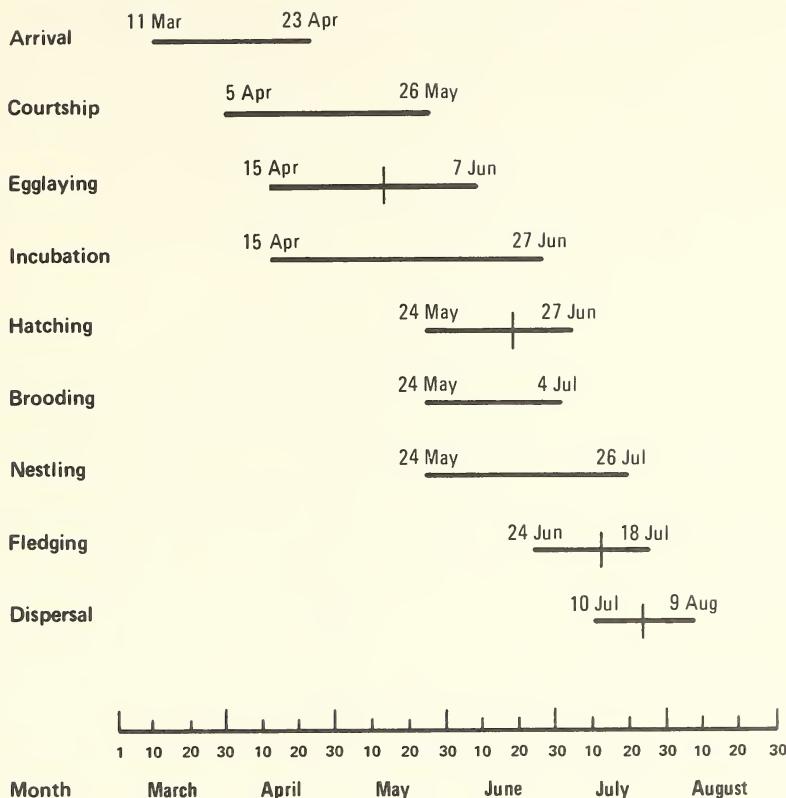


Figure 1. Nesting chronology of *F. c. richardsonii* in southeastern Montana. Horizontal lines indicate ranges of activity, vertical lines indicate means.

bated eggs, although males were occasionally observed on nests for short periods.

Earliest observed hatching occurred on 24 May 1980, and the latest on 27 June 1979. Nestlings were brooded 3 - 5 d, and remained in the nest 12 - 17 d before beginning to spend time on top of the nest canopy and/or in nearby branches. Young Merlins fledged from 26 - 33 ($\bar{x} = 29$) d after hatching. Fledging dates ranged from 24 June - 18 July. Fledglings remained in the vicinity of the nest from 7 - 19 ($\bar{x} = 13$) d after fledging. The latest dispersal of young and adults from a breeding territory occurred on 9 August 1979.

Reproductive Success. — Forty-eight active Merlin nests were located during the study, of which 43 (90%) were ultimately successful in producing fledglings. All nests were originally Black-billed Magpie nests located in ponderosa pine trees

on sideslopes of buttes.

The number of eggs laid per nest did not vary significantly from year to year during this study (Table 1). Brood sizes were also similar among years. Sex ratios of 157 nestlings indicated a slightly greater proportion of females (53%) than males (47%). Numbers of fledglings per active nest did not differ significantly among years, and for 4 yrs combined, was higher than the average number per successful nest (Table 2).

In 3 of the 4 yrs, and for the 4 yrs combined, significant mortality was observed from the time the eggs were laid until the Merlins fledged (Table 1). Average clutch size varied significantly from average brood size in 1978, 1979 and 1980, while clutch size was similar to brood size in 1981. Average number of fledglings per active nest was smaller than average brood size in 1979 ($P \leq 0.08$) and 1980. In 1978 and 1981, the number of fledglings per active nest did not differ significantly from

Table 1. Reproductive success for Richardson's Merlins in southeastern Montana, 1978 - 1981.

YEAR	SAMPLE SIZE	CLUTCH SIZE ($\bar{x} \pm SE$) ¹	BROOD SIZE ($\bar{x} \pm SE$)	FLEDGLINGS/ ACTIVE NEST ($\bar{x} \pm SE$)	EGGS HATCHED (%)	YOUNG FLEDGED (%)	EGGS FLEDGED (%)
1978	8	4.1 ± 0.2 ^a	3.3 ± 0.4 ^b	3.0 ± 0.6 ^b	79	92	73
1979	18	4.3 ± 0.2 ^a	3.6 ± 0.4 ^b	3.3 ± 0.4 ^{*c}	84	92	78
1980	15	4.5 ± 0.2 ^a	3.5 ± 0.4 ^b	3.3 ± 0.4 ^c	79	94	75
1981	7	4.3 ± 0.4 ^a	4.3 ± 0.4 ^a	3.3 ± 0.9 ^a	100	77	77
Combined data	48	4.3 ± 0.8 ^a	3.6 ± 1.4 ^b	3.3 ± 1.6 ^c	84	90	76

¹Mean ± standard errora,b,c Means within rows (clutch size, brood size, fledglings per active nest) with the same superscript are not significantly different ($P > 0.05$)*In 1979, fledglings/active nest was smaller than brood size at $\alpha \leq 0.08$.

average brood size. For the 4 yrs combined, clutch size, brood size and number of fledglings per active nest were different.

DISCUSSION

Breeding Chronology. — The presence of male Merlins in early March when the study area was first visited indicated that some males may have arrived earlier, or possibly over-wintered in the area. Male *F.c. richardsonii* in Saskatchewan arrived at breeding sites as early as late February or early March, up to a month before females (Fox 1964).

The chronology of Merlin breeding activities in southeastern Montana was similar to breeding

chronology of captive *F.c. richardsonii* in Alberta (Campbell and Nelson 1975) and wild Merlins in Saskatchewan (Fox 1964; Oliphant 1974) and Alberta (Hodson 1976). However, some breeding activities began earlier in the spring in Montana than in Canada. As an example, the peak egg-laying date in Saskatchewan was 20 May (Fox 1964), while Merlins in Montana had generally completed laying by this date.

Reproductive Success. — Reproductive success remained relatively consistent throughout the study, as evidenced by the low year-to-year variability of clutch size, brood size and number of fledglings per active nest. Average clutch size,

Table 2. Reproductive success of Richardson's Merlins in various areas in the Northern Great Plains of the United States and Canada (sample sizes in parentheses).

STUDY	LOCATION	\bar{x} CLUTCH SIZE	\bar{x} BROOD SIZE	\bar{x} FLEDGLINGS/ SUCCESSFUL NEST
Fox 1964	Saskatchewan	4.5(10)	2.7(10)	---
Fox 1971	Great Plains (forested)	4.1(9)	4.0(16)	---
Fox 1971	Great Plains (prairie)	4.5(10)	2.7(17)	2.8(6)
Hodson 1976	Alberta and Saskatchewan	4.6(156)	3.5(107)	3.2(108)
Oliphant and Thompson 1978	Saskatchewan	---	---	4.0(47)
Fox and Donald 1980	Alberta	4.1(10)	3.7(10)	---
Fox and Donald 1980	Alberta	3.4(10)	1.9(10)	---
This study	Montana	4.3(48)	3.6(48)	3.7(43)

brood size and number of fledglings per successful nest for the 4 yrs combined are similar to results reported by Fox (1964, 1971); Fox (1964, 1971); Hodson 1976; Fox and Donald (1980); and Oiphant and Thompson (1978) (Table 2). Average clutch and brood sizes for our study are towards the upper range of reported values, and although fledging data from other studies are limited, the average number of fledglings in this study is generally higher.

Percentages of eggs which hatched and resulted in fledglings in southeastern Montana are within the range of reported values. The hatching success rate of the Merlin in Montana is higher than the 60% and 58% hatching rates reported by Fox (1964) and Hodson (1976), respectively. In Alberta, 85% of the young Merlins fledged (Hodson 1976), while 96% fledged in Saskatchewan (Fox 1964). The percentage of nestlings which fledged during this study is within this range.

Mortality tended to be highest prior to hatching for Montana, as evidenced by the significant loss of eggs before the nestling stage. However, post-hatching mortality was common during each year, and for the 4 yrs combined, resulted in a significant loss of Merlins before they fledged. Causes of mortality in this study were not specifically identified, but could be attributed to predation of eggs and nestlings and inclement weather around hatching time. Cold, rainy weather in Alberta during the hatching stage resulted in severe losses of active nests (Hodson 1976). Human disturbance did not appear to be a major cause of nest failures. Precautions were taken by study personnel to minimize disturbance of breeding Merlins and nestlings, and the isolation of most nests made harassment from other human activities unlikely.

Results of this study indicate that the sequence and duration of Merlin breeding activities in southeastern Montana were similar to the breeding chronology reported in Canada, although breeding activities appeared to begin earlier in the spring. Reproductive success rates in southeastern Montana were generally higher and consistent among years when compared to other studies. Mortality was highest before hatching, followed by the period between hatching and fledging. Although human disturbance from research activities did not appear to be a cause of mortality, extensive human activities, such as energy development and mineral exploration, and development of more extensive

agricultural practices may disrupt breeding activities. Data provided by this study will be useful in monitoring the status of this Merlin population in light of future land development activities.

ACKNOWLEDGMENTS

Research in 1978 and 1979 was funded by the USDA Forest Service, Custer National Forest. Research in 1980 and 1981 was funded by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station in Rapid City, South Dakota. We thank George T. Allen, Daniel W. Carney, Richard LeVesque and Stephen L. Mackey for assistance in data collection in the field. Gene Hoff provided housing for field personnel during the study. Critical comments on an earlier draft of the manuscript were provided by I.J. Ball, Richard L. Hutto, B. Riley McClelland, Christopher Servheen and Daniel W. Uresk.

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PRODUCTIVITY, POPULATION DENSITY AND RATE OF INCREASE OF AN EXPANDING MERLIN POPULATION

LYNN W. OLIPHANT AND ELIZABETH HAUG

ABSTRACT - The growth of a newly established population of the Merlin (*Falco columbarius*) in the city of Saskatoon, Saskatchewan, was monitored from 1971 to 1982. Each year nesting pairs were located and their young were counted and banded. The breeding population increased from one pair to sixteen pairs over the twelve year period. The calculated rate of increase (r) of this population was 0.233. Productivity averaged 4.2 young/successful nest and 3.7 young/nest attempt. The density of this population in 1982 was the equivalent of 55.2 pair/100 km².

Man's activities have often been the cause of long term declines in many raptor populations (Newton 1979). In contrast, the urban environment of a few cities on the Canadian Prairie-parkland have provided a new and highly suitable man-made environment for the Merlin (*Falco columbarius*) (Oliphant 1974; Smith 1978). Following a few nestings in the 1960's and early 1970's, the Merlin population in the city of Saskatoon, Saskatchewan, exhibited a dramatic increase. This population expansion has provided a unique opportunity to measure the actual rate of increase (r) of a raptor population in a previously unused environment.

METHODS

Surveys of suitable nesting habitat within the city were made each spring. Taped calls of Merlin vocalizations, which were utilized during the last 5 years, greatly reduced the effort needed to detect breeding pairs. Reports of Merlin sightings were investigated and often resulted in discovery of nests. In most years (1974-82) the nests were not climbed until the last half of June when the young were counted and banded.

A "breeding pair" was defined as a pair at a nest site at least into the time of incubation. This criterion was necessary because many pairs relocated in new territories even up to a week or two prior to egg laying. A "successful nest" was one which produced at least one advanced nestling of banding age. The number of young produced was not known for some sites (nest not climbed or

Table 1. Numbers of breeding pairs of Merlins and production of young in Saskatoon from 1971-1982.

YEAR	NO. BREEDING PAIRS	MINIMUM NO. YOUNG PRODUCED	ESTIMATED NO. YOUNG PRODUCED	AVERAGE NO. YOUNG /SUCCESSFUL NEST	AVERAGE NO. YOUNG/NEST ATTEMPT
1971	1	3	3	3.0 (1)	3.0
1972	2	5	5	5.0 (1)	2.5
1973	4	4	8*	4.0 (1)	2.0*
1974	2	9	9	4.5 (2)	4.5
1975	3	14	14	4.7 (3)	4.7
1976	5	15	19*	3.8 (4)	3.8*
1977	6	22	22	4.4 (5)	3.7
1978	7	30	30	4.3 (7)	4.3
1979	10	37	37	4.1 (9)	3.7
1980	12	40	40	4.0 (10)	3.3
1981	14	57	61*	4.4 (13)	4.4*
1982	16	50	54*	4.2 (12)	3.4*
Totals Or $\bar{x} \pm SE$	82	286	302	4.2 \pm 0.03 (n = 68)	3.7 \pm 0.07 (n = 82)

*Productivity of one nest estimated as described in Methods section.

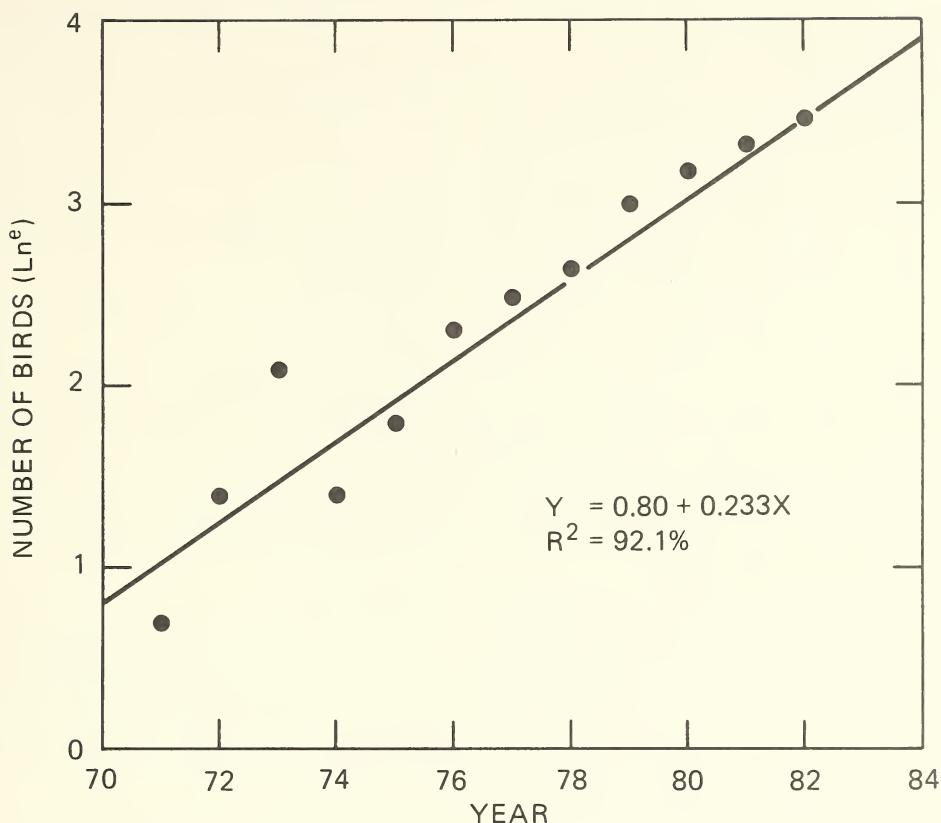


Figure 1. Growth of breeding population of Merlins in Saskatoon from 1971 to 1982.

number of young fledged unknown). Production at these sites was estimated by assuming a successful nest produced young equal to the average of all successful nests for that year and a nest with unknown outcome produced young equal to the average of all nests (successful and unsuccessful) for that year.

The actual rate of increase (r) per year of the breeding population was estimated by taking the regression coefficient of \log_e of the number of breeding birds versus year (Caughey and Birch 1971). Analysis of variance was used to test the significance of the regression coefficient.

RESULTS

Prior to 1971 there were 3 Merlin nest records for Saskatoon (1963, 1965 and 1970). Of the 82 known nestings between 1971 and 1982, 71 were successful, 10 failed and the outcome of one nest was unknown. All of the nest sites were in old American Crow (*Corvus brachyrhynchos*) or Black-billed Magpie (*Pica pica*) nests which, with three exceptions, were in large spruce (*Picea sp.*) trees. Table 1 summarizes

the numbers of pairs and production of young from 1971-82.

The growth of the breeding population is shown in Figure 1. Other than a decline in 1974, there has been a steady exponential growth over the study period. Regression analysis revealed a rate of increase (r) per year of 0.233 ± 0.022 . This linear relationship was highly significant ($F = 116.9$; $df = 1, 10$; $P < 0.001$) and represents a 26% increase in the breeding population per year.

Although Saskatoon has a total area of 122 km^2 , only the older parts of the city have mature trees offering suitable nesting habitat for Merlins. All of the nest sites (1971-82) were located within a 35 km^2 core area. In 1982 all 16 pair nested within a 29 km^2 area. The distance of each 1982 nest site to the nearest adjacent nest site averaged 1.2 km and varied from 0.7 km to 2.3 km.

DISCUSSION

Several factors contribute to making the urban environment of Saskatoon a suitable nesting habitat for the Merlin. A primary factor is the presence of spruce trees which were planted early in the history of the city. As these trees matured they provided suitable nesting habitat for Crows and Black-billed Magpies. Houston (1977) has documented a major influx of these two species into Saskatoon between 1968 and 1972. Until the large stick nests of these corvids were present there were no suitable nesting sites for Merlins which, like other falcons, do not build their own nests.

Another important factor is prey availability. The large urban population of House Sparrows (*Passer domesticus*) provides an abundant prey base heavily utilized by the Merlins (Oliphant 1974; Oliphant and McTaggart 1977). Prey density is probably the most important factor responsible for the current high-breeding density of the Merlin.

A third factor is the proximity of the South Saskatchewan River which runs through the middle of the city. The urban population was most probably derived from the Merlins that occur naturally along the major river systems on the prairies (Oliphant and Thompson 1978; Houston and Schmidt 1981).

Nesting habitat, prey availability and intraspecific competition do not appear to be limiting population growth in Saskatoon at this time. Given these conditions, the calculated rate of increase (*r*) of this population should approximate the maximum rate of increase (*r* max) for this situation (Caughley and Birch 1971). This assumes that the population is closed (no ingress or egress). Although this assumption is certainly not valid in the strictest sense, we believe that the majority of birds nesting in the city were indeed fledged from city nests.

Opportunities to estimate the capacity for increase of a wild raptor population are rare. Ratcliffe (1980) describes the decline and resurgence of the Peregrine Falcon (*Falco peregrinus*) in Britain first due to shooting and secondly to pesticides. Rates of increase of the population were not calculated, however.

The Merlins of Saskatoon have already achieved the highest recorded nesting density for this species. The overall breeding density for 1982 was equal to 55.2 pairs/100 km². The densest group of nests was a group of 5 nests contained within 1.3 km² (384.6 pairs/100 km²). Newton et al. (1978)

reported maximum Merlin densities of 10 and 13 pairs/ km² in two study areas in northern Britain. The closest nestings they recorded were 3 pairs at the corners of a triangle 1.0 - 1.1 km apart. This is very similar to the *average* distance between nearest neighbors in the 1982 Saskatoon population. In Wales (Williams 1981) the highest Merlin density recorded was 9 pairs in 35 km² (25.7 pairs/100 km²) with 7 of these pairs found within 6 km² (116.7 pairs/100 km²).

This high density in Saskatoon far exceeds recorded non-urban density on the Canadian prairies. During a population study of Ferruginous Hawks (*Buteo regalis*) in southern Alberta, a minimum Merlin nesting density of only 1.9 pairs/100 km² was recorded (Schmutz 1982). In limited areas of good habitat, however, non-urban Merlin densities may be higher and occasionally pairs may nest less than 1 km apart (A. Schmidt, pers. comm.).

ACKNOWLEDGMENTS

Coordination of the Merlin survey was done by John Polson in 1980 and 1981 and by John Feldsine in 1982. We also thank Paddy Thompson, Stacey Tessaro, Jane Jenkins, Adam Schmidt, Bob Rafuse, Stuart Houston, Al Smith, Jim Slimmon, Bruce Hanbridge and John Hanbridge for help with the survey or information on Merlin nestings. Andy Didiuk and Dick Neal made constructive comments on an earlier draft of this paper.

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BREEDING BEHAVIOR OF THE MERLIN: THE COURTSHIP PERIOD

JOHN W. FELDSINE AND LYNN W. OLIPHANT

ABSTRACT - Behavioral observations were made on an urban population of the Merlin (*Falco columbarius richardsonii*) nesting in the city of Saskatoon, Saskatchewan. Fourteen distinct behavioral displays and four vocalizations were identified during the courtship period. The behavior of the birds was remarkably similar in most respects to large falcons such as the Peregrine Falcon (*F. peregrinus*), Prairie Falcon (*F. mexicanus*) and Gyrfalcon (*F. rusticolus*), which have been studied more thoroughly.

Information on the breeding behavior of the Merlin is scanty and sometimes contradictory. Brown (1976), referring to the British Merlin (*F.c. aesalon*), states that "Merlins do not perform spectacular aerial display flights" while Cramp and Simmons (1980) briefly mention such aerial displays. Most of the literature dealing with Merlin breeding behavior focuses on the nesting and raising of young (Rowan 1921-22; Craighead and Craighead 1940; Lawrence 1949; Campbell and Nelson 1975) with little information on behavior during the courtship period. This study was designed to compile an ethogram of the behavior of the Merlin from pair formation to the time of egg laying.

METHODS

Most of the observations were made on a population of Merlins nesting in Saskatoon, Saskatchewan, a city of 1220 ha. and a population of 155,000 (see Oliphant 1974 and Oliphant and Haug 1984 for details of this Merlin population). Data were obtained during a behavioral study conducted in 1982 and 1983 by John Feldsine supplemented by casual observations between 1971 and 1984 by Lynn Oliphant (estimated 800 h). During the 2 yr study 16 nest sites were visited each year from mid-January to the end of April. A tape recording of Merlin vocalizations was played at each site to draw out concealed birds and to initiate behavioral displays. Scattered observations were made at several nest sites throughout the day but the majority of observations was made between sunrise and 1100 H. In addition, intensive observations of 2 pairs of Merlins were made in 1982. A total of 175 h of observations were made on these birds between February 17 and April 30 from a parked vehicle using binoculars and a spotting scope between sunrise and 1400 H. Casual observations were also made in 1982 on a pair of Merlins that raised young in captivity.

RESULTS

We were able to recognize 14 courtship displays and 4 primary vocalizations. The displays are in some cases comprised of several components, which may be employed in more than one display. Not all of the displays described were seen in both of the intensively studied pairs. These 2 pairs represented the seasonal extremes in terms of appearance on territory; 1 pair was first observed courting on territory on 16 February, the other not until 14

April. The early pair was not as elaborate or expressive in its displays as was the late arriving pair, nor did it display so frequently.

Vocalizations

1. Ki-ki-kee (Kek-kek-kek). This is the most commonly heard call and takes on several different forms, which vary in intensity, speed, rhythm and number of syllables according to the situation. It is used by both sexes with the male's call higher in pitch and more rapidly delivered. This call accompanies several courtship displays and territorial or other aggressive encounters, although in an aggressive context, it is deeper and resembles a kac-kac-kac sound (Craighead and Craighead 1940).

2. Tic (Chip). Used by both sexes in almost all courtship rituals and is typically repeated several times at intervals of a few seconds. Again, the male's call is higher in pitch than the female's. Often this call is given alternately by the pair, especially when near each other but not in visual contact.

3. Copulation Chutter (Copulation Bleat, Chrerr). Somewhat like the sound made by a short blast on a police whistle. When used by the male, this call indicates a desire to copulate. Females occasionally use it in encounters involving food, e.g., when the male returns with prey but fails to signal for a food transfer. This may indicate an extremely hungry female. Also used by non-resident birds of either sex when approaching a resident female.

4. Food Begging Whine. Used strictly by the female and consists of a series of monotonous whining notes resembling a very slow ki-ki-kee. It apparently tells the male either "give me the food that you have" or "go get me some food". Occasionally females gave this call before, during and after a copulation sequence. It resembles and is presumably derived from the begging call of the young.

Courtship Displays

1. Power Flying. One of the earliest male courtship displays and may continue throughout

the courtship period. It consists of a strong flapping flight with deep wingbeats accompanied by rolls which alternately display the dorsal and ventral aspects of the plumage when viewed from the side (Fig. 1.1). Power Flying may be terminated by a Slow Landing Display, Power Dive or a Rocking Glide usually past a perched female and/or potential nest tree. Power Flying is used as a territorial display to a rival or potential or existing mate. When performed in the presence of a rival male it reaches its greatest intensity. We have observed 2 males from adjoining territories Power Flying past each other at their common boundary. The Tic-Tic vocalization is usually given during this display. Volume and frequency of the vocalization and snappiness of the rolling vary with the intensity of the display. One male was observed Power Flying repeatedly over a period of about 1 wk following the death of his mate just prior to egg laying. No other birds were observed in the area during these displays suggesting that Power Flying may be used to attract potential mates into a male's territory.

2. Power Diving. Another male display which appears to be a more intense variation of Power Flying with the only major difference being the angle of flight (Fig. 1.2). This display may be initiated by a direct high-level climb over the territory or preceded by Power Flying at heights which may reach several hundred meters. The steepness of the dive may vary from about 45° to near vertical. Flapping flight may continue throughout the dive accompanied by 180° rolls. As speed increases the wings are partially folded. The dive may be terminated with a U-shaped climb or often by Power Flying or a Rocking Glide display past a potential mate or nest site. The context of this display is one of territory defense and advertisement. This display was most often precipitated by one or more rival males on the resident male's territory. As many as 4 birds were present on some occasions, and we suspect that the female copulated with one of the rivals as well as the resident male. Cramp and Simmons (1980) report that pairs were observed Power Diving together. We have never observed females Power Flying or Power Diving.

3. Rocking Glide. A less intense version of Power Flying (Fig. 1.3). The components of the 2 displays are similar except that there is no flapping flight with the Rocking Glide. The falcon initially flaps to build up speed or comes out of a Power Dive and then sets the wings to glide. It then performs

90° - 180° rolls depending upon the speed attained beforehand. As in the previous 2 displays the rolling component of this display alternately flashes the blue back and contrasting lighter underparts of the male. The plumage contrasts are not so obvious when the display is performed by females or immatures. Probably as a result of the slower flight speed, the tail and wing feathers are somewhat more flared than when Power Flying.

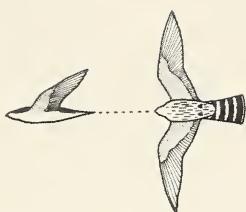
This is a fairly common display and was frequently indulged in by both sexes, although more often by males. Males may use this display to attract mates to their territories or upon return to an established territory. In the latter situation the male begins rocking and sounding the Tic-Tic call when passing by a perched female. The use of this display by females was more aggressive and was most often observed in response to a taped female call. Females are often more aggressive than males in defense of the nest site, and intruding females often elicited a Rocking Glide display from a resident female. This display was often terminated with a Slow Landing display at the nest tree.

4. Flutter Flying. A common aerial display and may be observed almost daily at an active nest site. The flight pattern is usually circular or figure-eight shaped (Fig. 1.4). Flight speed is slow with rapid shallow wing beats generally below the level of the body. It is similar to the fluttering flight of the Eastern Kingbird (*Tyrannus tyrannus*). The flight often terminates in a Slow Landing display. Flutter Flying probably functions as a mild territorial advertisement and/or display to a perched mate. The Ki-ki-kee and/or Tic-Tic vocalizations are usually given by the flying male, and the female often answers.

5. High Circling/Soaring. Although the Merlin is often reported as never soaring, we often observed 1 or more (up to 4) birds circling at heights up to several hundred meters. These birds often set their wings and soared if conditions were favorable. Circling/Soaring was seen by both resident and non-resident birds of both sexes. In the former it probably served as a mild territorial display while for the latter it may serve as a means for surveying another territory from an advantageous position.

6. Slow Landing Display (Hitched Wing). Commonly a terminal component of other displays, the Slow Landing display is a male display made while coming in to perch (Fig. 1.5). The flight pattern when approaching the perch is similar to

1-1



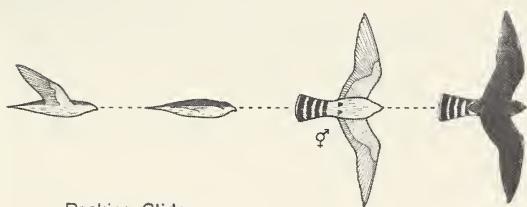
Power Flying

1-2



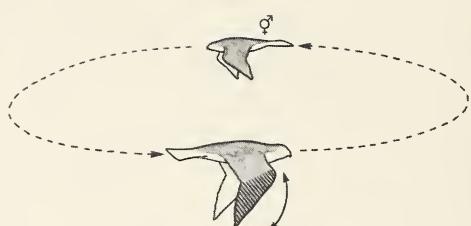
Power Diving

1-3



Rocking Glide

1-4



Slow Flutter Flying

1-5



Slow Landing Display

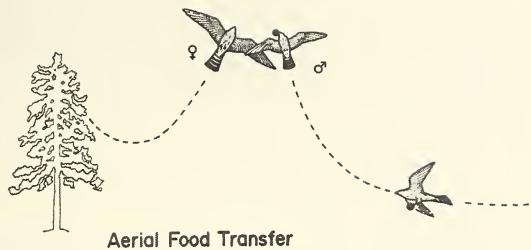
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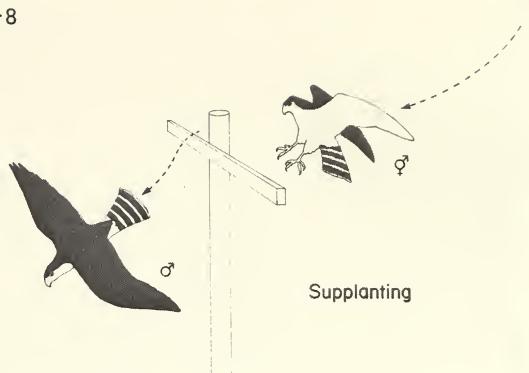
Food Begging

Figure 1. Diagrammatic representations of twelve major courtship displays of the Merlin. Symbols (σ ♀) indicate the sex of the bird typically making the display.

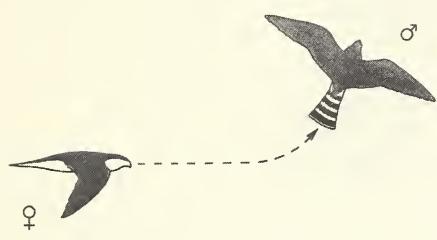
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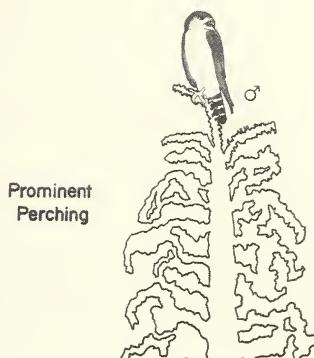
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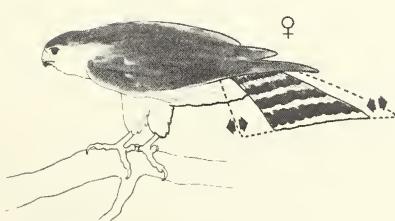
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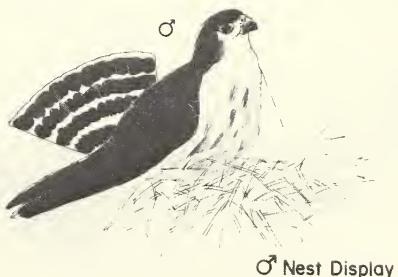
1-10



1-11



1-12



(Continuation of Figure 1.)

the flight when approaching for copulation. The body attitude varies from about 45° to nearly vertical and the legs are dropped. Movement is almost entirely confined to the outer wing, and the tail is generally fanned. Forward progress is slow and owl-like. The bird alights stiff legged with head bowed. Slow Landing may occur immediately before or after copulation and may also be a terminal component of other aerial displays. When used before copulation, the copulation chutter may immediately precede the Slow Landing display. On other occasions the Ki-ki-kee call is given during the flight or no vocalization is given.

7. Food Begging. A female display generally made from a perch. When perched, the bird sits with puffed out plumage (Fig. 1.6) and emits a series of monotonous whines or wails, very much like a slow Ki-ki-kee. Intensity and duration of the call is probably a good indication of hunger level. If very hungry she may flit from perch to perch emitting the wails constantly. Often the male responds by initiating a food transfer. If he is without food, he may leave the territory, presumably to hunt. If he does not respond and has food, she may fly to him and initiate a Forced Food Transfer by snatching the prey from him. If he is without food she may supplant him from his perch. When supplanted, the males usually left the territory presumably to hunt. The begging call is given almost constantly during all of these actions and sometimes continues after the male has disappeared. This display is performed exclusively by the female and is very similar to the begging behavior of nestlings. It reaches its maximum intensity a few weeks prior to egg laying.

8. Food Transfers. We have observed 3 forms of this display: air-to-air, perched, and air-to-perch. Air to air transfers occur with the female flying out to meet the male as he returns to the nest site with food (Fig. 1.7). The birds fly toward one another and rise in a simultaneous, nearly vertical stalling climb until they are nearly breast to breast. The male will often have transferred the food to his beak. As they pass closely in the air the female reaches out with a foot and grabs the prey. Rowan (1921-2) calls this behavior Courtship Feeding and considers it to occur only rarely. Aerial transfers are much more common after the young have hatched than during courtship period. Perched food transfers take place much as described by Wrege and Cade (1977) for the Peregrine (*Falco peregrinus*)

with bowing and sounding of the Ki-ki-kee and/or Tic calls by both birds. The female sometimes makes the Food Begging whine during the entire ritual. On occasion the females seemed irritated, aggressive and probably hungry. They flew quickly to the male's perch, often running towards him upon landing, grabbed the food without display or ceremony (a Forced Food Transfer). A variety of calls was heard during these encounters, a very excited and aggressive sounding Ki-ki-kee, a Copulation Chutter, or the Food Begging whine from the female, and a rapid, high pitched Ki-ki-kee from the male. During Air to Perch Transfers either bird may remain perched. If the male perches he transfers the prey from foot to beak and the female flies by and grabs it with a foot. Food transfers begin rather late in courtship and increase in frequency towards the time of egg laying.

Food caching is common throughout the breeding cycle and is performed by both sexes (Oliphant and Thompson 1976). Ritualized caching of prey by the male within sight of the female followed by retrieval by the female is commonly observed in captive peregrines. Although we did not observe this in the Merlin, it may well occur.

9. Supplanting. During supplantations, 1 bird flies to another perched individual (generally a male) and drives that bird from its perch (Fig. 1.8). This behavior occurred in 3 different contexts: (1) a resident male supplanting a rival male, (2) the resident female supplanting her mate and (3) one or both resident birds supplanting an intruder such as an American Crow (*Corvus brachyrhynchos*) or Blacked-billed Magpie (*Pica pica*). An aggressive Ki-ki-kee call was usually heard during these encounters.

In all contexts this behavior may be interpreted as a display of aggression and when used against intruders or rivals it also appears to be a defense of territory. When occurring between the mated pair, expression of female dominance seems the likely motivation and may be used to encourage the male to begin hunting.

10. Tail Chasing (Fig. 1.9). This behavior was only observed on a few occasions. Once a female was observed vigorously chasing her mate who had just returned with prey. While chasing him she repeatedly called using the Copulation Chutter. He eventually dropped the prey. At another location a female was observed chasing a male at great speed. He appeared and sounded as if his life was in grave

danger. The chase coursed around trees and shrubs 2 or 3 m off the ground. The pair soon disappeared and the outcome was not determined. Cramp and Simmons (1980) report that tail chases often end in copulation. Captive female Merlins have been observed to pursue actively their mates. These tend to be very aggressive interactions, and when this occurs in confinement, the male is sometimes killed (Campbell and Nelson 1974). The female from our captive pair caught and grappled with her mate on several occasions in 1982 just prior to egg laying. Clipping her primaries reduced her flight ability and normal mating occurred soon after. In 1983 this female killed the male in spite of having her primaries clipped. Apparently it is necessary for the male to have plenty of space in order to avoid being caught by the female.

11. Prominent Perching. Merlins often perch on a high vantage point near the nest site for long periods of time (Fig. 1.10). This is probably a territorial advertisement, but often appears to be simply loafing. The bird surveys the surrounding area constantly and occasionally may preen or sound the Ki-ki-kee or Tic-Tic calls. This was a commonly observed behavior most often involving the male, but occasionally the female. A large high rise building was often used by both sexes and acted as a focal point for many aerial displays by the males. Television antennas and certain trees (spruce and weeping birch particularly) also offered favored perch sites in Saskatoon.

12. Male Precopulation Display. The male has a number of ways in which he signifies readiness to copulate. He most often perches in a tree close to the tree where the female is perched and may call frequently (Ki-ki-kee and/or Tics). He may also bow and fan his tail. Just prior to flying to the female he stands tall, stares intently at the female and utters the Copulation Chutter one or more times perhaps in response to a mild solicitation by the female or perhaps attempting to initiate solicitation. When flying towards the female he uses the Flutter Flight with his legs dangling, often continuing to give the Copulation Chutter. Copulation ensues if the female is receptive with the final mounting of the male being similar to the Slow Landing Display.

13. Female Copulation Solicitation (Fig. 1.11). The female signals readiness to copulate by bowing deeply and fanning her tail. This often follows an exchange of vocalizations with the male and Precopulation Displays by the male. Both birds

typically vocalize during copulation. The female makes a modified hoarse Ki-ki-kee call and often makes a slow drawn out Ki-ki-kee immediately following copulation while the male Chutters. The male often makes a Slow Landing Display following copulation. Copulation may occur very early during courtship (up to 3 or more months prior to egg laying) but becomes much more frequent (up to several times an hour) as egg laying approaches.

We have not considered copulation as a courtship display in itself, but it is obvious that copulations that precede egg laying by several weeks to months do not function in fertilization but rather to cement the pair bond.

14. Male Nest Display (Fig. 1.12). Both sexes enter potential nests and often make Tic vocalizations during the courtship period. Since it was generally impossible to observe the birds when on the nest, our only observations of this display (3) are from our captive pair which were watched from behind one-way glass looking into the nest. In this display the male lowered himself on the nest as if he were settling on eggs. He then extended his wings and drooped them and fanned his tail nearly vertical. He extended his head forward and then withdrew it while arching his back. The drooping wings were trembled throughout the display. As the head was extended forward, the tail and lower back were raised above the horizontal so as to display the fanned tail and dorsal plumage. The female was a passive observer on the edge of the nest during the entire display with the male facing the female. No vocalizations were given. This display is very similar to that of a juvenile House Sparrow (*Passer domesticus*) begging food from an adult, and was first reported by Fyfe (in Trimble, 1975).

DISCUSSION

In describing the behavior of the Merlin, we have drawn somewhat arbitrary lines between individual displays or vocalizations as well as between what we classified as a complete display and what was simply a display component. Many behavioral actions (rocking in flight, bowing, tail flashing) were thus considered components of displays rather than displays in themselves. We have attempted to follow accepted terminology and classification from previous descriptions of falcon behavior although some deviation was necessary. For example, Wrege and Cade (1977) and Nelson (1977) consider the Head Low Bow to be a major display of the peregr-

rine. We do not consider it well developed enough in the Merlin to be considered any more than a component of other displays.

The difficulties of assigning a particular functional significance to displays that are probably often, if not always, multifunctional should also be recognized. The primary functions of behavioral displays during the courtship period include the establishment and defense of a nesting territory, attraction of a suitable mate and the establishment of a strong pair bond, all of which are necessary for successful breeding. Determining which of these functions are the primary focus of a given display is difficult to ascertain simply from the context of the situation without experimental manipulation.

Vocalizations

The courtship vocalizations used by Merlins are similar both in structure and context to those of the large falcons with which we are familiar (the Peregrine, Gyrfalcon and Prairie Falcon). They differ mainly in having a higher pitch associated with their smaller body size. The Tic call is the most divergent and is a short staccato version of the large falcons' "Eechip" call. It is the most like the shortened "Chup" version of this call not having the high pitched initial segment. The Female Begging call or "Treble Whine" (Nelson 1977) and Copulation Chutter are almost identical to those of the large falcons, and the Ki-ki-kee is the equivalent of the large falcons' deeper Kac-kac-kac. In general, the Merlin is more vocal than large falcons with the possible exception of the Gyrfalcon which appears to have a more varied and frequently used vocal repertoire.

Courtship Displays

The courtship behavior of the Merlin and especially aerial displays has been largely overlooked in the literature (Rowan 1921-22; Trimble 1975; Cramp and Simmons 1980). In contrast to the conclusion of Cramp and Simmons that display flights are "rather inconspicuous and rarely observed," the Merlins we observed regularly performed complex aerial courtship flights that were nothing short of awesome. The Power Flying and Power Diving flights with side to side rolls are essentially identical to those described for the peregrine by Nelson (1977) and are presumably similar to other large falcons (Cade 1982). The impression given by the Merlin, while performing these displays, is one of a

much larger, heavier and more powerful falcon.

Other behavioral displays that the Merlin shares in detail with the peregrine include the Slow Landing Display, High Circling/Soaring, Prominent Perching, Flutter Flying, Female Begging, Food Transfers and Supplanting. Bowing is much less prominent in the Merlin than large falcons, although it is present as a low intensity component of several displays. Rarely is the deep bowing, typical of large falcons, seen in Merlin displays. The Nest Ledge displays typical of both sexes of large falcons (which include much bowing) may be absent in the Merlin, being replaced by the very different male nest display, possibly as a result of the spacial limitations imposed by the stick nests typically used by Merlins in North America. Nest displays in ground nesting populations of Merlins may be different. Although we did not describe it as a separate display, scraping movements similar to those of cliff-nesting falcons were made by our captive pair as evidenced by a well-developed nest scrape on a gravel ledge their first year (1981). Cramp and Simmons (1980) describe a Female Nest Display similar to the motions of settling on eggs, and we observed both sexes of wild pairs repeatedly visiting potential nests and could hear Tic-Tic vocalizations. Scraping on the stick nest cup may well be occurring at these times or possibly mild forms of the Nest Ledge Displays typical of large falcons.

Fanning or flashing the tail appears to be much more common in the Merlin than large falcons. It is often seen as a component of male displays and is typical of Copulation Solicitation of the female where the tail is kept fanned until actual mounting by the male. The sharply contrasting tail of the Merlin makes this a potentially strong visual stimulus. Merlin courtship behavior is decidedly more complex than that of the American Kestrel (*F. sparverius*), although the displays which are common to both species are similar. Two distinct aerial displays have been described for the kestrel, the Flutter Glide and the Dive display (Willoughby and Cade 1964). The Flutter Glide is performed by kestrels in much the same manner as Flutter Flying in Merlins. In the kestrel this type of flight is performed mainly by the female, while in Merlins it is more commonly performed by males. The kestrels' Dive Display is similar to the Undulating Flight Display of the peregrine and Gyrfalcon as described by Nelson (1977) and Cramp and Simmons (1980). We have not observed it in the Merlin al-

though it is somewhat similar to Power Diving. The overall behavioral repertoire and intensity of displays of the Merlin is markedly more similar to the large falcons than to the kestrel.

Our lack of observations of overt intraspecific aggression directed toward non-resident birds was somewhat surprising as most falcons are thought of as being highly aggressive and territorial (Wrege and Cade 1977; Nelson 1977; Cade 1982). We have observed only 2 cases where actual physical contact between the resident bird (both males) and non-resident birds (also males) was made and both of these occurred in the fall. Only one case of overt aggression was observed during the courtship period when an adult male swooped on another male from a great height near a territorial boundary. The attacked bird screamed and was visibly upset, but no further interaction ensued. Non-resident birds (both adult and immature) were regularly seen on established nesting territories. Interaction ranged from completely ignoring the intruder to a variety of territorial displays, including Power Flying and Diving, Rocking Glide and Slow Landing Displays by the resident male. Earlier in courtship, before nest site selection and final establishment of territorial boundaries, group displays by several birds are not uncommon. Once such group display involved 4 adult males and at least 1 female (W.J.P. Thompson, pers. comm.). Although it is often difficult to keep track of individual birds when several are present, we feel that copulation attempts (some successful) by non-resident males may occur relatively frequently.

Given the lack of intraspecific aggression directed towards non-resident birds by a territorial pair, it is somewhat surprising that the female of a pair is sometimes so aggressive towards her mate. At least in captivity, high proportions of females regularly attack their mates and often succeed in killing them. This appears to be much more frequent among Merlins than larger falcons. Similarly

interspecific aggression directed towards other raptors, crows, etc., is often intense and is carried out by both sexes.

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CAPTIVE BREEDING OF THE EUROPEAN MERLIN (*Falco columbarius aesalon*)

WILLIAM RUTLEDGE

ABSTRACT - Two pairs of the European Merlin (*Falco columbarius aesalon*) were established in two contiguous Hurrell-type skylight and seclusion breeding pens in 1977. One male had been taken from the wild, the other 3 were captive-bred F₁'s. Both males were in adult plumage but the females were sub-adult. All had been mated and were tolerant of limited intrusion that became necessary. A choice of nest site between an artificial crow's nest and a roofed open nest-box was provided in each pen. The crow's nest was chosen in one pen, the nest-box in the other. Provision of ground sites was considered to be unnecessary. Nest-site selection, food passing, mating, egg-laying, incubation and hatching are described, followed by feeding and development of the young. One pair laid 4 eggs; 1 hatched. The other laid 5 eggs; all hatched. Owing to the apparent initial inefficiency of the parents in feeding newly hatched young because of interference by the male, the singleton and 2 of the brood of 5 were removed to a brooder and hand-fed until about 8 d old. The former was returned to its parents, and the other 2 were fostered with that pair. All young were reared successfully and five were issued on loan to falconers. Incubation period was between 31 and 32 d. The earliest to roost away from the nest were 2 males in their 25th d, and the latest a female in its 28th d. The males were hard-penned at about 40 d. The diet comprised half-grown surplus laboratory white mice, of which an ample deep-frozen supply was available.

This work was done at Beckhampton, Marlborough, Wiltshire.

The breeding of the European Merlin (*Falco columbarius aesalon*) in captivity in 1977 described here was not the first success in a project begun in 1971. A pair allocated to L.H. Hurrell had already bred in 1975 and 1976. Hurrell had shown a film of the breeding at the I.C.B.P. Conference on Birds of Prey, Vienna (1975), the Hawk Trust's Conference, Harrow, Middlesex (1976), and at the International Conference on Falconry and Conservation, Abu Dhabi (1976). It seemed desirable to publish a detailed account and to recognize the considerable support given by the Scottish Home and Health Department in granting a licence, in 3 successive years, to take a young Merlin from the wild for use in the project.

Breeding Material Available - Two males and 2 females of the European Merlin were used. They were a 1974 Scottish-licensed male (Lochan), a 1975 captive-bred F₁ male (Brae), and two 1976 captive-bred F₁ females (Myrtle and Corrie) from the first, kestrel-fostered, and the second, Merlin-reared, clutch, respectively, from the pair with Dr. Hurrell. This pair comprised a 1973 flight-impaired male (wild taken) (Laggan) and a 1973 Scottish-licensed female (Erica).

It should be noted that whereas the 2 males were adult approaching 3 and 2 yr old, respectively, the 2 females were not yet 1 yr old. All 4 had been previously mated and were so up to the breeding season.

Accommodation - A pair of contiguous Skylight and Seclusion pens (Hurrell in Mavrogordato, 1973) on a south-facing wall 2.40 m high, topped with concrete slabs, was used. Sections of the wall 4.50 and 3.30 m long formed the backs of pens 1

and 2, respectively; the sides, each 5.80 m long and 2.40 m high, were of translucent corrugated polythene, as were the 4.50 m - and 3.30 m - long south walls (Fig. 1). The roof was 45 mm square-mesh, heavy nylon netting spread 50 mm below a layer of 40 mm wire netting.

The timber-walled observation hide was in the SE corner of pen 1 and SW corner of 2, with access from outside. Access to each pen was by a small door, opening outwards from the pen into the hide.

Nest Sites - Each pen had 2 elevated nest sites; an artificial crow's (*Corvus* sp) nest with overhead shelter from rain, and an open nest-box of a shallow wooden tray 70 cm long x 35 cm from back to front x 10 cm deep with a rain-proof roof sloping from 40 cm height in front to 30 cm at the back. A landing board 20 cm wide was along the front. Nest-boxes were placed in both pens on the north-facing wall within 1.50 m of the hide in full view. In pen 2 the crow's nest was between the hide and nest-box. In Pen 1 the crow's nest was left in its 1976 position under the south-facing wall. Owing to its distance from the 2-way mirror in the hide it was necessary for this crow's nest to be no more than 0.75 m from the ground for its contents to be visible. All other sites were 2 m from the ground. Moreover, in order to see details in the crow's nest in pen 1 at this distance (about 5 m) a pair of binoculars with short range focus were useful.

In Britain Merlins usually nest on the ground in either heather (*Calluna vulgaris*) or bracken (*Pteridium aquilinum*). Therefore, much time was spent in 1971 in providing them. This proved unnecessary, however, as no pair showed any interest in ground sites. Additionally, an old crow's nest had

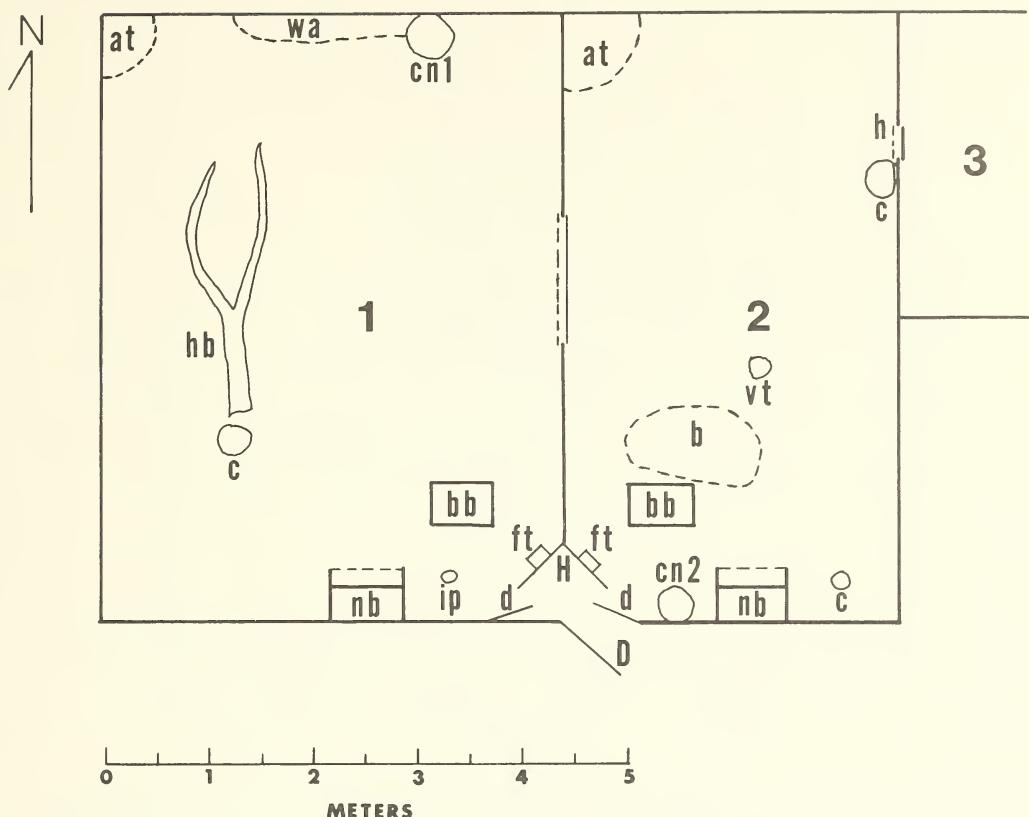


Figure 1. Plan of both pen 1 and 2. D or d - door area, H - hide, ft - feeding trays, bb - bath, nb - nest-boxes, c - cairn, cn - crow nest, a t - artificial tree, b - bracken, h - shuttered hatch, vt - vertical tree, ip - isolated post, hb - tree branch, wa - wall tree.

been placed in the top of an artificial tree (a section of a pine tree (*Pinus* sp) with the top cut out) in the pen's NW corner. A prototype of the nest-box, intended to represent a cliff site, had been attached to the south-facing wall as well.

Before the 1977 season the old crow's nest was removed because it was too high for visibility. The trees, however, continued to be used as a perch. It appeared that the natural crow's nest was not durable enough to withstand the early destructive activities of Merlins pulling at twigs and scraping in the nest cup. By 1977, a more robust artificial crow's nest was designed with a very durable cup plastered with a mixture of silt and rotted farmyard manure. The cups were partly filled with a mixture of peat and coarse sand, on the surface of which was scattered a layer of 30-40-mm-long pieces of thin dry twigs. The trays of the nest boxes were similarly

treated. The twig chips supplied material for the female to pick up. We observed incubating Merlins break off pieces of twig from parts of the nest within reach and drop these into the nest cup at the bird's breast. A female was seen doing this while lying in the nest long before oviposition; the male also did so, but less often.

Diet - Half-grown frozen laboratory mice were fed, but until early April 1977 day-old cockerel chicks occasionally made up 50% of the daily ration. On all such occasions the chick's yolk sac and intestines were removed and feet and tarsi cut off. The chicks were also roughly skinned and cut up into head, thoracic and pelvic portions. There were grounds for thinking that excessive intake of chick yolk was undesirable and that feet and tarsi, swallowed whole, tended not to be digested.

After early April the diet was 100% laboratory

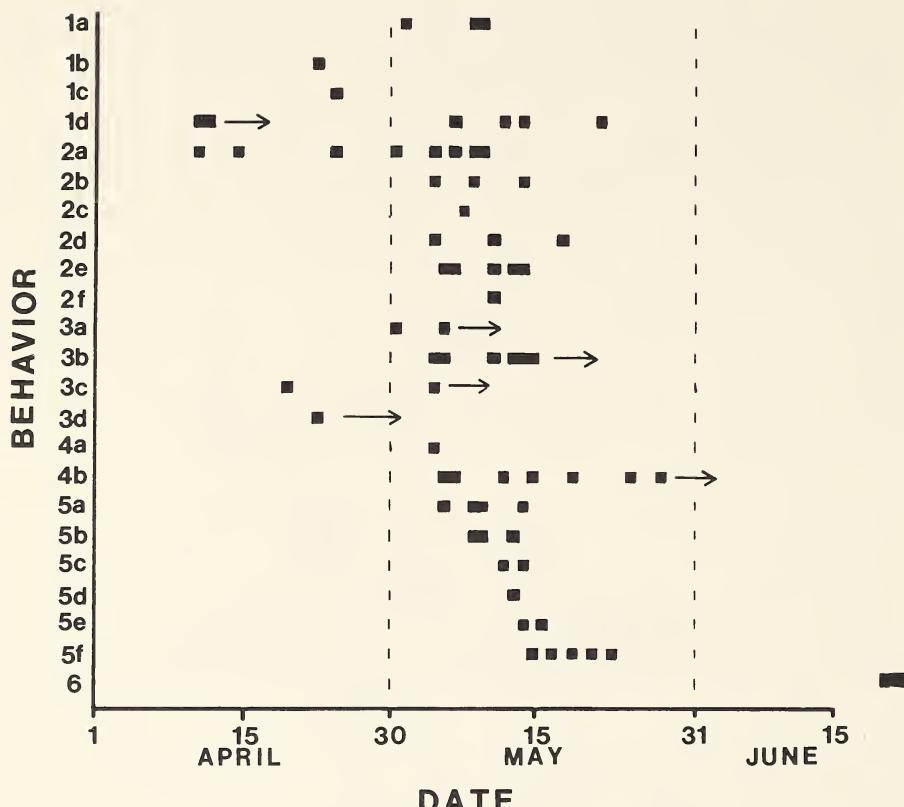


Figure 2. Sequence of behavior in No. 1 Pen. (1) a. female harassing male; b. male still mistrusting female; c. male bonding with female; d. male food caching. (2) a. male nest scraping; b. female nest scraping; c. female in scrape; d. female starts twig pulling; e. male site display; f. female site display. (3) a. male *kwi* call; b. male *kip* call; c. female *kwey* call; d. female *chup* call. (4) a. female responds to male food call; b. beak-to-beak food pass. (5) a. male mating approach; b. copulation attempt; c. successful copulation; d. oviposition lassitude; e. female pouchiness; f. eggs laid. (6) eggs hatch - 3 on 20 June, 1 on 21 June, 1 on 23 June.

mice. The adults did not pluck the mice very thoroughly, although it was noticed that as the breeding season approached more extensive plucking was done, particularly by the male when food passing had begun. Therefore, for the first 10 d after hatching of the young, all mice, except those put in after dark for the early-morning feeding, were 'prepared' to reduce the ratio of fur to flesh in each food item. In what came to be known as "Mark I (MK I) prepared," the mouse head was removed, the body skin loosened from the body, which was pushed further into the skin and the surplus skin cut off. In "Mark II," the headless body of a rather smaller completely skinned mouse was packed in on top of a MK I preparation, the neck skin of which was then tied with white cotton thread, thus further reducing the ratio of fur to flesh.

In the present study, preparation of MK II mice was used. It seemed that feeding of young ended when the food item had been distributed to them rather than when their hunger had been satisfied. Therefore, the larger size of the MK II mouse was likely to be beneficial.

Making up of Pairs - The 1975 captive-bred F₁ male (Brae) had been in pen 2 with 2 sibling males for over 1 yr by 4 December 1976 when the 2 latter were removed. The 1976 captive-bred F₁ female (Myrtle) was then introduced. They had settled down together within a week. Circumstances did not permit the release of the 1974 Scottish male (Lochan) into pen 1 before the 1976 captive-bred F₁ female (Corrie) had become established there. He had been familiar with pen 1 and, when introduced

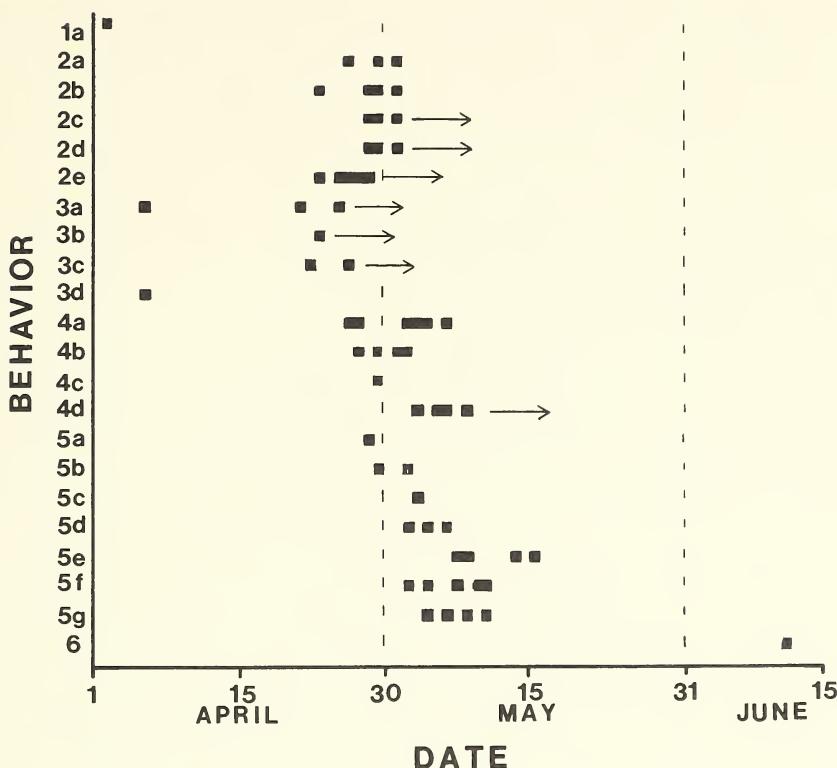


Figure 3. Sequence of behavior in No. 2 Pen. (1) a. male food caching; b. female nest scraping; c. female on scrape; d. female twig pulling; e. male site displays. (3) a. male *kwi* call; b. male *kip* call; c. female *kwey* call; d. female giving young call. (4) a. female takes food from cache; b. male offering food; c. attempted male/female food pass; d. successful beak-to-beak food pass. (5) a. male mating flights at female; b. female deters mating flights; c. apparently successful copulation; d. as in b; e. other successful copulations; f. oviposition lassitude; g. eggs laid. (6) first egg hatched. (remainder infertile).

on 6 February 1977, seemed at first to hold his own but soon became nervous of Corrie, particularly when he had food, on which occasions she was liable to harass him. Reasonable accord was not achieved until towards the end of March and full confidence was not shown until the end of April.

Observations - Regular daily observations on both pairs were made, particularly at feeding time. The sequence of the more important steps up to and including egg hatching is shown separately in Figures 2 and 3.

Although egg-laying began earlier in pen 2 than in pen 1, the cycle in pen 1 is shown in Figure 2 before that in pen 2 (Fig 3) because there were more apparent abnormalities in the latter.

The only apparent irregularity in pen 1 was the delayed start of caching food by the male (Fig 2, 1d)

by about 9 d, as compared with pen 2 (Fig 3, 1a) which might be attributed to persistence of harassment of the male by the female (Fig 2, 1a, 1b). When it did take place, it did not initiate the food pass, the latter taking place on the day following the first observed occasion of the male's calling *kwi* . . . with food in his beak. The food pass (4b) took place with its accompanying *kwi* and *kwey* calls (3a, 3c) while nest-site selection (2e, 2f) was still going on. The food pass was quickly followed by mating approach flights (5a), the early ones of which were deterred by the female. A possibly successful mating took place after 3 d (5b), and probably successful ones 2 d later (5c).

Oviposition lassitude (5d) was evident 3 d after the first observed possibly successful mating; and sagging of the abdomen (pouchiness) (5e) on the

following day. On the next day the first of 5 eggs (5f), laid at 48-h intervals was seen. Dates of laying were 15, 17, 19, 21, 23 May. Three hatched on 20 June before 1100 H, 1 on 21 June by midday, and the final 1 on 23 June. This suggests that incubation began 1 d before egg No. 4 was laid, giving an incubation period of 31-32 d.

In pen 2 the breeding cycle was delayed after nest-site selection by the prolongation of the stage of food caching by the male and collection by the female ("remote food passing" of Nelson 1977, quoted by Cade, 1982, p. 25). This was due to the failure of the female to respond adequately for over a week (4b) to food items offered by the male. There was a further delay (5a, b, d) before apparently successful mating took place (5e), by which time oviposition lassitude had been apparent for 5 d (5f), and two eggs had been laid (5g). This delay might account for the infertility of 3 of the 4 eggs.

During oviposition lassitude, about 3 d before the first egg was laid, the female performed a movement (8 in 1d), here termed 'dunking', similar to that made when sousing the under-tail coverts during bathing. It was difficult to be certain when incubation began, but it probably did not until 11 May, the day on which the fourth and last egg was laid.

Site-Selection Display - On arrival at the scrape the male held his wings high over his back for a moment, with the tips pointing upwards. In the complete pattern the male then partly lowered the wings and walked about on the nest in a stilted manner for a short time before starting to bow towards the female. In this, the head, body, and partly open wings would be aligned horizontally in her direction with the tail, usually partly fanned, cocked up at an angle. At the bottom of the bow, the wing tips and tail were pointing upwards at an angle of perhaps 30°. The soft *kip* call would be uttered during bowing.

Mutual bowing displays over the nest scrape occurred occasionally. Male bowing in the nest scrape while holding a mouse in his beak occurred and was probably part of food-pass display. On 3 May, before beak-to-beak passing had been achieved in pen 2, the male was doing this, and then deposited the mouse in a corner of the nest-box. After he had done so, the female arrived and took the mouse. He flattened out in the scrape with wings slightly open and held this position until the female moved slowly to the front of the nest-box and flew to the other

end of the pen. He had been seen in a similar position on 2 May with the female standing alongside and later settling down in a lying position. She nibbled at his beak.

The crows nest was used in pen 1 and the nest-box was used in pen 2.

Food Caching by the Male - This might take place either as initiation of the food pass ("remote food passing") or when for any reason the male had a food item not required by the female.

In the former case the site chosen was where the female could see what he was doing; in the latter it was usually in a more concealed position. The food item, still in the beak, would be deliberately pushed into the chosen position and left there, after which the male would stand up tall, looking intently at it, then back away a few steps before leaving.

Mating Approaches and Mating - The male indicated his intention to make an approach by stretching his head forward, sleeking his body feathers and slightly opening the wings in the plane of the body. The tail was held lower than the plane of the body, giving an arched-back effect. He stared in the direction of the female, and on taking off in flittering flight, uttered a specific, single, rather drawn-out call, *kwark*. If the female was prepared to accept him, she assumed a horizontal position and remained steady as he mounted; he might maintain his position by beating his wings. If, however, she intended to deter him, she uttered a single call, *koi*, or gave some unidentified signal, which may have been failure to adopt the accepting attitude.

On only 2 occasions was a call heard during mating, uttered by the female, which could only be recorded as either *kwey . . . kwek* or something resembling the young food-call (*eep . . . eep*).

Protest Flying - In April increasing evidence of territorial awareness was marked by what may be described as 'protest flying' against low overflying birds. Both of a pair, or both pairs, would suddenly start flying wildly around the pen, sometimes throwing themselves feet upwards against the roof netting, and uttering calls of anger or alarm, (*kek, kek, kek . . .*).

Even after incubation began the sitting bird would come off and take part. The protests seldom lasted more than 1 min, and eggs were usually quickly covered again. The female in pen 1 reacted more strongly to intruders than did the others.

Feeding of the Female during Incubation - During incubation the male provided most but not

all of the female's food. He took mice from the feeding tray to a regularly used plucking perch. When it was adequately plucked he called *kwi . . . kwik* and awaited a positive response, the *kwey . . . kwek* call of the female and her arrival to receive it there. Occasionally he transferred food at the nest. The female ate the item away from the nest and the male would promptly cover the eggs. After feeding, the female sometimes did not return to incubate immediately. If there was no response from the female to the male's call, he would either eat the mouse or cache it.

Hatching - Signs of possible approach of hatch were noted in pen 2 on 10 June (probably d 31 of incubation) although no pipping of the eggs could be seen. The female was doing a greater share of the incubation, was reluctant to come off when given a food item, and later would not allow the male to take over incubation. She was doing an unusual amount of looking down towards the eggs, and continued to draw in twig chips. Twice on the following day both birds were in the nest scrape. One young was seen at 1500 H.

In contrast, the pair in pen 1 showed no air of expectancy at the corresponding time and on d 30 of incubation the female left the eggs uncovered, after having come off to feed, for intervals of 5-7 min.

Feeding of the Young - In pen 1 the first hatching was seen at 0700 H. The first observed feed took place at 1030 H, by which time there was a second young, which also received food. Altogether, 5 feedings were seen between 1000-2050 H on d 1. Intervals between known consecutive feedings ranged from 1 to 1½ h. At a later date (d 11), 7 feedings were observed. Times between known consecutive feedings ranging: ¾ h, 1 h, 1 h, 1 h.

Interference by the male, usually an interception and eating of food morsels that were being offered the young, took place frequently from d 2 until about d 6, when at least some of the intercepted morsels were passed to the young.

In pen 2 no further egg hatched after 1 on d 32. Interference by the male was more disruptive and on d 3 the young was temporarily removed for hand-feeding. The parents continued to incubate the remaining eggs.

By d 4, it seemed that the youngest (No. 4) in pen 1 was not getting enough food in competition with the 3 older siblings. It was removed to a brooder for

hand-feeding. In anticipation of similar difficulty with young No. 5, it was removed as soon as possible after hatching. These 2 young were subsequently fostered into pen 2 on d 11 and 12.

In spite of the early interference, the males continued their plucking and offering of mice (now all MK II prepared) to females as they had done during incubation. During the first week, the male transferred food at the nest, but thereafter she flew to him on his plucking perch when he called.

In pen 1, full co-operation with the female in feeding was established by d 11. The male was first seen feeding alone on May 14, and on d 20, each parent took a mouse to the nest at the same time and distributed morsels separately. In contrast, the male in pen 2 was seen feeding alone only once. When offering morsels of food, the female used a single, soft *chup* call, of which the male's version was *kip*.

Development of the Young - Development of the young in pen 1 is shown in Table 1. When first hatched, they were covered with white down through which body colour was partly visible, giving the impression that the down was faintly pink in colour.

The eyes appeared to be sufficiently open for the young to see and snap at food morsels on d 4. Their movement in response to temperature coincided with being left uncovered at intervals from d 8 onwards. Parents shaded them during midday heat. On d 13 we provided overhead shade for the nest. This was providential because between d 13-18 a very hot spell occurred with temperatures reaching 27.5°C.

On d 19 a ladder was installed from the ground to the nest, and it was used on d 24 to 25 by the young to regain the nest. Within a further 2 d, 2 young roosted away from the nest. Although they were able to break up a food item effectively from d 24-26 they were still fed up to d 30. It was expected that they would be hard-penned soon after primary No. 9 (counted from carpal joint outwards) was as long as No. 8. This occurred at about d 38-40. The rates of growth for Nos. 4 and 5, while being hand-fed are shown in Table 2, and some weights for all 5 are given in Table 3.

The development of the single female that hatched in pen 2 is shown in Table 4. The continued incubation of the remaining eggs facilitated the return of it after being hand fed from d 3 - 9. The unhatched eggs were infertile. Although the

hand-fed male young were about 12 d younger than the female in pen 2 they were adopted. The female young did not roost away from the nest until d 28.

The hand-fed young (Table 2) were accommodated in the brooder in a shallow bowl lined with

tissue paper surrounded by a bound ring of twigs. They were given 8-9 feedings between 0700 and 1300 H of the following day. No. 4 was returned to parents on its 8th d, but was transferred to pen 2 on its 11th d. No. 5 was fostered direct from hand-feeding to pen 2 on its 8th d.

Table 1. Development and progress of the nestlings in No. 1 Pen.

FEATURE	DAY NUMBER (FROM HATCHING OF NOS. 1-3)
Hatching of Nos. 1-3	1
Hatching of No. 4	2
Hatching of No. 5	4
No. 4 removed for hand-feeding (aged 2d)	4
No. 5 removed for hand-feeding (aged a few hours)	4
Nestlings left uncovered at intervals	8
Movement of nestlings on nest in response to temp	8 →
Wing-flapping and rousing	8
Close ringing	8 - 9
Parents shade young in midday heat	8, 10, 11
No. 4 returned to pen	9
No. 5 fostered direct from hand-feeding into No. 2 pen	11
No. 4 transferred to No. 2 pen	12
Overhead shade provided for nest	13
Hot spell (shade max. 24-27.5°C)	13-18
Sitting up on tarsi prolonged	14
White down superseded by smoky grey	11 - 14
Rectrice tips and remige quills visible	13 - 14
Active interest in movements of parents	15 - 16 →
Standing up on feet; begin to walk	17
Increase in wing-flapping	17
Walking actively on nest	19
Ladder from ground to nest installed	19
Two nestlings perched outside nest in contiguous tree (Fig. 1 wa)	22
One nestling on ground (returned by hand)	23
Parents leave food for nestlings to break-up (with partial success)	23
Two pale bands visible on tails	23
Two nestlings on ground; one bathed; both returned to nest by ladder	24
Nestlings break-up food effectively	24 - 26
All 3 nestlings on ground; 2 colour-ringed	25
The two more advanced nestlings roost away from nest	25
Flying activity progresses	26 →
Much time spent lying on nest or elsewhere, apparently asleep	26 - 38
Last occasion when a parent feeds morsels to a nestling	30
A nestling takes food from tray	29
A nestling caches food item received from parent	30
Nestlings believed to be hard-penned	38 - 40
Nestlings taken up for training	40 - 41

Table 2. Routine weighings of two nestlings hand fed up to day eight.

NESTLING	WEIGHT(G) AND TIME							
	1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	8
4 *	-	@21 2015	@25 0700	30 0700	40 0630	50 0745	65 0745	80 0700
5 **	@10 1630	12 0700	18 0700	25 0630	30 0730	40 0700	50 0700	65 1345

* Nestling 4 removed from parents on day 1 at 1430 H.

** Nestling 5 removed from parents when a few hours old.

Calls - These have already been mentioned in the text as they occurred and are listed below:

(1) *Kip*: This soft call, usually repeated rhythmically at 1 - 2 sec intervals, is used by the male in several connections in the breeding season:

- (a) When he is plucking a food item preparatory to offering it to the female or eating it himself and he will continue to call as he feeds.
- (b) When scraping in a nest site.
- (c) In nest-site selection bowing display.
- (d) When he wants to take over on the nest.
- (e) When doing his share in feeding of the young.

Campbell and Nelson (1975) describe two forms, 'Chip or Tick' and 'Soft Chip or Tick', attributing the latter to the female when feeding young. As shown below, the latter has been represented by *chup*, which Campbell and Nelson interpret as a deterrent used by the female on the nest, but was not noticed here in this connection. Rowan (1921-22) mentions a very soft monosyllabic *tick* uttered by both birds on arrival at the nest, but he makes no mention of its use when the female was feeding young, yet his hide was only 2.5 m from the nest.

(2) *Chup*: Believed to be the female's version of *kip* and used:

Table 3. Weights showing rate of growth of nestlings in No. 1 Pen.

NESTLING	WEIGHT(G)									
	8	10	11	12	25	40	41	49	55	
1	80	—	—	130	@198	—	178	—	—	
2	80	—	—	140	@198	—	188	—	—	
3	60	—	—	—	—	170	—	—	—	
4*	80	—	120	—	177**	—	—	165		
5*	65	105	—	—	—	—	—	—	@170	

* Nestlings 4 and 5 were hand fed in a brooder for the greater part or all of their first eight days.

** Nestling 4 weighed on day 24.

Table 4. Development and progress of the nestling in No. 2 Pen.

FEATURE	DAY NUMBER
One egg hatched	1
Male disrupts attempts at feeding	1 - 3
Nestling removed for hand-feeding	3 (evening)
Parents continue to incubate remaining eggs	4 - 10
Infertile eggs removed and nestling returned to parents	10
Male becoming less disruptive at feeds	11
Male sometimes leaves nest after handing over of food	11 →
Nestling being frequently left alone during day	14
At dusk, female crouching over or beside nestling	14
Remige quills beginning to show on nestling	14
Hand-fed nestling No. 5 of No. 1 Pen fostered	20
Nestling No. 4 fostered from No. 1 Pen	21
All 3 nestlings still huddle together for night	23 - 26
Nestling No. 1 actively playing with twigs, etc.	24
Nestling No. 1 actively wing-flapping	24
For some days male would frequently return to nest and rob female of food item, which she might retrieve or that he would return	24 - 28
Nestling No. 1 returned to nest in evening via ladder	27
Two pale bands showing on tail	27
Nestling No. 1 breaks up a mouse, also later accepts morsel	28
Nestling No. 1 to a high perch in evening, probably roosted there	28
Transferred to separate pen	29
Taken up for transfer to a falconer (not yet fully hard-penned)	37

- (a) When plucking, and feeding herself, or the young in the nest.
 (b) It is probably used when taking over from the male on the nest.
 (c) In mutual bowing in nest site.

(3) *Kwi, kwi, kwi, kwik*: A single syllable, rapidly repeated 4 or 5 times. Used by the male particularly when he has plucked a food item and intends to offer it to the female, but sometimes used when he has no food item. This, and the female's version, *kwey . . . kwek* are undoubtedly the 'Short Chatter' of Campbell and Nelson.

(4) *Kwey, kwey, kwey, kwek*: Believed to be the female's version of *kwi . . . kwik* and used in response to it to indicate that she wants to receive the item. It may be used to draw the attention of the male to her need for food. The 2 calls were very frequently used in mutual responses by a pair in a previous season without food being involved.

It is strange that the female of the pair studied in the wild by Rowan (1921-22) responded to the

male's 'Short Chatter' with what appeared to be a form of the young food call, and not with her version of the 'Short Chatter'. The 'Short Chatter' of male and female were the most characteristic and frequently heard calls during the breeding season in the present study. There is, however, a very similar call, but rather shriller in the male and harsher in the female, that appears to be used to give the opposite message, "I have food, keep away." It was usually heard early in the year. It was once heard, in May 1974, from a female under circumstances suggesting territorial advertisement to another female.

(5) *Kwark*: A single, drawn-out call uttered by the male just before flying towards the female in a mating approach.

(6) *Koi*: A single, brief call, seldom heard but apparently given by the female to deter the male from a mating approach. The call had been heard 3 times in 1975, twice in the context of mating approaches and once when the male, of a pair in which the

female had consistently evaded mating, alighted close to the female without any apparent mating intent on 23 May. He departed almost at once. On only 2 occasions was any call heard during mating, on 7 and 9 May, both after egg-laying began. The call was given by the female and could only be recorded as either *kwey . . . kwek* or the young food call. It is possible that it may have been something specific.

(7) *Eep, eep, eep . . .*: The young food call, heard after they had left the nest, associated with an adult having food. Also used by the female in pen 2 occasionally in March and early April, and again in the succeeding autumn.

(8) *Kek, kek, kek . . .*: The alarm call, rapidly and continuously repeated. This is the 'Aggressive Chatter' of Campbell and Nelson.

DISCUSSION

Campbell and Nelson (1975) found their Merlins (*F. c. richardsoni*) hypersensitive to human interference, which caused aggression, sometimes fatal, by the female towards the male. Campbell (1980) suggested that if Merlins were well manned, they would be less hypersensitive. This was well demonstrated in the tolerance in the 2 pairs as exemplified by the female in pen 2 having had to be pushed/lifted off the fostered young that she was brooding in order that a second one might be introduced. None of the Merlins had been given any occasion to become imprinted on man when young, but all had been manned at one time or another. Outside the breeding season they would, given a few days' practice, come to the fist in their pens.

Campbell (1980) moots the thought that aggression he saw might have been due to putting the Campbell and Nelson (1975) birds together too early, or leaving them together throughout the non-breeding season. A little information on this point was obtained early in 1977, when Heather, a sibling female of Myrtle (female of pen 2) was returned on 20 February because of aggression towards the male with which she had been paired elsewhere. She was isolated in a small pen that had a small, shuttered communicating hatch into pen 2 with watching perches placed within 30 cm of it in each pen. On 22 April 1977 the blank shutter was lowered, leaving only a nylon mesh shutter between the 2 pens. Almost immediately, Brae and Heather were face to face on opposite watching perches,

evincing interest but no threat, and both at one time or another tried to get through to the other side. Myrtle on arrival, made a fierce attack on Heather across the barrier, to which the latter responded equally fiercely. The blank shutter had to be hauled up quickly. On 26 April, Heather was transferred to be paired with a leg-impaired haggard male. Breeding did not take place, but nor did harassment.

It seems possible, therefore, that if the introduction between Lochan and Corrie had been deferred until March-April and done more gradually, less aggression might have resulted. A trial in 1975, aimed at simulating the usually sequential spring arrival of male and female Merlins on the breeding grounds (Brown & Amadon 1968; Cade 1982) showed the feasibility of a 2-stage introduction of a male, isolated in pen 1 to a female in pen 2 by manipulating in March-April a double-shuttered hatch such as that described above.

Corrie, paired with Ben (a sibling of Brae) in 1979 and 1980, reared young, but during the first week of April 1981 she killed him without warning. It may be significant that during the breeding season Corrie reacted more strongly to low over-flying birds than did the others.

It has been the practice in this project to keep pairs of Merlins together throughout the year; and, up till the end of 1982, this was the only fatality of this kind that occurred. But it appears that there is a latent danger of violence just before or during the early stages of the breeding cycle, which might be triggered by human interference and possibly by other factors.

The breaking off of pieces of twigs from the perimeter of the nest and/or the drawing in of twig chips and dropping them into the nest scrape is of particular interest, although its purpose is not clear. When first observed before 1977, it seemed clear that this could account for the fact recorded in the ornithological literature that Merlin nests on the ground in the wild are often lined with heather stalks and bents. It appears that it was not until the work in Northumberland (Newton et al. 1978) that Merlins in the wild were actually recorded as placing such items, picked up from within reach, into the nest scrape, beginning before laying and continuing into incubation. Nibbling of thick heather stems by the sitting bird also occurred at many ground nests (Newton et al. 1978). In any case, whatever the purpose, it seems desirable to provide

twig chips in nest sites.

Flattening out in the scrape, by the male in the presence of the female, which nibbled at his beak, is probably a form of 'Fixed Bow' derived from mutual courtship bowing over the nest cup or scrape. Cade (1982) believed the latter to be conducive to mutual familiarization at close quarters. Flattening out was seen in a remarkable degree in 1975 between Laggan and Melanie, perhaps because there seemed to be some obstacle to Melanie's acceptance of mating approaches by Laggan. It was first observed and took place several times on 7 May. By this time beak-to-beak food passing was well established, with the female frequently passing the item back to the male. Mutual calling *kwi, kwey* was also frequent, but Melanie had consistently deterred mating approaches. Flattening out was usually initiated by the male calling *kip* in the crow's nest in pen 1 following which the female would join him, but sometimes the female might be there already. They would bow towards each other calling *kip* and *chup* before both birds, the female in the nest cup, flattened out with the tail partly fanned and raised at an angle of ca 30°. Both birds might remain 'frozen' in this position for up to 5 min. The male would usually stand sooner, remain looking at the female for up to 1 min, as though doubtful what to do, before flying away. The female then usually stood up also. Mating did not follow any of these sessions. They continued to be seen sometimes up to 5 or more times a day, until 26 May, 2 d before Laggan was transferred.

Cade (1982) mentions that a female falcon indicates her readiness to mate by turning away from the male, which presumably facilitates his mounting. However, this turning away was not seen in the Merlins. It was noticed that matings appeared to be more consistently successful when the female was not perched on a high horizontal perch parallel to the back wall but on an isolated post, thus permitting the male to approach from any direction.

The Hurrell-type pens proved ideal for their purpose. The only potential hazard is accumulation

of snow on the roof netting in winter. In the normal winter climate of southern England all that should be necessary is to go in with a forked stick and shake down the snow. In construction of Hurrell-type pens in the northern hemisphere it would be desirable to place the observation hide in the southern wall and the nest sites adjacent to it in order to avoid excessive insolation of the latter and provide optimum viewing.

ACKNOWLEDGEMENTS

The author is grateful to the Advisory Committee on the Protection of Birds for Scotland of the Scottish Home and Health Department for licences to take wild Merlins. Particularly we thank the late George Waterston, O.B.E., LL.D., for his interest, encouragement and support; the Highland Wildlife Park, Ltd., for the loan of a flight-impaired Merlin and to D.G. Hunter of the Agricultural Research Council for making available the deep-frozen laboratory mice, and to members of his staff, R.J. Taylor for making the necessary arrangements, and D. Shirt and S. Collis who handled the mice. A more extensive draft of this paper is on deposit with the Hawk Trust in Great Britain.

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GROWTH RATES AND FOOD CONSUMPTION OF HAND-RAISED MERLINS

LYNN W. OLIPHANT AND STACEY V. TESSARO

ABSTRACT - Growth curves were constructed for two male and two female Merlins that were hand raised. Growth rates and maximum size of the hand-reared birds appear to be substantially lower than wild birds, possibly due to a lack of moisture in the diet. Daily food consumption was measured and used to estimate food requirements for a Merlin family group. For a pair with 4 young, a total of 800 sparrow-sized birds are required for a 120-day breeding season.

Each year hundreds of raptors are hand-raised by falconers or by the various institutional breeding projects. This presents a unique opportunity to gather data on growth rates, food consumption and general development. Such information is useful for accurate aging of nestlings, comparisons of growth rates under different conditions (differing prey densities, brood size, etc.), determination of prey requirements of a nesting pair of birds, and optimizing conditions of hand-rearing. This study describes observations on the development of 2 pairs of the Merlin (*Falco columbarius richardsonii*) that were hand-reared.

METHODS

Pair #1 was taken from a nest on 15 June 1975 as small downies of unknown age. Pair #2 was hatched in captivity (Roll-X incubator, 36.7°C) in 1979 from a clutch of eggs taken immediately after clutch completion. Both pairs were initially maintained in simple brooder boxes heated by light bulbs. Temperature was regulated on the basis of behaviour of the young falcons, being gradually reduced to room temperature.

Diets and feeding regimes for the 2 pairs were slightly different. Pair #1 was fed a mixture of laboratory mice (head, gastrointestinal tract and skin removed) and day-old chicks (feet, beak and skin removed) in a ratio of 3 mice to 1 chick. Food was ground in a meat grinder and frozen in meal-size packages. The birds were fed as much as they would eat 5 times/d for the first 6 d, 4 times/d for the next 10 d and 2-3 times/d thereafter. For each feeding the meat was thawed, brought rapidly to room temp and fed by forceps until the Merlins could eat from a small saucer. In addition to their regular fare, they were given a freshly killed House Sparrow (*Passer domesticus*) that was minced by hand and fed fresh on 4 occasions.

Pair #2 was fed only freshly-killed Coturnix (*Coturnix* sp.). For the first 3 d after hatching, these Merlins were fed small amounts of diced breast muscle, heart, liver and small crushed bone fragments. Afterwards they were fed freshly ground whole quail (beak, gastrointestinal tract and skin removed). This pair was fed 4 times/d for the first 15 d, 3 times/d from the 15th to 22nd d and 2 times/d afterwards. They were fed in the same manner as pair #1 and allowed to eat as much as they wanted.

Both pair were weighed to the nearest 1/100 g on a Sartorius electrical balance before and after feeding to determine the weight of food consumed. Weights used to document daily weight gain were morning weights prior to the first feeding of the day. Little casting material was given and weights of the few castings were ignored.

Pair #1 was placed in a hack box with 2 other Merlins taken

from a nest just prior to fledging which were a few days further advanced than the hand-reared pair. All 4 fledged together although the hand-reared female, being the youngest, was not capable of sustained flight until 5 d later and was picked up for a final weighing 2 d after fledging.

Pair #2 was tame hacked for a week after training to a lure allowing them to be brought in every night. After the hack, this pair was kept in outdoor mews and both birds flown twice daily for the next month, primarily at large flocks of House Sparrows (*Passer domesticus*) as part of a crop depredation experiment. During this time they were fed 2 times/d on either Coturnix Quail or wild birds they had caught, receiving about half a crop in the morning and a full crop each evening (1 1/2-2 sparrows/d).

Growth curves for both pairs were generated using a computer program to fit the data to a smooth curve. The growth function used for this curve is the differential equation of Richards (1959).

RESULTS

Both pairs consisted of 1 male and 1 female. Pair #2 hatched within an hr of each other on 14 June. Weights at hatching were 13.0 g and 13.7 g. The hatching dates for the 1975 pair were estimated to be 6 June (male) and 9 June (female) using physical development and weights as compared to pair #2 and wild nestlings of known age. Growth curves for both pairs are shown in Figs. 1 and 2 with day 0 being hatching day. The growth curves exhibit a typical sigmoid shape reaching peak weights between day 23 and 27 with a slight drop in weight afterwards. The inflection, or point of highest growth rate, was reached at day 14 or 15.

Pair #1 was considerably larger than pair #2 and attained maximum weights of 265 g (female) and 203 g (male) as compared to 226 g (female) and 174 g (male). Maximum weights were 10-30 g higher than weights at fledging. Pair #2 was flown at 207 ± 5 g (female) and 146 ± 5 g (male). Their weights were remarkably consistent from day to day.

Food consumption (Figs. 3 and 4) showed an almost straight line increase from hatching to day 12-14 (Fig. 4). Consumption then levelled off and was maintained at maximum levels with some fluctuation for the remainder of the rapid growth phase, decreasing when body weight approached

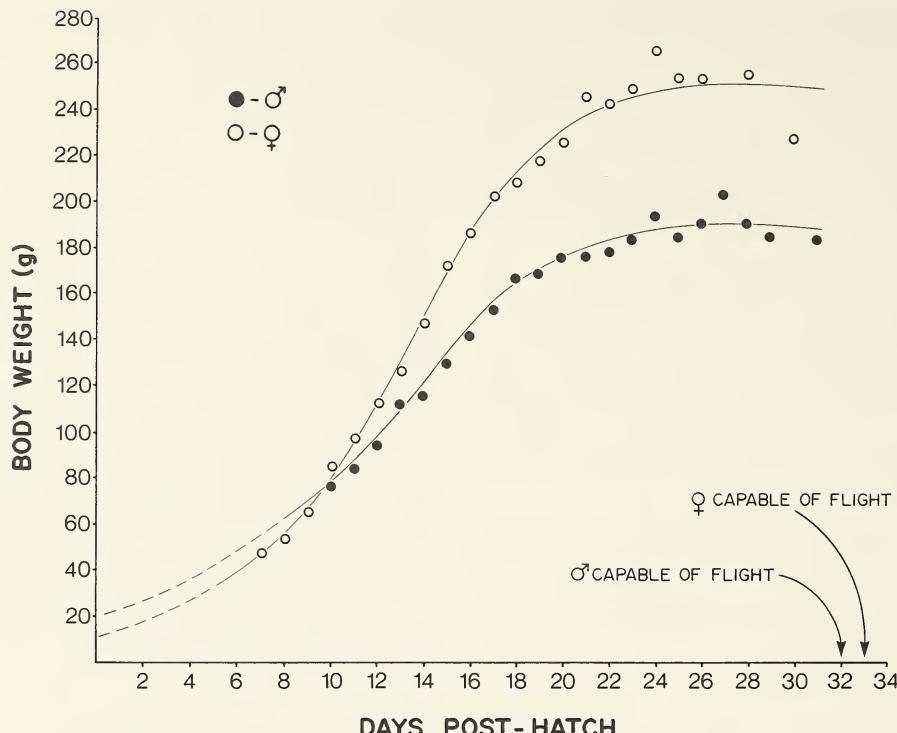


Figure 1. Growth curve for Pair #1.

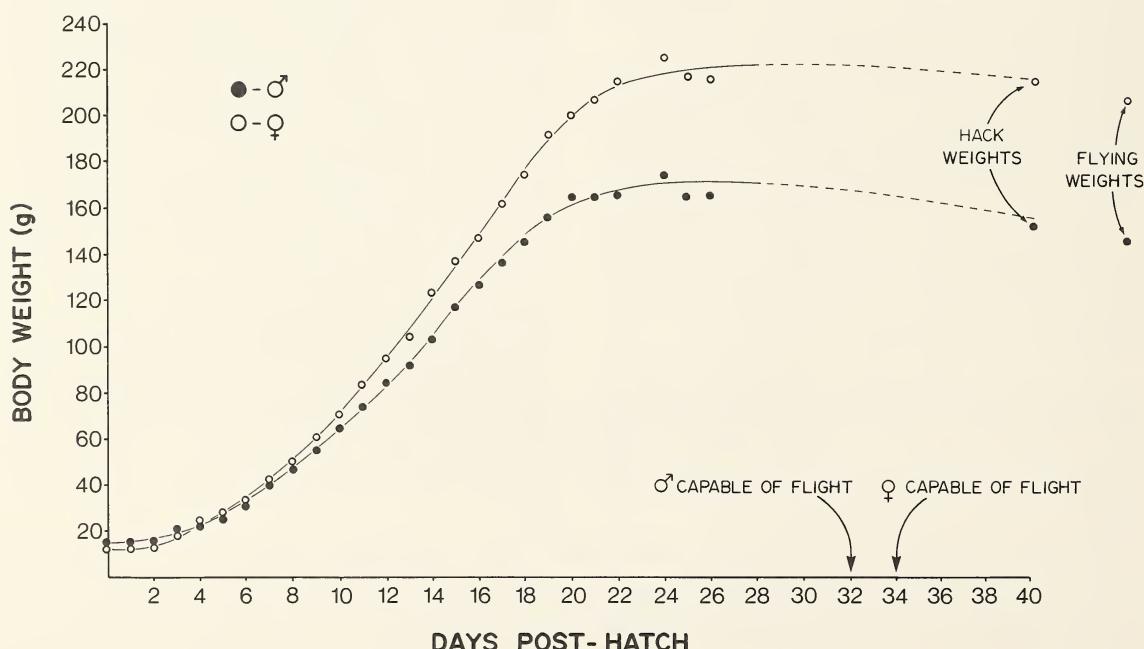


Figure 2. Growth curve for Pair #2.

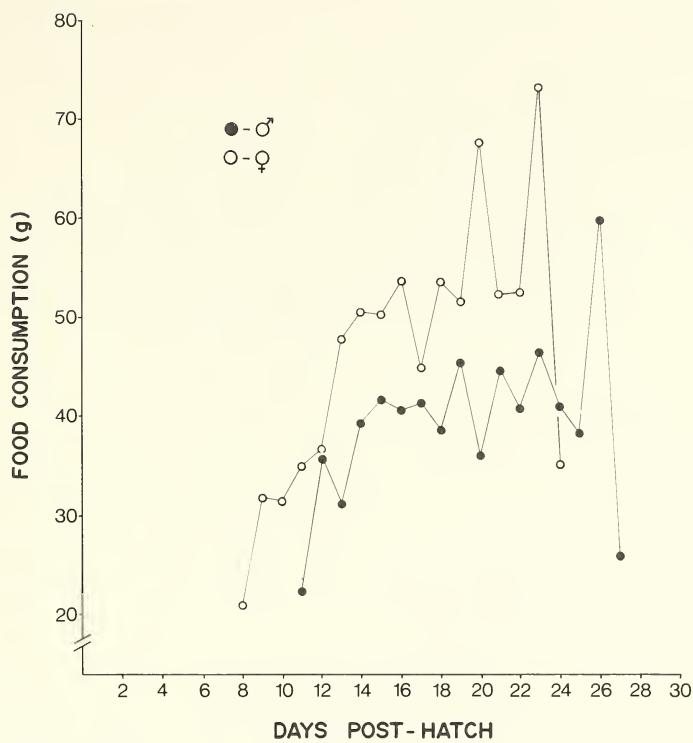


Figure 3. Food consumption - Pair #1.

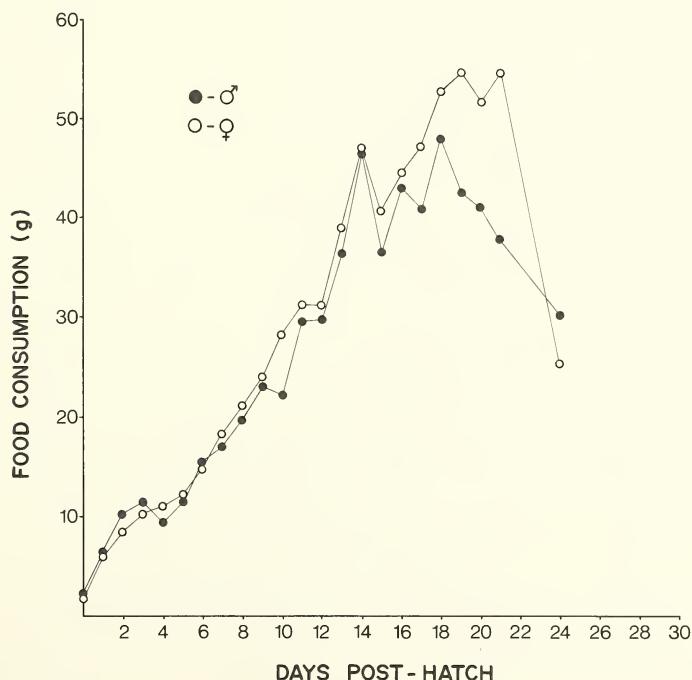


Figure 4. Food consumption - Pair #4.

the maximum. The average amount of food consumed during this period was very similar for the males (40.0 g/d). The female from pair #1 consumed 52.4 g/d as compared to 46.1 g/d for the other female. Food consumption decreased by day 23-27 to about 30 g/d for both males and females.

General observations on the development of the 4 birds are presented in Table 1. There was a slight variation in the appearance of various behaviour patterns with males developing ahead of females. Post-hatching development is broken down some-

what arbitrarily into 5 major periods: day 0-3 (newborn); 4-11 (small downy); 12-21 (large downy); 22-28 (brancher); and 29-independence (fledgling).

DISCUSSION

Basic growth parameters for Merlins have been reported (Ricklefs 1968a, b) but are incorrect. The original data from which these growth parameters were derived are for the Prairie Falcon (*Falco mexicanus*) (Fowler 1931) and the reported weights

Table 1. Post-hatching Development

	DAY	OBSERVATIONS
Newborn	{ 1 1 3	Hatch; eyes closed, down wet. Down dry. Eyes open.
Small Downy	{ 4-8 9-11	Enter period of rapid growth; Become aware of surroundings; Second down coat develops. Sheathed contour feathers appear; Sitting erect on tarsi; Wing flapping begins.
Large Downy	{ 12-14 15-17 18-21	Primaries break sheaths; First casting. Rectrices break sheaths; Egg tooth is lost; Standing upright. Cheek and flank feathers develop; Flight feathers developing rapidly; Grappling and holding food with feet; Increased wing flapping; Leveling off of food consumption and weight gain.
Brancher	{ 22-28	Maximum weight attained; Rapid replacement of down by contour feathers (down visible only on head by 28 days); Short jumping "flights."
Fledgling	{ 29-34 35-40 40-50 50-60	Fledging; become capable of sustained flight. First long flights and development of flying abilities; Interest shown in potential prey (first pursuit of bird at 36 days, 1979 (male). First bath. Hunting begins; first kills on flying insects; first bird kill [Day 42, 1979 (female)]. Some down still remains on head. Completion of feather growth. Become independent; disperse.

were incorrectly converted from ounces to grams and mistakenly reported as *Falco columbarius*.

The significance of the lower weights at full growth for pair #2 as compared to pair #1 is difficult to assess due to small sample size and minor differences in feeding regimes, handling, etc. Data collected on weights of wild nestlings of known age suggest, however, that even pair #1 was smaller and exhibited slower growth rates than most wild nestlings. Weights of 12 wild females between 20 and 28 d old all exceeded 250 g (limit of scales used) and weights of 5 wild, 11 d old nestlings (unsexed) weighed an average of 129.6 g (103-160 g) as compared to 80 g for pair #2 and 90 g for pair #1. It should be noted that our estimate of the hatching dates of pair #1 may be as much as 2 d too early based upon the observed weights of wild nestlings. The difference in growth rates cannot be attributed solely to differences in food quality between our hand-reared birds and wild birds. Weights of 3 captive bred Merlins (2 females, 1 male) raised by their parents but fed only *Coturnix* quail averaged 120 g at day 11.

In 1979 we had the opportunity to directly compare our hand-reared pair (#2) with a wild nestling (male) which had hatched on the same date. The wild Merlin had fledged prematurely from a nest site. The birds were 27 d old at the time of comparison but on the basis of feather development and flight capabilities the wild bird appeared to be 4-5 d more advanced than the hand-reared pair.

There has been recent evidence to suggest that growth rates and final body size may be less in falcons reared by people as compared to those cared for by falcons (The Peregrine Fund; MacDonald Raptor Research Centre, pers. comm.) Jim Weaver (The Peregrine Fund) suggested that this difference might be due to fluids added to the food from the nasal glands of the adult falcon during feeding. Addition of physiological saline to the food appears to counteract this slower growth which is especially apparent during the early stages of development (Oliphant, unpub. obs.). Olendorff (1972) has also noted the potential problem of dehydration in hand-reared buteos and, more recently, Wallace at the University of Wisconsin (Dobbs et al. 1979) showed that diets containing less than 55% moisture slowed growth or even halted growth in young of the Turkey Vulture (*Cathartes aura*). The moisture content of 5 wk old quail given by Dobbs et al. (1979) is very low (45%) in compari-

son to other whole animal food. It appears that until further studies are done, it would be prudent to add water or physiological saline to ground quail being fed to hand-reared raptors.

There was a noticeable difference in the tarsus, cere and orbit color of our hand-reared birds as compared to wild nestlings. Our birds had blue or blue-green skin as compared to the bright yellow color of wild nestlings of advanced age. This is undoubtedly due to the relative lack of carotenoid pigments in the diet of our hand-reared birds.

Development of vocalizations was retarded in our hand-reared birds. When pair #1 was placed in the hack box with the 2 late taken wild young, they only made food begging cries typical of nestlings. The 2 late taken wild young had already developed a typical adult call with a rapid stacatto delivery. Even a wk after fledging this difference was still apparent. The response of these birds to a wild adult male Merlin that appeared in the hack area was also very different. The late taken birds begged for food and chased the adult male but the hand-reared birds ignored him.

Based upon our values, the total food requirements for 1 Merlin from hatching to fledging are about 1,000 g. This can be expected to vary slightly depending on sex and size of the particular nestling and nutritive value of the food consumed.

Sparrow-sized birds are the principal food of Merlins (Oliphant and McTaggart 1977; Hodson 1978). Average weights of freshly killed sparrows in Saskatoon were 28.6 g in summer (n=15) and 35.6 g in winter (n=10). The weight of a plucked carcass with head and tarsus removed averaged about 80% of fresh wt. This gives a value of about 25 g of useful food per average sparrow kill. The total food requirements per Merlin during the nestling period is therefore about 40 sparrows. Based upon the food consumption of pair #2 after fledging, an additional 38 sparrows would be required from the time of fledging to independence at day 55. Assuming similar food requirements for a pair of breeding adults over an entire 120-d breeding season results in an additional 210 sparrows required per adult. The total calculated prey requirements for a breeding pair and 4 young would therefore be 732 sparrows.

Observations at wild nests in the city of Saskatoon indicate that these calculations are close, but probably on the low side. We recorded a total of 5 sparrows killed (3-4 expected) during incubation by

watching at 1 Merlin nest site from dawn to dusk. A similar watch at a nest site with 5 one wk old young recorded 10 sparrow kills (8-9 expected). This slightly higher than calculated kill rate could be due partially to the occasional loss of some kills during plucking or food transfers (whole carcasses were occasionally found at nest sites) and loss of cached food (Oliphant and Thompson 1976) either stolen by other birds or simply forgotten. The actual number of House Sparrow-sized birds killed by a breeding pair with 4 young is probably close to 800 for a 120-d breeding period. This is somewhat lower than that estimated by Lawrence (1949) which would have amounted to a total of 1,140 for a brood of 4 young over a 120-d breeding season.

ACKNOWLEDGEMENTS

We thank Paddy Thompson, Bob Rafuse, Sue McTaggart, Bruce and John Hanbridge for help in obtaining and rearing Merlins and gathering data on prey utilization by wild pairs. The Saskatchewan Department of Tourism and Renewable Resources issued the necessary permits. Dr. Charles T. Collins kindly supplied the computer printouts of the growth curves. This study was supported in part by an NSERC grant to the senior author.

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MIGRATION OF THE MERLIN ALONG THE COAST OF NEW JERSEY

WILLIAM S. CLARK

ABSTRACT - Merlins were captured along a migration route in New Jersey from 1968 to 1979. Sixty-one percent of 1550 Merlins captured at Cape May Point in autumn were female. Seventy-six percent of 105 Merlins captured at Sandy Hook in spring were female. Eight percent and 59% of the Merlins captured were adults at Cape May Point and Sandy Hook, respectively. The dho-gaza was the most effective capture device. Females migrated before males in autumn and vice versa in spring. Both sexes are captured more frequently after noon in autumn and spring, but many males were captured in the morning in spring. Timing of spring migration was more compressed. Mean wt and wing chord measurements were calculated. Adults were significantly heavier than immatures (*t*-Test, $P < 0.001$). In spring, Merlins were considerably heavier than in autumn. Most Merlins can be sexed by wing chord length and wt. Subcutaneous fat visible beneath the skin was estimated and was not correlated to mean wt. Band recoveries indicate a migration pathway along the Atlantic Coast with wintering in Florida and the Greater Antilles, but none from Cape May Point have been recovered in Central America or northern South America. Some Merlins moved northward in autumn.

The Merlin (*Falco columbarius*) is of panboreal distribution. Most studies of the species have concentrated on the breeding season (Fox 1971; Oliphant and Thompson 1976; Newton et al. 1978) or systematics (Temple 1972a). Although most races are migratory (Peters 1964; Dementiev et al. 1966), and a few studies of Merlin migration have been published (Williamson 1954; Brown 1976; Thompson 1958), nothing has been published regarding migration of populations of eastern boreal North America *F.c. columbarius*.

This paper reports Merlin migration from data gathered during long-term raptor migration research at Cape May Point and Sandy Hook, New Jersey. Cape May Point is located at the southern tip of New Jersey where the greatest concentrations of migrating raptors in North America occur during the autumn migration (Dunne and Clark 1977; Dunne 1980). Sandy Hook is located on the south side of the New York Harbor and has been found to be a spring concentration point for raptors, especially small falcons (Clark 1978).

METHODS

During 12 autumns, my cooperators and I have operated a raptor banding station at Cape May Point. During 1977-1980, a

second banding station was operated during spring at Sandy Hook. Merlins and other species of raptors were captured at both locations using bownets, mist nets and dho-gaza nets (Clark 1970, 1981). Captured falcons were banded using U.S. Fish and Wildlife Service bands and in most cases were weighed to the nearest gram and wing chord measurements in mm were taken. Merlins were aged and sexed using the technique outlined in Temple (1972b). Data on wing chord and weight were used to verify sex determinations using the statistical computer program SAS Discriminate Function Analysis.

During 1978 and 1979, Merlins captured at Cape May Point were visually checked for subcutaneous fat on the sides of the breast, in the throat cavity and on the belly by blowing the feathers out of the way. Presence or absence of fat was recorded according to the coding scheme in Table 1.

RESULTS AND DISCUSSION

Data were obtained for 1550 Merlins captured at Cape May Point during the years 1968-1979 (Table 2) and 104 at Sandy Hook during the years 1977-1980 (Table 3).

Age and Sex Ratios. — Only one exception was found to Temple's (1972b) key for ageing and sexing Merlins. Many immature plumage males had both gray and buffy colors in the light tail bands ($N = 577$), while immature females had only buffy tail bands ($N = 852$). Temple noted that immature males had only gray color in tail. Immature plum-

Table 1. Coding scheme for subcutaneous fat in captured Merlins.

FAT CLASS	SIDE	THROAT	BELLY
0	None	None	None
T (Trace)	A trace of fat is noted in any of the areas		
1	Slight-medium bulge	Present	(or)
2	Medium-large bulge	Lined	and Lined

Table 2. Merlins banded Fall, 1968-1979, Cape May Point, New Jersey

	MALES	FEMALES	TOTAL
Immature	574	812	1,386
Adult	41	77	118
Unknown	2	44*	46
Total	617	933	1,550

*Includes 43 unknown from 1971

age females also had less well defined tail bands than those of males.

Merlins are sexually dimorphic with females larger than males. A plot of wt vs wing chord separated the sexes (Fig. 1), even though there is a slight overlap in either measurement between sexes. The data were also checked for accurate sex determination using discriminant function analysis. The same sex was selected by the program and the banders for every data pair of wing chord and wt.

Table 3. Merlins banded Spring, 1977-1980, Sandy Hook, New Jersey

	MALES	FEMALES	TOTAL
Immature	3	40	43
Adult	22	39	61
Total	25	79	104

Ninety-two percent of the Merlins captured in the autumn were first-year birds (Table 2). This age ratio was consistent with that of other raptors captured at Cape May Point; American Kestrel (*Falco sparverius*) 92.5% (N = 8091), Sharp-shinned Hawk (*Accipiter striatus*) 94.6% (N = 13,867), and Coopers Hawk (*Accipiter cooperii*) 92.7% (N = 756).

Age ratios reported for songbirds banded on the coast reflect the same phenomena (Robbins 1977).

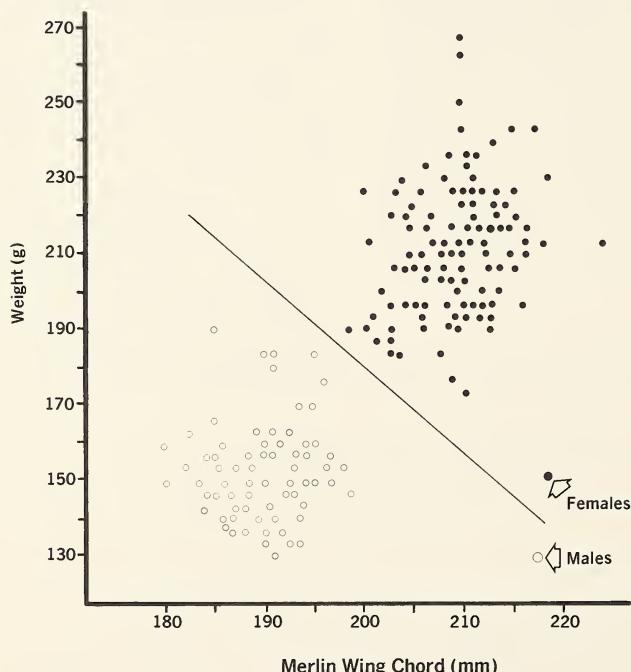


Figure 1. Comparison of wing chord and weight of migrant Merlins captured at Cape May Point, New Jersey.

Table 4. Merlins captured by type of trap.

TRAP TYPE	CAPE MAY POINT, N.J.			SANDY HOOK, N.J.		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
Dho-Gaza	264 (43%)	371 (41%)	638 (43%)	10 (40%)	31 (39%)	41 (39%)
Mist Net	170 (28%)	211 (23%)	381 (25%)	0%	2 (31%)	2 (%)
Bow Net	177 (29%)	333 (36%)	509 (33%)	15 (60%)	46 (58%)	61 (59%)
Other	—	—	4	—	—	0
Total	611	915	1,532	25	79	104

Presumably the best explanation is that immature raptors and songbirds are concentrated along the Atlantic coast during fall migration by the wind drift and leading line phenomena described by Mueller and Berger (1967). The higher winter mortality of immature raptors compared to adults (Newton 1979) may partially explain the higher percentage of adults in the spring sample (Table 3).

Capture samples (Tables 2 and 3) showed an unbalanced sex ratio in favor of females. At Cape May Point, 61% of the Merlins captured were

females; at Sandy Hook, 76%. These samples are significantly different ($P < 0.001$) from each other and from the expected 50-50 sex ratio (Fox 1964) ($P < 0.001$). Possible explanations for the observed skewed ratios include capture bias, differential migration and differential survivability. Based on Merlins being caught and not being caught, there seems to be little or no sex bias in the capture techniques. If there is a different migration pathway for males, it is probably not over land, as no other raptor banding stations capture many Mer-

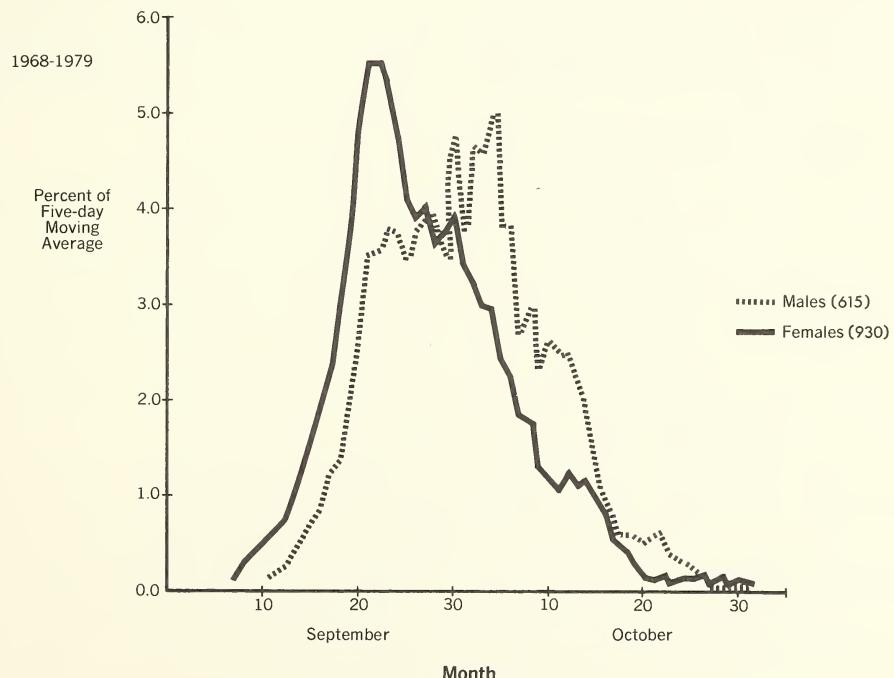


Figure 2. Merlins captured at Cape May Point, New Jersey, in the fall (1968 - 1979) by date by sex.

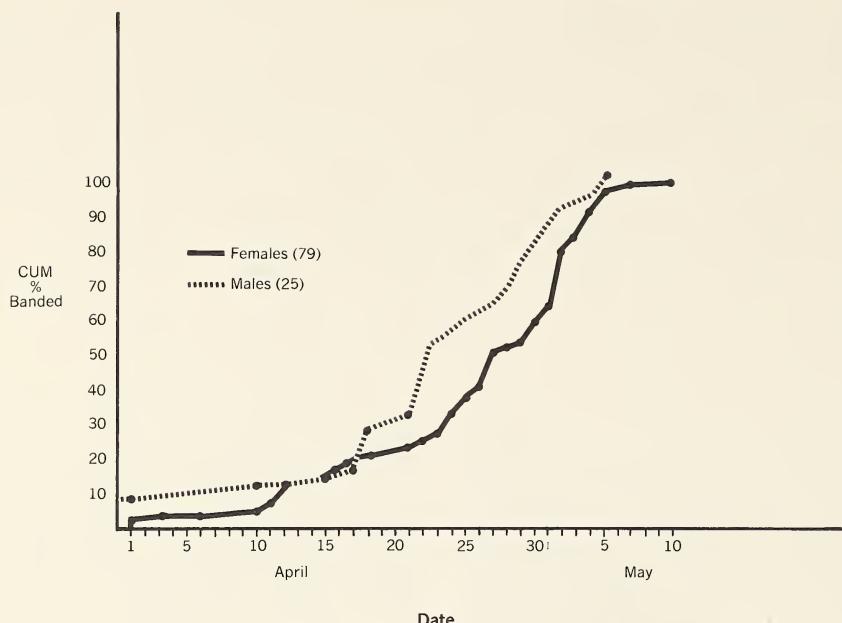


Figure 3. Merlins captured at Sandy Hook, New Jersey, in the spring by date by sex.

lins. Merlins have been reported in the fall migrating over water off the eastern coast of North America (anon. 1979). There are insufficient data to determine if there is differential survivability between males and females.

Capture Techniques — Merlins were captured by 3 types of traps (Table 4). The modified dho-gaza (Clark 1981) is the most effective trap for capturing Merlins. There are minor differences in percentages by capture method among the 4 to 5 different stations at Cape May Point caused by terrain differences. Generally, dho-gazas (and mist nets) are more effective when there is a dark background behind them and bow nets are more effective in more open locations. Differences between the capture technique percentages of Cape May Point and Sandy Hook are probably due to differences in terrain. The Sandy Hook stations are in much more open terrain with little backdrop available.

Diurnal and Seasonal Timing — The Merlin was one of the earlier autumnal migrants at Cape May Point, arriving in numbers by September 10, and completing the passage by mid-October (Fig. 2). Females migrated earlier in the season than males and peaked earlier (Fig. 2). Rosenfield and Evans

(1980) theorize that migrating immature female Sharp-shinned Hawks precede males because of their dependence on larger avian prey. My data for Merlins support their hypothesis, as the Merlin also subsists almost entirely on birds and females migrate first.

Males precede the females in spring (Fig. 3). This is consistent with behavior of other migrant species with the adult males arriving on territory first (Roest 1957). The spring migration period spanned a shorter time than the autumn period. The autumn migration "season" for Merlins is over a month while the spring migration period lasts only about 15 d. In spring they do not appear in numbers until after 20 April and most have passed by 5 May.

There is very little difference in the time of day the sexes are captured at Cape May Point (Fig. 4). In general, the data support the observation that Merlins are more plentiful in the afternoon.

Migrating Peregrine Falcons (*Falco peregrinus*) have been characterized by having 3 different flight characteristics during the day (Cochran 1975). First, from predawn to the time of thermal formation, they hunt using powered flight in the desired migration direction at an altitude of around 30m.

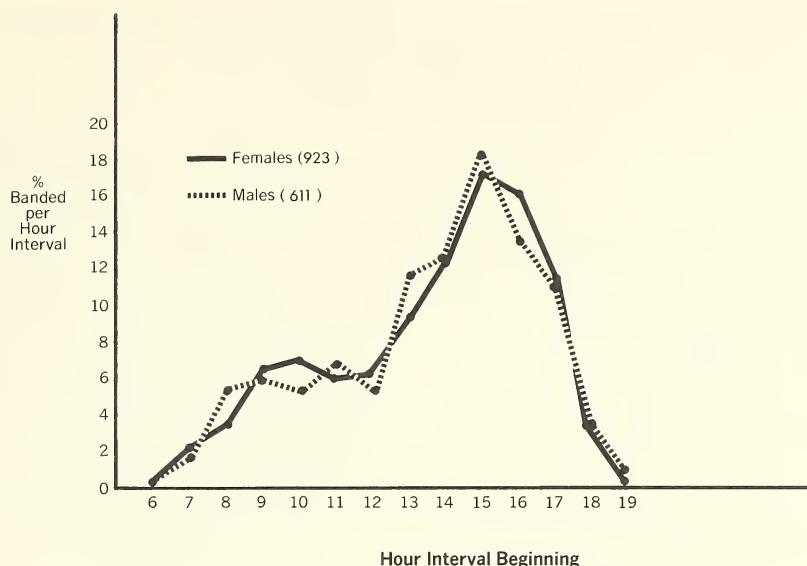


Figure 4. Merlins captured at Cape May Point, New Jersey, in the fall by time of day by sex.

During mid-day, they utilize thermals in the manner of most migrating raptors. In the afternoon, when thermal production slows down or ceases, they begin a low-level hunting flight, generally in a random direction. I believe that the Merlins migrating along the Atlantic Coast use similar strategies. On many occasions Merlins that had

perched for the night on snags at Cape May Point were not present the next morning at first light (Dunne, pers. comm. 1981). The Merlins may have begun migrating using powered flight hours before sunrise, changed to thermals later in the morning, and finally, when thermal formation weakened later in the afternoon, they dropped to low altitudes

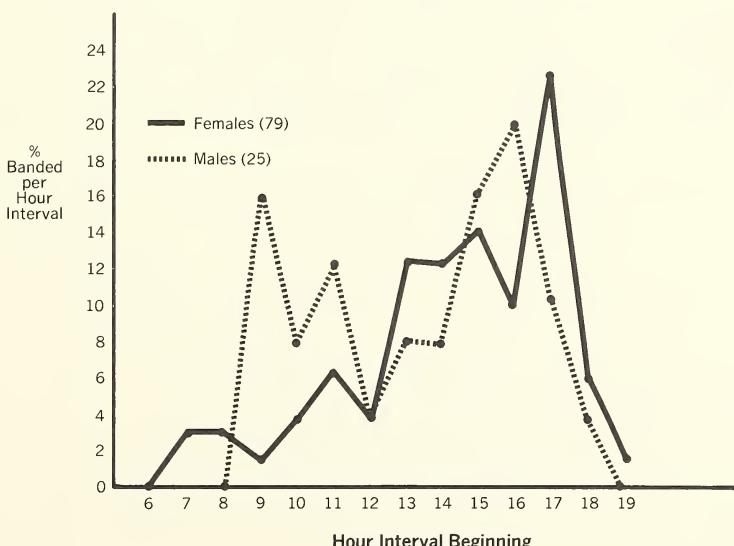


Figure 5. Merlins captured at Sandy Hook, New Jersey, in the spring by time of day by sex.

Table 5. Mean weight and wing chord of Merlins banded in the Fall at Cape May Point, New Jersey.

		ADULT*	IMMATURE*	t-TEST FOR DIFFERENCE (P<0.001)
Weight	Male	158.6g (40) ± 11.6	152.7 (506) ± 10.7	Yes
	Female	217.7g (72) ± 14.3	211.3 (27) ± 15.6	Yes
Wing Chord	Male	190.4 (40) ± 4.2	190.2 (546) ± 5.0	No
	Female	211.7 (73) ± 3.8	210.4 (759) ± 4.3	Yes

*(Sample size in parenthesis)Mean ± SD

and began low-level hunting flight. Merlins were captured in numbers late in the day, long after other raptor species have ceased migrating. Merlins were also captured in numbers on overcast, drizzly days when thermals, if present, were weak. The situation is not quite so clear when one looks at the equivalent data for the spring captures at Sandy Hook (Fig. 5), probably due to the small sample size.

Measurement Data — Mean wt and wing chord measurements were calculated for Merlins captured at Cape May Point (Table 5) and Sandy Hook (Table 6). Adults of both sexes were significantly heavier than immatures (t-Test, P < 0.001). Only for females did adults have significantly longer wings than immatures. Interestingly, Temple

(1972b) reported no significant differences in age class measurements of wing chord for *F. c. columbarius*. The mean wing chords reported by Temple were not significantly different from my data (t-Test, P > 0.001). The spring data (Table 6) show almost the identical mean for wing chords as in the fall, but considerably heavier wt than in the fall.

Fat — There are few references to fat deposition in raptors (Newton, pers. comm. 1977). Gessemann (1979) documented and quantified fat deposition in American Kestrels by sacrificing them and extracting fat. He attributed changes in fat deposition to migrational needs.

Merlins were checked for fat deposition during autumn 1978 and 1979. Of the 279 Merlins in-

Table 6. Mean weight and wing chord of Merlins banded in the Spring at Sandy Hook, New Jersey.

		ADULT*	IMMATURE*	t-TEST FOR DIFFERENCE (P < 0.001)
Weight	Male	169.0 (22) ± 13.7	155.9 (3) ± 10.2	No
	Female	243.6 (39) ± 21.6	234.4 (40) ± 13.4	Yes
Wing Chord	Male	190.1 (22) ± 3.4	188 (3) ± 2.4	No
	Female	211.9 (39) ± 4.4	210.5 (39) ± 3.8	No

*(Sample size in parenthesis) * Mean ± SD

Fig. 6 Merlin Band Recoveries from Cape May Point, N.J.

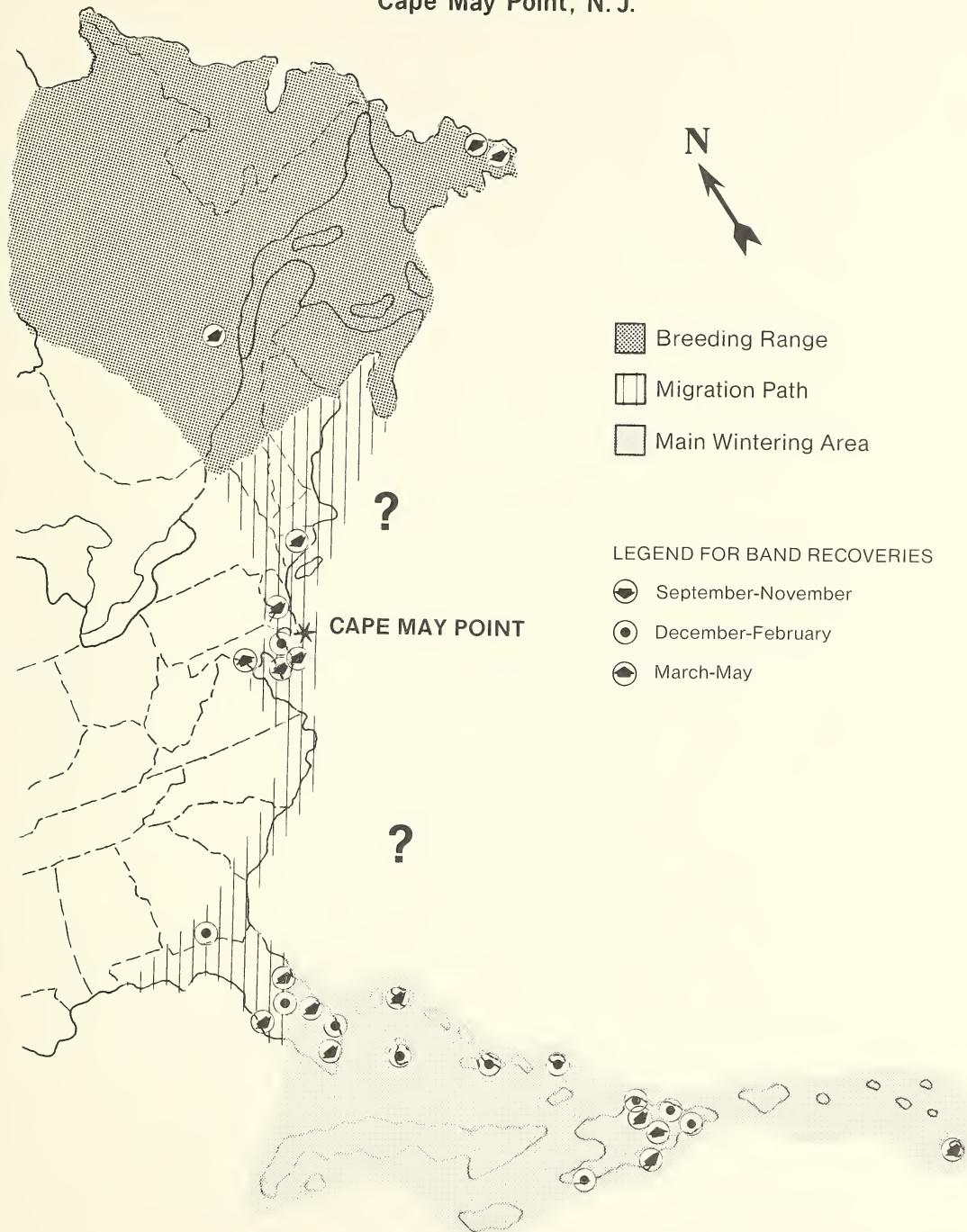


Figure 6. Map of recoveries from Merlins banded at Cape May Point, New Jersey.

spected, 232 had at least a trace or more of fat. Weight was not correlated with increasing fat deposition. A possible explanation for this is that crop and stomach contents were not measured. Oliphant (pers. comm. 1981) indicated that Merlins are capable of eating more than 50 g at one time.

Band Recoveries — Band recovery locations of Merlins from Cape May Point are plotted in Fig. 6. Breeding range in Fig. 6 was hypothesized based on the breeding range of the Merlin given by the AOU Checklist (5th Ed.) and the few recoveries from breeding areas. This breeding area is the probable origin for the Merlins occurring at Cape May Point.

The main flight path of Merlins during autumn migration is along the east coast of North America based on counts at hawk watches (Dunne 1980). Few Merlins are encountered on migration in eastern North America other than along the Atlantic coast (Soucy 1976; Field 1978; Holt 1980). Merlins also migrate across the open ocean (McLean and Williamson 1958), are regularly encountered at sea off the east coast of North America in the autumn (anon. 1979), and are casual in Bermuda (Friedman 1950). It is not known what fraction of the eastern Merlin population uses an over water migration pathway in the autumn.

Based on band recoveries, the main wintering area for eastern Merlins is Florida and the Greater Antilles (Fig. 6). A few individuals also winter along the Atlantic coast north to New England. Two recoveries of Merlins banded by other studies in autumn along the Atlantic coast and recovered in Cuba support this theorized winter range. The AOU Checklist (1957:121) gives the wintering range of the eastern Merlin as: "... from southern Texas (Brownsville), southern Louisiana (New Orleans), Alabama (Anniston), South Carolina and Georgia south through Mexico, Central America, and the West Indies to northern Peru, Columbia and northern Venezuela, casually north to Nebraska, Iowa, Illinois, Indiana, Ohio, southern Ontario, southern Quebec and Maine."

Since the Cape May Point winter recoveries are from a much more limited area, Merlins from the more western part of the breeding range must be wintering in the other sections. Band recoveries of this species from Latin America tend to support this. Three recoveries from Wisconsin bandings were in northern South America, 2 in Columbia and 1 in Ecuador (however, 1 recovery from Wisconsin was from the Dominican Republic). The

only Central American recoveries are 1 banded in Ontario and recovered in Honduras and another banded in the Northwest Territories and recovered in Costa Rica (data from Bird Banding Lab., U.S. Fish & Wildlife Service).

The majority of the band recoveries were from females (23 out of 29 or 79%), but the banding ratio is 60% female. A possible reason for this could be due to band retention differences between the sexes. Females are given a size 4 lock-on band, while the males have been given size 3A butt-ended bands. Dunne (pers. comm. 1980) has observed male Merlins successfully removing bands within 15 minutes after being banded. We have recently begun to use USFWS size 3 bands on the males, which are stiffer and should result in better retention.

These 29 recoveries from a banding sample of 1550 yield a recovery rate of 1.8%. Fyfe and Banasch (1981) reported a recovery rate of 1.97% from banding a similar number of Merlins. Thompson (1958) reported a 15% recovery from Great Britain banding and Smith (1981) reported a 16.7% rate in Alberta. However, these populations are non-migratory, and the majority of recoveries in both studies were within 64 km of the banding site. Icelandic Merlins migrate through the British Isles and winter there as well as in southwestern Europe, but no band recovery percentages have been reported (Williamson 1954; Brown 1976).

Most band recoveries of Merlins banded at Cape May Point are from dead birds. Nine had been shot; 7 of these in the Caribbean where it is not against the law to shoot raptors. Four were found dying, probably a result of striking windows, buildings or wires, and 12 were found dead, with the cause of death not obvious.

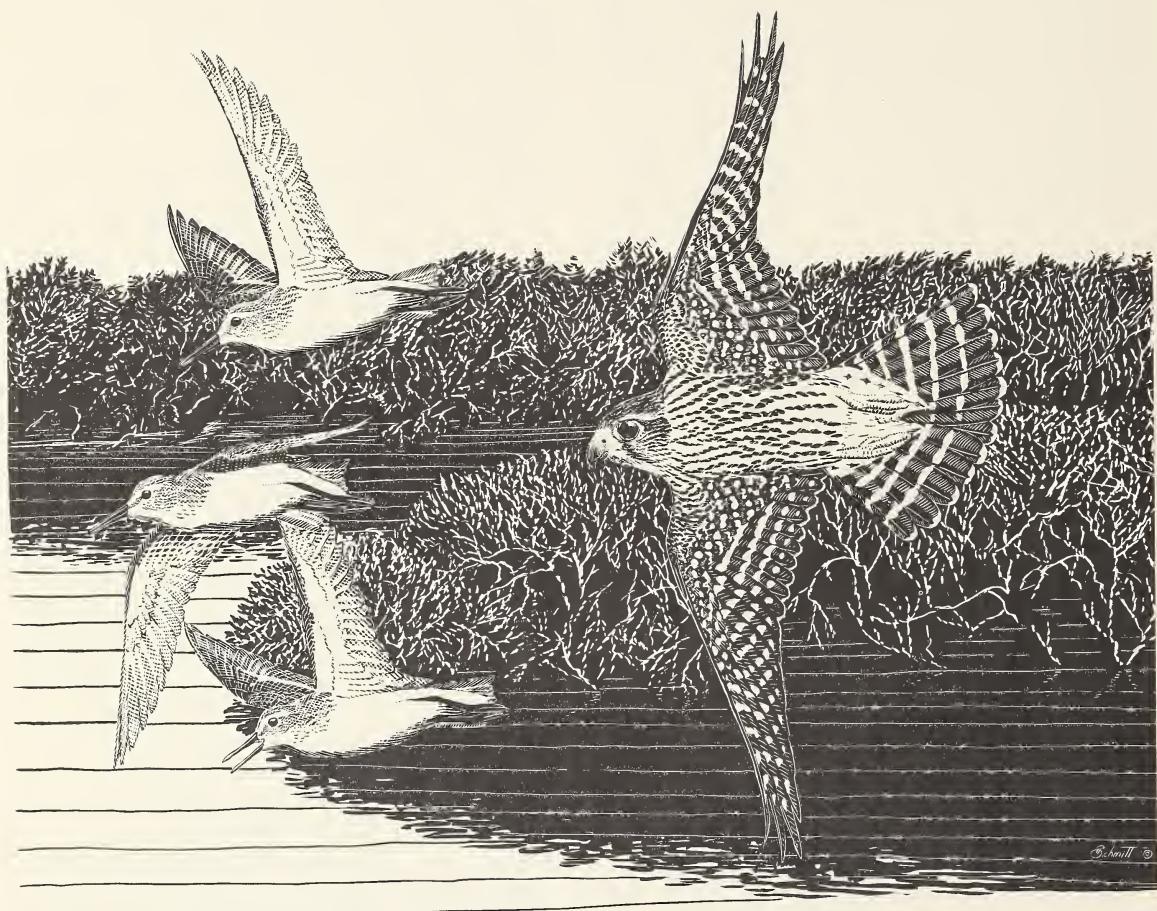
Two Merlins were recovered north of Cape May Point shortly after being banded, 1 in Connecticut. This may indicate that the autumn migration is not a simple north to south movement. Another was captured alive and released 6 days after banding at Cape Charles, VA. Three were recovered wintering in the U.S. and 8 in the Greater Antilles. There was 1 spring recovery inland from the coast. There are few summer recoveries of this species in the breeding range, probably due to remoteness of the breeding area and the Merlins' secretive behavior. There have been no recoveries of Merlins banded at Sandy Hook and no Merlin recaptures that were previously banded at Cape May Point.

ACKNOWLEDGMENTS

This study has been possible because of the efforts of numerous banders and countless helpers, all of whom put in long hours of dedicated work. Financial support has been supplied, in part, by the Raptor Information Center, NWF and by the Army Material Command through Dr. F. Prescott Ward. Most of the work was carried out by volunteers. Thanks go to Tom Pierson, who extracted and manipulated much of the data and carried out most of the statistical analysis. And special thanks to Sue Artis for retyping the many drafts. Appreciation is given to Maurice LeFranc, Mark Fuller, Chris Servheen and Lynn Oliphant for reviewing the draft MS and making critical comments. The raptor banding project is one aspect of the raptor migration research being conducted by the Cape May Bird Observatory.

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MERLIN CHASING SHOREBIRDS
by John Schmitt

MERLINS AND THE BEHAVIOR OF WINTERING SHOREBIRDS

DOUGLAS A. BOYCE JR.

Falcons are commonly reported to associate with high concentrations of prey (Glue 1968; Roderick et al. 1968; Scott 1968). Wintering shorebirds, because of their concentrations near intertidal feeding areas, may be particularly vulnerable to such predation. Shorebirds, especially juveniles, experience high mortality rates (Martin-Lof 1961; Boyd 1962; Holmes 1966; Soikkeli 1970; Goss-Custard 1980) and a substantial proportion of which may be due to predation by raptors — particularly the Merlin (*Falco columbarius*) (Page and Whitacre 1975; Kus et al. 1984; Townshend 1984). Goss-Custard (1980) hypothesized a protective response by shorebirds to avian predators. Others found that there are advantages for some small shorebirds to associate with flocks when under attack (Goss-Custard 1980; Meyers 1982). Page and Whitacre (1975:82) found that "small shorebirds in flocks had less chance of being eaten by the Merlin than did shorebirds which occurred singly". Here I report information that shows an additional mechanism for avoiding predation when in a flock.

I studied the hunting behavior of Merlins on mixed shorebird flocks consisting of Dunlin (*Calidris alpina*), Least Sandpiper (*Calidris minutilla*), and Western Sandpiper (*Calidris mauri*) during November through January of 1975 and 1976 at northern Humboldt Bay, California. Humboldt Bay is a particularly good place to observe raptor attacks on shorebirds because incoming tides force shorebirds to abandon their feeding grounds on expansive mudflats and to congregate in compact groups of several thousand at the edge of the bay or in protected impoundments.

At high tide ($\pm \frac{1}{2}$ h) falcons, including Merlin, Peregrine Falcon (*Falco peregrinus*), and Prairie Falcon (*Falco mexicanus*), arrived and hunted roosting shorebirds daily during the study period. Smaller shorebirds, primarily Dunlin, Least Sandpiper, and Western Sandpiper, flew and congregated into tightly knit flocks of several hundred to several thousand upon the approach of any falcon. Larger shorebirds, American Avocet (*Recurvirostra americana*), Marbled Godwit (*Limosa fedoa*), and Willet (*Catoptrophorus semipalmatus*), showed no response to Merlins and only flew when the larger Peregrine or Prairie Falcon arrived.

Merlins always positioned themselves high over the water's surface (30-60m) while shorebird flocks wheeled back and forth in synchrony over the surface below. Upon attack, the flock shape changed from spherical to teardrop. Merlins attacked by diving almost vertically at the flock and chasing trailing individuals; if unsuccessful in singling out a member, the falcon regained the original pitch above the flock and repeated the attack. Flocks often turned sharply while the Merlin maneuvered for position above. Under careful observation it appeared that the status of flock members positioned along the flock's periphery changed rapidly (within seconds) between "leaders" and "trailers" depending on the direction the flock turned. Since Merlins always attacked the trailing edge of the escaping flock's tear-drop or fusiform shape, shorebirds positioned in the flock interior were at an advantage because they were rarely trailers during attacks.

I observed individual shorebirds singled out on 10 different occasions. Two of the shorebirds successfully outran the Merlin and rejoined the flock. Three were captured in mid-air. Three of the other 5 shorebirds were knocked into the water by Merlins and the last 2 were pursued so closely that they dove directly into the water. Each shorebird that was stranded in water submerged as the Merlin swooped down. This was a successful short term solution but given enough time the Merlin captured them (2 of 5 captured).

Four of the 5 water-bound shorebirds were 'assisted' by the flock from which they had been separated. In each case, the flock flew low directly over the stranded shorebird. The Merlin, as a result, always rose directly above the approaching flock. In 3 cases the stranded shorebird, within the first few passes by the flock, left the water and rejoined the flock as it passed overhead. One of the stranded shorebirds appeared to have a broken wing and could not rejoin the flock even though the flock flew over it many times. The other shorebird was captured before a flock flew over it.

Others have recorded shorebirds diving into water in an attempt to escape raptors. John Schmitt (pers. comm.) observed 3 additional instances at Humboldt Bay where shorebirds flew into water

when pursued by Merlins and I observed 9 other occasions where shorebirds flew into water when chased by Peregrine Falcons. I also observed a male Northern Harrier (*Circus cyaneus*) single out a small shorebird from a flock and cause it to fly into water. As with the Merlin, the flock returned and the shorebird rejoined it. I hypothesize that these birds are attempting to escape from raptors by purposely flying at full speed into cover. Neotropical birds, for example, have been observed to fly at high speed directly into tree foliage when closely pursued by the Orange-breasted Falcon (*Falco dieroleucus*) (Boyce 1980).

Both the individual and flock benefit when the raptor slows down to pick up the stranded bird. The flock is not in danger because of the Merlin's changed behavior (i.e., hovering). This allows the fast flying flock to return with no risk and recover the stranded member, and escape before the falcon can regain pursuit speed. The Merlin does not immediately pursue the escaping flock because it continues searching for the water-bound bird it believes still remains in the water below.

Shorebirds may experience reduced mortality by being associated with a flock for 3 immediate reasons. First, the probability of being the target of an attack is reduced when other targets are immediately available; second, the tightly whirling flock makes it difficult for Merlins to select an individual for attack; and finally, observations of small shorebird flocking behavior suggest that flocks will return over the location of a waterbound bird and allow the shorebird an opportunity to rejoin the flock and avoid capture.

A less obvious reason for reduced mortality, by being associated with a flock, is the position maintained by the individual within the flock while under attack. Kus et al. (1984) reported, at Bodega Bay, that juvenile Dunlins were over-represented in Merlin kills compared to the population at large and suggest that inexperience in maintaining coordinated synchrony with the rest of the flock may increase their risk. It is possible that shorebirds located in the flock's center are experienced adults

and those toward the periphery are inexperienced juveniles.

I thank Colleen Handle and Jim Sedinger for reviewing the manuscript.

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NOTES ON WINTERING MERLINS IN WESTERN MONTANA

CHRISTOPHER SERVHEEN

ABSTRACT - Wintering Merlins (*Falco columbarius*) were studied in Missoula, Montana, from 1977 through 1979 where all 3 North American subspecies winter together. The main food of the Merlins is the Bohemian Waxwing (*Bombycilla garrulus*), which congregate in large flocks throughout the winter to feed on fruits of ornamental trees in residential areas of the city. Possible origins of the 3 subspecies and hunting techniques are discussed.

The Merlin has been considered an uncommon breeding species throughout its range (L. Oliphant, this issue) in North America. Many aspects of Merlin biology are unknown including winter habits. This paper reports on Merlins wintering in an urban area in western Montana.

STUDY AREA AND METHODS

Wintering Merlins were studied within Missoula, a city of 36,000 population located in a mountain valley in west-central Montana. The Missoula valley has an elevation of 950 m and is approximately 32 km long by 16 km wide and is surrounded by precipitous forested mountains up to 2,900 m in elevation. Missoula is west of the Continental Divide in the upper Columbia River drainage. Large ornamental trees are established throughout much of the residential area of the city. Prior to settlement, the valley was probably devoid of large trees except those along the Clark Fork River which bisects the city. The winter climate varies, but much of the winter is cold with temperatures of -15°C not uncommon. Precipitation averages 33 cm per year and snow often covers the ground throughout the winter. Winds are generally light to moderate.

Observations were made from October through March, 1977 through 1979. Merlins were observed perching, feeding, and chasing prey. Individual Merlins were trapped, measured, photographed, and banded with USFWS bands. Prey remains were collected under perching trees and identified to species. In 1979 a single Merlin was fitted with a tail-mounted radio transmitter and tracked for 10 d.

RESULTS AND DISCUSSION

Subspecies present. — Seven Merlins were captured within the city of Missoula during the study. Of these, 4 were measured and banded with USFWS bands. The remaining 3 were captured by falconers and were photographed but not measured. These 7 Merlins were characterized to subspecies using the criteria from Temple (1972) (Table 1).

The identification of *F. columbarius suckleyi* was based on the extremely dark plumage with no visible tail bands on the dorsal surface and 3 very faint tail bands on the ventral surface. The identification of *F. c. columbarius* females was more difficult. Tail barring was not useful as the percentage of birds with 4 tail bars is not significantly different between western taiga *F. c. columbarius* and coastal forest *F. c. suckleyi* (Temple 1972). Tail length and wing chord measurements were not useful in differentiating *F. c. columbarius* from *F. c. suckleyi* because of probably feather length differences with age and overlap in 95% confidence intervals for feather length between coastal forest and taiga populations (Temple 1972). The most useful criterion was the presence or absence of anterior and posterior web barring of

Table 1. Characteristics of Merlins captured in Missoula, Montana, during the winters of 1976-77 and 1977-78.

SUBSPECIES	SEX	AGE ^a	WT(G)	BAND #	# TAIL BANDS (MM)	WING CHORD (MM)	TAIL LENGTH
<i>F. c. columbarius</i>	M	A	154	1143-57207	4	190	116
<i>F. c. columbarius</i>	F	A	223	1143-57208	4	210	128
<i>F. c. columbarius</i>	F	S	275 ^b	1143-57209	4	213	135
<i>F. c. richardsonii</i>	F	A	235	793-03903	5	225	137
<i>F. c. richardsonii</i>	M	S	160	----	4	203	122
<i>F. c. suckleyi</i>	F	A	---	----	3	---	---
<i>F. c. columbarius</i>	F	S	---	----	4	---	---

^a A = Adult; S = Subadult (estimated based upon plumage and feather wear)

^b Weight with a full crop; bird was captured with a full crop

the primaries. All 4 individuals thought to be *F. c. columbarius* had no barring on the anterior web and complete barring on the posterior web. The individual *F. c. suckleyi* had no anterior barring and incomplete posterior barring.

Tail length measurements agreed with ranges measured by Temple (1972) (Table 1). The *F. c. richardsonii* female was in adult plumage with several worn feathers indicating it had gone through at least 1 molt. Tail length of this bird was within 1 standard deviation of mean adult female tail length measured by Temple (1972) for *F. c. richardsonii*. The *F. c. columbarius* female with tail length of 135 mm (#1143-57209) was thought to be less than a year old judged by uniform feather wear. The tail length was at the high range of western taiga specimens measured by Temple (1972) as would be expected in a subadult with longer feathers.

Origin of the Wintering Population. — The occurrence of all 3 subspecies in Missoula during winter is unusual because of the separate and distinct breeding range of each (Temple 1972). Western Montana is one of the few areas in North America where the breeding ranges of all 3 subspecies are relatively close together. This juxtaposition of breeding ranges is probably responsible for the origin of all 3 subspecies wintering in Missoula.

Breeding of *F. c. richardsonii*, the prairie race, has been documented in areas of southern Alberta (Hodson 1976) and Montana (Becker, this issue) east of the Continental Divide. No published breeding records of this subspecies are available from west of the Continental Divide (those breeding in southwest Wyoming are morphologically nearest to *richardsonii*, Ed.), although Craig and Renn (1977) described two instances of Merlins (subspecies not defined) nesting in southern Idaho in cool desert upland habitat more typical of *F. c. richardsonii* habitat than that of *F. c. columbarius* or *suckleyi*. The limited data on *F. c. richardsonii* west of the Continental Divide suggest that *F. c. richardsonii* individuals wintering in Missoula may have crossed the Continental Divide (150 km to the east of Missoula) during fall and spring migration.

F. c. columbarius has not been positively documented as a breeding subspecies in Montana, although scattered Merlin nesting records from west of the Continental Divide cited by Ellis (1976) and Weydemeyer (1973), and documented by other qualified observers (E. Foss, pers. comm.) are probably *F. c. columbarius* based on Temple's (1972)

maps and the nesting habitats selected. Due to the difficulty of finding Merlin nests (Ellis 1976; L. Oliphant, pers. commun.) it is likely that *F. c. columbarius* may nest in western Montana in greater numbers than previously thought, although it is still rare. The boreal forests of western Canada may support significant numbers of breeding *F. c. columbarius*, and the Rocky Mountain trench provides an excellent migratory pathway to funnel migrating individuals from northern forests into the Flathead Valley immediately north of Missoula. Thus, *F. c. columbarius* individuals wintering in Missoula could come from local and/or more northerly breeding populations.

The origin of *F. c. suckleyi* in Missoula is unusual in light of its current coastal breeding distribution from southeast Alaska to southwest British Columbia. Missoula lies approximately 830 km inland from the Pacific northwest coast. The rich coastal fauna and relatively stable winter weather conditions result in a reduced seasonal migration for resident coastal raptors such as the Peregrine Falcon (*Falco peregrinus pealei*) (Beebe 1960, 1974) and Bald Eagle (*Haliaeetus leucocephalus*) (Servheen and English 1979). Such reduced migrational movements would also be expected for *F. c. suckleyi* which can prey on large flocks of shorebirds which winter in Pacific coastal areas (Page and Whitacre 1975; C. Anderson, pers. comm.). The long distance inland movement to winter in severe weather conditions exhibited by *F. c. suckleyi* in Missoula remains unexplained.

Food Habits. — Food habits of wintering Merlins in Missoula are closely associated with large flocks of Bohemian Waxwings (*Bombycilla garrulus*) which winter in Missoula and feed on abundant fruits of mountain ash (*Sorbus spp.*) and crabapple trees (*Malus spp.*) which are grown as ornamentals in the city. This association has also been reported by Smith (1978). Prey remains under Merlin perching trees consisted of Bohemian Waxwings.

Hunting flights on waxwings usually were initiated from high perch trees where the Merlin had a view of waxwing flocks flying above the open tree canopy of residential areas. Merlins were observed attempting to fragment a waxwing flock by direct flight, and then pursuing an individual separated from the main group. The pursued waxwing usually tried to escape by flying to cover, but the Merlin usually attempted to stay below the waxwing and thus force it up and away from cover. I have ob-

served 2 instances of straight pursuit where the Merlin was able to out-fly the waxwing. Both times the waxwing exhibited rapid evasion turns only when the Merlin was upon it, but I was unable to see the end of either flight.

Another flight observed involved a single waxwing diving for a group of 4 small conifers with the Merlin approximately 6 m behind. The Merlin entered the conifers after the waxwing, much like a Sharpshinned Hawk (*Accipiter striatus*), and the 2 moved through 2 other conifers until the waxwing left the trees. The waxwing then began to fly upward in a spiral with the Merlin flying below in large circles to gain altitude. The waxwing escaped as the Merlin did not climb fast enough to attempt capture. The Merlin eventually gave up pursuit and flew to a perch in a nearby tree.

Waxwings occur in flocks of up to 2,000 to 3,000 and respond to Merlin attacks by bunching into tight ball-like formations. They will form dense evasion clouds when a Merlin appears and smaller flocks will attempt to join the large group.

Roosting. — In the winter of 1978-79, a tail-mounted radio transmitter was placed on a Merlin. That winter was the coldest on record, and waxwings were very scarce. The Merlin was tracked for 10 d. It roosted at night inside dense ornamental spruce (*Picea* spp.) trees within 10 to 50 m of houses and busy streets. Weather severity with temperatures down to -30°C was probably a factor in selection of dense spruce. On one morning with extremely cold temperatures, the Merlin did not leave the night roost tree until between 1030 and 1130 H. When the Merlin was in these trees it apparently was perched close to the trunk in the interior and it was impossible to see from the outside of the tree.

ACKNOWLEDGMENTS

I am grateful to the many individuals whose knowledge, expertise, and interest in Merlins made this work possible. In particular I would like to thank Pete Jenny, Bob McDonald, Hal Williams, John Tubbs, and Dale Becker for trapping and observational assistance. Special thanks to Clifford Anderson and Lynn Oliphant for insights during many hours of discussion.

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OBSERVATIONS OF WINTER FOOD CACHING BY THE RICHARDSON'S MERLIN

IAN G. WARKENTIN AND LYNN W. OLIPHANT

Reports of food caching and retrieval are common in both wild and captive raptors. These behavior patterns have been observed in the American Kestrel (*Falco sparverius*) (Tordoff 1955; Mueller 1974), Northern Goshawk (*Accipiter gentilis*) (Schnell 1958), Prairie Falcon (*Falco mexicanus*) (Oliphant and Thompson 1976), Lizard Buzzard (*Kaupifalco nongrammicus*) Peregrine Falcon (*Falco peregrinus*) and Secretary Bird, (*Sagittarius serpentarius*) (Brown and Amadon 1968: 78) as well as many species of owls (Collins 1976). Food caching by the Merlin (*Falco columbarius*) has been reported during the breeding season (Oliphant 1974; Oliphant and Thompson 1976) and also during the winter (Pitcher et al. 1979; Bud Anderson, pers. comm.).

The observations herein were collected as part of a wintering ecology study of the Merlin in Saskatoon, Saskatchewan. Using a mobile null peak antenna system, I.G.W. monitored the activities of 3 Merlins fitted with tail-mounted transmitters (Model SM-1, AVM Instrument Company): a 2-yr old male and 5-yr old female banded as nestlings in Saskatoon and a 2-yr old female banded as a nestling in Regina, Saskatchewan. The female from Regina was brought to the Western College of Veterinary Medicine in Saskatoon for treatment of an ulna fracture suffered on 5 December 1983 and released in the city on 25 January 1984. The 2 others were trapped in Saskatoon, fitted with transmitters and released within 2 h of capture. The average temperature in Saskatoon during February 1984, when these observations were made, was -4°C.

The 2-yr old female was monitored for 225 h over a 49 d period. During this time her food caching and retrieval activities centered around a linear grouping of 6 spruce trees ranging in height from 3 m at one end to 5 m at the other. On 3 February 1984 at 0830 H she perched on the second tallest spruce and began a searching pattern that consisted of hopping from branch to branch, carefully examining each one as she worked her way down the tree. She concentrated her search on one side of the tree starting on a branch about 3 m high and ending

up on the ground below the tree. After examining the ground under the tree for 1 min she flew to a distant perch to begin hunting. During the day she caught and ate 2 House Sparrow (*Passer domesticus*), then returned at 1540 H to perch on the same tree visited that morning. At 1600 H she twice repeated her search of the same area of the tree before perching on an adjacent spruce. From this vantage point she spotted a rodent on the ground below the tree that she had presumably cached in the tree previously. She flew down to pick up the prey and carried it to a nearby power pole and ate it. Her return to the same tree and success in finding cached prey suggests that the behavior exhibited that morning was an unsuccessful retrieval attempt.

On 5 February 1984 this same female caught and ate a House Sparrow at 0935 H. After 3.5 h she began to hunt again and at 1330 H caught a sparrow and carried it to the tallest spruce tree in the group. Perched on a branch halfway up the tree and about 1 m from the trunk, she plucked feathers from the sparrow's head and neck for 2 min, then used her beak to carefully place the carcass in a fork of the branch she was perched on. She left to continue hunting and at 1430 H she captured another House Sparrow. During the remainder of the afternoon, she made 5 hunting attempts but failed to kill again. At 1745 H she retrieved her cache of that afternoon by flying directly to the fork in the branch used to support the carcass. She carried it in her feet to a perch 50 m away to eat. On the morning of 8 February 1984 the Merlin perched in a spruce tree making only 1 unsuccessful hunting attempt on a House Sparrow. At 1105 H she returned to the tree used for caching on 3 February 1984 and immediately located a cached House Sparrow on a branch about 3 m high.

I.G.W. observed the male Merlin on 22 February 1984 at 1730 H using the same searching pattern as the female. He began his search on a branch 3 m up a spruce tree and hopped branch by branch to the ground twice before flying to a lamp post across the street. Within a minute he returned to a branch in the same area of the tree and emerged with the fully plucked hind quarters of a small bird. Due to

transmitter failure this bird was only observed for 8 h over a 2 d period.

During 65 h of observations over an 11 d period, the 5-yr old female was observed to use a cache once. She flew directly to a branch near the top of a 10 m high spruce at 1430 H on 25 February 1984 to retrieve a cached House Sparrow that she carried to a nearby elm to eat.

The 2-yr old female displayed a sequence of caching followed immediately by a return to hunting on 5 February 1984. This suggests that she was hunting in the absence of an immediate food need, caching food for a period of prey scarcity or greater caloric demand. The attempted retrieval at 0830 H on 3 February 1984 may represent such a situation where the previous night's temperature was 5°C lower than the nightly low of the 3 preceding nights. At least 2 retrievals described above were caches left overnight. With average nightly temperatures of -8.5°C during February 1984, these carcasses would have been frozen. There were no observed behavioral changes in the pattern of eating a frozen carcass but the caloric value of a frozen sparrow may be less.

During 225 h of observations, the 2-yr old female used only the 2 spruce trees mentioned for caching food. This is similar to Tordoff's captive American Kestrel (1955), which consistently used the same hiding place for its excess food. Stendell and Waian (1968) also noted the extended use of one tree for caching in wild American Kestrels. Oliphant and Thompson (1976) found that Merlins seldom used the same tree for caching during the breeding season. The difference in the pattern of food caching in Merlins between wintering and breeding periods may be the result of the degree of piracy by other birds. Consistent use of the same tree should make retrieval easier but the dense Black-billed Magpie (*Pica pica*) and American Crow (*Corvus brachyrhynchos*) populations during the breeding season may

make piracy a greater problem. Individual difference may also account for the degree of consistency.

All 3 Merlins monitored exhibited food caching behavior. This, along with the frequent use of caches by the 2-yr old female, suggests that this behavior is advantageous and plays an important role in their wintering ecology.

We thank Paddy Thompson for technical assistance. Support was provided by the Canadian Wildlife Service University Research Support Fund, the Frank M. Chapman Memorial Fund, and the Canadian Plains Research Centre.

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EARLY NESTING RECORDS FOR MERLINS IN MONTANA AND NORTH DAKOTA

DALE M. BECKER

A questionnaire regarding Merlin (*Falco columbarius*) eggs sent to several natural history museums in North America revealed a number of previously unreported sets collected in Montana and North Dakota. The first breeding records for the Merlin in Montana were recently reported by Ellis (*Condor* 78:112-114. 1976). However, 3 egg sets collected in Montana pre-dated Ellis' (1976) report. R.B. Hitz collected 2 eggs near Sun River on 5 July 1867 (National Museum of Natural History, USNM 13478). Two eggs were collected near Helena on 26 May 1882 by A.H. Palmer (Milwaukee Public Museum, MPM 417). The third set, consisting of 4 eggs collected in Dawson County on 11 May 1895, was collected by C.A. Thurston (Harvard University Museum of Comparative Zoology, MCZ 4285).

Several early nesting records for Merlins in North Dakota were reported by Stewart (Stewart, R.E. Breeding birds of North Dakota, North Dakota State Univ., Fargo. 1975). Additional nesting records for North Dakota include sets of 4 and 5 eggs collected in Stark County by R. Dodd on 25 May 1897 and 25 May 1900, respectively (Western Foundation of Vertebrate Zoology, WFVZ 1077684 and 79652-5). A third set was collected on 13 May 1924 near Columbus by an unknown collector (University of Michigan Museum of Zoology, UMMZ 190898). Museum records provide useful historical information on nesting Merlins in the United States, yet they are often overlooked as sources of historical range use.

This project was funded by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station at Rapid City, South Dakota, under Cooperative Agreement No. 14-16-0009-80-989. J. Hinshaw (University of Michigan Museum of Zoology), L.F. Kiff (Western Foundation of Vertebrate Zoology), N. Kracunas (Milwaukee Public Museum), R.A. Paynter, Jr. (Harvard University Museum of Comparative Zoology), and W.D. Vanko (National Museum of Natural History) provided information on the egg sets. I.J. Ball, J.S. Marks, C.W. Servheen, C.H. Sieg, and D.W. Uresk provided critical review of an earlier draft of the manuscript.

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MERLIN FEEDING ON ROAD-KILLS

ELIZABETH HAUG

In late April, 1979, I was radio-tracking Coyote (*Canis latrans*) near Woodruff, north-central Wisconsin. While driving along a paved secondary road, at approximately 1000 H, I observed 20-30 dead or crippled Purple Martin (*Progne subis*) in a tight group on the road. They had apparently been attracted to radiated heat from the paved surface, a behavior previously documented for several bird species (Whitaker, L.M., *Wilson Bulletin* 72:403-404, 1960) and had been run over by a vehicle. Approximately 5 min later, while engaged in my radio-tracking work approximately 10 m from the accident site, a female Merlin (*Falco columbarius*) landed on the pavement next to a crippled martin. The Merlin appeared to observe the martin intently for a few seconds. It then reached out, picked up the martin in its talons and flew into adjacent woods. I remained at the scene for another 10 min during which the Merlin returned twice, each time picking up a crippled martin and flying into the woods in the same general direction. As no young would be expected this time of year and considering the short time span in which these observations occurred, I assumed the Merlin was caching the martins. It is of interest to note that the Merlin appeared to select the crippled birds, which exhibited varying degrees of movement, rather than dead birds. This incident apparently represents an example of opportunistic feeding behavior by Merlins. Jenkins (*Ontario Bird Banding* 8(2):40-41, 1972) noted a similar behavior where Merlins used moving vehicles to flush potential prey. This, however, represents the first report of opportunistic feeding by Merlins on prey crippled by a vehicle.

I wish to thank Lynn Oliphant and Andrew Didiuk for their suggestions on the manuscript.

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MEADOW VOLE PREDATION BY A MERLIN WINTERING IN SASKATOON, SASKATCHEWAN

IAN G. WARKENTIN

The prey of the Merlin (*Falco columbarius*) is predominantly birds weighing less than 50 g (Bent 1938; Brown and Amadon 1968; Cade 1982). Large insects such as dragonflies (Order Odonata), grasshoppers (Order Orthoptera) and moths (Order Lepidoptera) are commonly reported as part of the diet but less frequently taken (Allen and Peterson 1936; Breckinridge and Errington 1938; Cushing 1941; Bond 1951; Street 1960; Oliphant 1974). Mammals also make up a smaller proportion of the prey; Brown and Amadon (1968) suggest that it is about 5% for Merlins worldwide while 3.4% is reported by Fisher (1893) for Merlins in North America.

Among mammalian prey, bats (Order Chiroptera) are taken more commonly than terrestrial forms. In the United States, the Merlin is reported to prey upon *Myotis* sp. and the Red Bat (*Lasiusurus borealis*) (Allen and Peterson 1936; Johnson and Coble 1967). Stomach and pellet analysis also revealed the remains of rodents (*Microtus* sp.), pocket gophers (Family Geomyidae), Thirteen-lined Ground Squirrel (*Spermophilus tridecemlineatus*) and Least Chipmunk (*Eutamias minimus*) (Allen and Peterson 1936; Bent 1938; Burleigh 1972; Becker 1984). Although Decker (1972) reports a Merlin in Edmonton, Alberta, catching a brown myotis bat (*Myotis lucifugus*) and Oliphant found the skull of a Least Chipmunk in a Merlin nest in Saskatchewan (pers. comm.), Fyfe (cited in Trimble, 1975) records no mammals in the diet of Merlins breeding on the Canadian Prairies. Oliphant and McTaggart (1977) listed only small birds and insects for the diet of breeding Merlins in Saskatoon, Saskatchewan.

As part of a study of Merlins wintering in Saskatoon, Saskatchewan, I monitored 3 individuals fitted with tail-mounted radio-transmitters (Model SM-1, AVM Instrument Company) between 25 January and 13 March 1984. Although all of these birds preyed primarily upon House Sparrow (*Passer domesticus*), one Merlin was observed to take mammalian prey. This bird was a 2-yr old female, released in the city on 25 January 1984 after treatment for an ulna fracture suffered on 5 December 1983 in Regina, Saskatchewan. She usually hunted

on small unused lots and storage yards in an industrial section on the outskirts of the city. Weather during the observation period was unseasonably warm, as all snow in unprotected areas was melted by the last week of February.

During 225 h of observation, the Merlin consumed 22 House Sparrows and 8 rodents (2 immediately following her release and 6 in early March). I identified 1 of these rodents as a Meadow Vole (*Microtus pennsylvanicus*) by examining the guard hairs recovered from a plucking perch. The other 7 rodents were eaten on inaccessible perches and not positively identified. However, because of their appearance and location of capture, I assumed that at least 5 of these were also Meadow Voles. Successful hunting attempts on rodents were mounted from perches on power poles or building corners. The Merlin left the perch in a slow, fixed-wing glide to a point just over the prey followed by a quick downward plunge with the feet extended. Several attempts were also made from ground-level perches but these all proved unsuccessful.

Cade (1982) suggested that young Merlins rely on non-avian prey more than adults because they lack the skills to capture birds. Instead, they feed on insects and rodents which are easier to catch. Perhaps this female fed on voles during the period immediately after her release because she had not yet regained her bird-catching skills. The appearance of rodents, in the Merlin's diet in early March, may also represent the opportunistic nature of raptor hunting. Warm weather during this period melted most of the snow and thus more easily exposed the voles, which would normally be protected beneath this cover, and allowed the female to exploit their availability.

I thank Lynn W. Oliphant for guidance during the study and helpful comments on earlier drafts. Harrison B. Tordoff, Stanley A. Temple, Steve W. Platt and an anonymous reviewer also provided constructive criticism of the manuscript. Support was provided by the Canadian Wildlife Service University Research Support Fund, the Frank M. Chapman Fund and the Canadian Plains Research Centre.

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Proceedings of the Southeastern United States and Caribbean Osprey Symposium — published by The International Osprey Foundation, Inc., edited by Mark A. Westall. Eleven papers, 132 pages. Copies can be ordered from The International Osprey Foundation, Inc., P.O. Box 250, Sanibel, FL 33957 USA. Price: \$16.00 U.S.

A Dictionary of Birds. 195. Bruce Campbell and Elizabeth Lack (eds.), Buteo Books, Vermillion, South Dakota, 704 pp., 500 plus illustrations. Hardback: \$75.00. More than 1,010,000 words. — This is another volume published jointly between a British and United States firm. The Harrell's, (Bryon and Joyce) of Buteo Book fame and among the founders of the Raptor Research Foundation, have done an excellent service by providing a North American printing of many of the books originating in the United Kingdom, such as books on Peregrines, Barn Owls, Harriers, etc. They have thus made them more readily available in North America. The words of Frances James, president of the American Ornithologists Union, as written in the preface of this present volume, bare repeating here as concerns this new *Dictionary*, "... the role the dictionary will play in fostering communications among nations. For students it will serve as an entrance to the present status of the field. For scientists it will serve as a research tool and bridge between disciplines." And thus it will indeed be. More than 280 contributors from around the world have written sections for the book. The majority are, of course, European, actually British; but ornithologists from Africa, Australia, New Zealand, South and Central America, Southeast Asia, and elsewhere are represented. More than 60 are from the United States and Canada. Thus, the book is truly an international effort.

It is not clear to me exactly when the book was initiated but at least one of the contributors died in 1978. This *Dictionary* is basically a modernization of the original *Dictionary* published in 1895 by Alfred Newton that was revised and enlarged in 1964 in the form of the *New Dictionary of Birds*. Most topics have been enlarged and upgraded with current information. I have not had the time to compare how many additional topics there are, if indeed any, over the 1964 version, but I suggest that there are several. As with any dictionary the topics are listed alphabetically and cross-referenced. Most topics that are discussed in even the briefest fashion provide a few literature citations that were consulted in the preparation of the topic. I particularly liked the array of illustrations therein. For example, in the topic of Nest Function there is a nice series of diagrams on the various nests of the Magpie Goose showing both roosting and courting forms as well. But what, then, does the book have to offer to a falconophile or strigiphile — membership of Raptor Research?

For the owls, both the Strigids and tytonids are covered in one three-page section entitled Owls; but a considerable amount of the material in the five-page section on Vision also deals with owls. The main section on Owls is divided into subsections such as: General and Systematic Characteristics, Habitat, Distribution, Populations, Movements, Food, Behavior, Voice and Breeding. The account was written by Karel Voous and Heimo Mikkola. The chapter gives a good, albeit cursory, summary of what is known about owls. Unlike the owls the diurnal raptors are covered in several sections, viz. Falcon, Hawk, Osprey, Secretary-bird and Vulture in addition to a brief statement under a topic covered by the three ordinal names. While the Osprey is listed as a special category in Birds of Prey, it is in fact discussed under the Hawks rather than having any lengthy discussion of its own.

Treatment of the four major diurnal raptor groups is not equal nor uniform in the subject matter. The Falcon section is mainly a taxonomic treatment following Brown and Amadon's format wherein the primitive neotropical falconids are treated as three separate groups (Forest Falcons, Laughing Falcons and Caracaras), followed by a majority of the article discussing the True Falcons (lumping with them the falconets). This section was written by Leslie Brown (who did the falcons for *New Dictionary of Birds*) and Ian Newton. The Hawk section is organized somewhat differently, having both topics (i.e. movements, behavior, etc.) and then a survey of the major groups (i.e. kites, Snake Eagles, etc.). Most of the discussion of groups is done so at the subfamily level. Of interest is the Bat Hawk having been given its own separate section of treatment rather than being lumped in with the kites as has traditionally been done. This is probably because it is in a monotypic subfamily. Once again, like the Falcon section, the authors of the Hawk section were Leslie Brown and Ian Newton. The Secretary-bird has a three quarter page treatment by Alan Kemp. It is discussed on a topical basis but unfortunately has no discussion on their taxonomy or systematics. Lastly, the Vultures are discussed as two separate contributions — the Old World Vultures written by David Houston and the New World Vultures by John Ogden. The formats used, topics discussed and length of each is unequal. the Old World material covers two pages and a good deal of the discussion centers around the differences between the Griffon Vultures (a group of species in the genus *Gyps*) compared with "other Vultures." The discussion of the Griffons is basically a thumbnail sketch of their "life history." Ogden's discussion of the New World Vultures occupies about one-half a page and is mainly topical. Here again, a good discussion of their evolutionary relationships would have been timely and especially informative if compared to the Old World Vultures.

Aside from the above there is also a short two-page discussion on Falconry. This was originally written by A.G.O'C. Scott but has been redone by Bob Kenward, who most of the readership will know from his fine work on the Goshawk. This chapter is broken into brief review sections on Birds Used, Basic Equipment, Training, Flying at Quarry and Conservation Aspects.

Overall, the book is very well done and has a wealth of material. Now that the *New Dictionary of Birds*, done in 1964, is very hard to get, the present volume is a good addition to any library. I recommend it highly, and for the cost it is an excellent buy. Regardless of your interest in the world of birds, this book has something to offer everyone — C.M. White.

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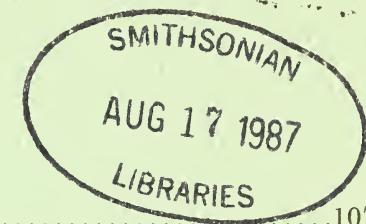
RAPTOR RESEARCH

A Quarterly Publication of The Raptor Research Foundation, Inc.

VOLUME 19, NUMBER 4, WINTER 1985

(ISSN 0099-9059)

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Gary E. Duke, Treasurer, Department of Veterinary Biology, 295K Animal Science/Veterinary Medicine Building, University of Minnesota, St. Paul, Minnesota 55108, U.S.A. Printed by Press Publishing Limited, Provo, Utah 84602. Second-class postage paid at Provo, Utah. Printed in U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 19

WINTER 1985

No. 4

TOWARD RAPTOR COMMUNITY ECOLOGY: BEHAVIOR BASES OF ASSEMBLAGE STRUCTURE

FABIAN M. JAKSIC

ABSTRACT — Despite definite advantages in comparison to other model systems (e.g. assemblages of passerine birds and lizards), raptor community ecology is in its infancy. I discuss the adequacy of raptors as model predators for the study of the relationships between behavioral processes (agonistic interactions and hunting modes) and assemblage-level patterns (community structure).

Community ecology studies of animals can be equated with the identification and quantification of the niche axes along which sympatric species appear to separate in order to reduce co-use of resources in limited supply. Schoener (1974) identified habitat, food, and time as the axes that most frequently separate vertebrate predators (including arthropod consumers such as passerine birds and lizards, as well as carnivorous vertebrates). Indeed, the study of insectivorous passerine birds as model predators has contributed substantially to the development of community ecology, as attested by the pioneering studies of MacArthur (1972) and Cody (1974; Cody and Diamond 1975); (see Strong et al. 1984 for more recent views). Subsequently, lizards have gained considerable importance as model predators (see Huey et al. 1983 for an overview of past and current contributions of herpetologists to community ecology).

The early findings of Schoener (*op. cit.*), although disputed by some in terms of the underlying causes (see Strong et al. (*op. cit.*) for a confrontation of views), have by and large been held as verified. Both with passerine birds and lizards it has been shown that species often segregate along habitat (or microhabitat) dimensions. However, the data demonstrating food segregation among these organisms are suspect for reasons described below, and the adequacy of activity time as a niche difference is under serious questioning (e.g., Jaksic 1982; Huey and Pianka 1983, Carothers and Jaksic 1984). Adding to the confusion is the fact that the three niche axes are usually correlated (segregation along one of them leads to segregation along another),

thus making causality difficult to resolve. The reasons for these correlations are easy to infer. For example, the trophic structure (patterns of prey use) of sympatric assemblages, which is described on the basis of the diets of the component predators (taxonomic composition, diversity, interspecific similarity, mean prey size, etc.) is only the outcome of behavioral processes occurring at the level of the local population. These processes involve not only prey selection, but also habitat preferences by the individual predators, their activity times, foraging modes and efficiencies, as well as morphological, physiological, and ecological constraints.

The gap between the summary description of food-niche patterns in predator assemblages and the foraging mode of individual predator species has recently been bridged for passerine birds (Eckhardt 1979; Robinson and Holmes 1982) and lizards (Huey and Pianka 1981). In my view, however, these two groups of organisms, which seem to be very suitable for studies of habitat preferences and microhabitat partitioning, are less suitable for the study of prey selection and food segregation. First, prey in their diet often are identifiable only to the ordinal level, and with some difficulty (at least for ornithologists) to the familial level, which represents an important shortcoming. Greene and Jaksic (1983) have shown that in dietary studies of predators identification of prey at the ordinal level (customarily used in passerine and lizard diet studies) underestimates diet diversity and overestimates diet similarity calculated at the species level of prey identification. Further, Greene and Jaksic (*op. cit.*) have shown that these biases arise in unpre-

dictable fashion, so that no reliable correction factors can be introduced in the computation of dietary statistics and consequently the food-niche patterns so far documented for passerine birds and lizards are suspect.

A second shortcoming of using passerine birds and lizards as model predators is that they are subject to predation themselves. This renders it difficult to resolve whether they maximize some prey selection function or compromise the use of optimal prey by minimizing predation risks (an important consideration in terms of optimal foraging theory: *see* Pyke et al. 1977).

These two shortcomings become especially apparent if one's intention is to correlate food-niche statistics (for whole predator assemblages) with the foraging modes of the constituent species. It is unfortunate that this is so, because I think that the question of how foraging mode is reflected in the trophic structure of sympatric predators is an important one in community ecology. Provided that neither passerine birds nor lizards seem particularly adequate model predators for such an enquiry, I contend that raptors (Order Falconiformes and Strigiformes) may help clarify the relationships between "basal" behavioral processes and "epiphenomenic" patterns of assemblage structure. In the following sections I discuss the pros and cons of using raptor assemblages as models for behaviorally-based community analyses and propose the type of information to be gathered.

RAPTOR ASSEMBLAGES AS MODEL SYSTEMS

Until recently, raptors have been neglected as model predators in community ecology. Nevertheless they have much to offer toward the clarification of niche relationships among sympatric consumers. Segregation of raptors along the habitat axis has been documented both intra- and interspecifically (e.g., Newton 1979; Schmutz et al. 1980; Nilsson et al. 1982; Janes 1984), but this segregation does not clearly result in access to different prey populations. Consequently, reduction of exploitative competition seems an unlikely cause for such phenomenon, nor does use of the same hunting habitat lead to compensatory differentiation along the food axis (Schnell 1968; Baker and Brooks 1981; Steenhof and Kochert 1985) which may be interpreted as resulting from the functional response of essentially opportunistic raptors to high prey densities (Jaksic et al. 1981; Jaksic and Braker

1983; Erlinge et al. 1984). In my impression, where habitat separation is observed among raptors, the proximate cause lies on agonistic interactions — a claim for which both direct (Rudolph 1978; Janes (*op. cit.*) and indirect evidence exists (*see* Newton 1979; Jaksic 1982; Mikkola 1983, for summaries of predation among raptors, an extreme form of agonistic interaction). Consequently, the use of exclusive ranges by raptors relate to reduction of interference rather than of exploitative competition.

Something similar may be said of the causes of temporal segregation. Jaksic (1982) documented that diurnal and nocturnal raptors do not differ enough in prey use (i.e., their diets are too similar) to justify the view that they reduce exploitative competition by differing in activity period (similar conclusions were reached by Huey and Pianka 1983). In fact, Jaksic (*op. cit.*), based on circumstantial evidence, contended that reduction of agonistic interactions was the likely target of such temporal segregation of activity. Carothers and Jaksic (*op. cit.*), have elaborated this point on more theoretical grounds, and for a variety of other organisms. Rudolph (*op. cit.*) documented temporal segregation between two sympatric owl species, mediated by predation of one upon the other. Notice, then, that where interspecific segregation of raptors along habitat and time dimensions has been reported, the proximate factor may well be aggressive exclusion rather than peaceful preemption of specific resources as accomplished by differential efficiencies in the exploitation of portions of the niche axes. The latter has been the general assumption underlying most studies of community ecology, and I think that the study of raptor assemblages can contribute greatly to the understanding of the alternative mechanism (interference competition) in generating the structure of communities.

What about food partitioning? Studies ranging in generality from selected pairs of species through small groups of related raptors to entire assemblages have rendered varied conclusions (e.g., Schmutz et al. (*op. cit.*); Jaksic and Braker (*op. cit.*); Knight and Jackman 1984; Marks and Marti 1984). Results indicate that sometimes prey is partitioned via size differences between raptors (accipiters are good examples of this: *see* Storer 1966; Opdam 1975; Schoener 1984), and that sometimes raptors differing greatly in body size take essentially the

same prey (Schmutz et al. (*op. cit.*); Jaksic 1983; Jaksic and Braker (*op. cit.*)). There is a tendency, though, for particular raptor groups to "specialize" on certain general prey categories (e.g., kites and harriers on small mammals and birds, small falcons on insects, larger falcons on medium-sized mammals and birds, eagles on hares; buteonines appear very catholic in diet). These different groups of raptors share in common similar morphologies and hunting modes (*see* Jaksic and Carothers 1985), which leads me to suggest that the reported trophic structure of the few raptor assemblages so far quantified (*see* Jaksic 1982, 1983; and Jaksic and Braker (*op. cit.*)) somehow reflects those similarities. I do not exactly share the view of Ricklefs and associates (e.g., Ricklefs and Cox 1977; Bierregaard 1978; Ricklefs and Travis 1980) that it is not necessary to go to the field for studying community ecology: morphologic analyses suffice. Instead, I espouse the view (*see also* Steenhof and Kochert (*op. cit.*)) that the study of the hunting behavior of raptors will tell us much about the way assemblages are structured. That is, how behavioral processes result in community patterns.

In comparison to both passerine birds and lizards, the scrutiny of raptor food-niche relationships is facilitated by their greater conspicuousness and use of prominent roosting and nesting sites, where detailed information on their diet can be obtained. However, they also show some shortcomings as model predators. Despite the fact of generally being top predators in terrestrial ecosystems, raptors are not entirely free of predation. Some species are indeed frequently preyed upon by other raptors (*see* Newton *op. cit.*; Mikkola *op. cit.* for summaries), and thus the study of raptor assemblages does not completely eliminate the dual constraints of energy maximization and mortality minimization. But at least in comparison to passerine birds and lizards, raptor behavior should, on the average, be less affected by predation.

The problem of the taxonomic resolution of prey (Greene and Jaksic (*op. cit.*)) is important in raptors that prey primarily on insects; but essentially carnivorous raptors abound, and their vertebrate prey is easily identifiable to the species level, particularly if mammalian (*see* Errington 1930; Burton 1973, for examples). In comparison to passerine birds and lizards, then, accurate estimates can be made of raptor diet diversity (= breadth) and interspecific similarity (= overlap). In addition, open-terrain

raptors are relatively large, conspicuous birds whose time budget, hunting mode, and hunting success, can be quantified with minimal equipment (*see* Rudebeck 1950, 1951; Warner and Rudd 1975; Tarboton 1978; Wakeley 1978a, 1978b; Mendelsohn 1982; Rudolph 1982). Consequently, the proportional use that raptors make of differing hunting modes can be recorded and examined in light of their diets and hunting success in different habitat types. In sum, at least as compared to passerine birds and lizards, raptor assemblages are excellent candidates for the study of food-niche relationships of sympatric predators as related to the hunting behavior of the component species. In the following section I propose the type of information to be gathered for such an aim.

INFORMATION REQUIRED TO ASSESS COMMUNITY-ECOLOGICAL CORRELATES OF RAPTOR HUNTING BEHAVIOR

1. The use that sympatric raptors make of different hunting techniques. — Raptor hunting activities can be dichotomized as either perch- or aerial-hunting. Within this second category, at least four techniques can be recognized: a) hovering flight: a stationary flight that may or may not take advantage of the wind conditions; used by small falcons (e.g., *Falco sparverius*), small kites (e.g., *Elanus* spp.), and by the Burrowing Owl (*Athene cunicularia*); b) cruising flight: a high-speed, low-altitude flight; used by large falcons (e.g., *Falco mexicanus*) and accipiters (*Accipiter* spp.); c) quartering flight: a low-speed, to-and-fro flight; used by harriers (*Circus* spp.), and some owls (*Asio flammeus*, *Tyto alba*); and d) soaring flight: low-speed, high-altitude flight that takes advantage of either thermal or obstruction air currents; used by eagles (e.g., *Aquila* spp.) and buteonine hawks (*Buteo* spp.), among others. More detailed descriptions of these hunting flight techniques can be seen in Brown and Amadon (1968), Warner and Rudd (1975), Everett (1977), Tarboton (1978), Wakeley (1978b), Cade (1982), Rudolph (1982), Collopy (1983a), and Collopy and Koplin (1983). Recognition of these five techniques seems necessary because there are indications that they facilitate access to different habitats and prey types, and also because their energetic costs differ (*see* Jaksic and Carothers 1985 for a selective summary). The time allocated to the different hunting techniques by sympatric raptors should be evaluated and, noting the prey captured

with each, the ecological consequences of raptor use of differing techniques assessed.

2. The use that sympatric raptors make of different habitat types while hunting. — Here, it is necessary to evaluate the time spent by raptors hunting in different habitat types (see Wakeley 1978a; Bechard 1982, for examples), because it is likely that prey availabilities differ among habitats (see USDI 1979 et seq.; Baker and Brooks 1981; Bechard 1982, for such findings). Perhaps only broad categories of habitat use by raptors need to be recognized, depending on the physiognomy and landscape units that characterize the study site. For interesting examples of ad-hoc habitat categorizations see USDI (1979 et seq.).

3. The hunting success of sympatric raptors in different habitat types and in using different hunting techniques. — The hunting success can be estimated as the number of successful prey strikes over the total hunting time spent by the different raptors. Unsuccessful prey strikes also should be counted to determine the hunting efficiency (successful strikes/total strikes with known outcome) of raptors using different hunting techniques (Collopy 1983a; Collopy and Koplin (*op. cit.*)). The prey captured ideally should be identified to the species level with the aid of adequate viewing devices. Direct observations are possible especially during the breeding season, when birds can be tracked to the nest after a successful prey strike, and the prey can be identified there if not at the capture site (e.g., Collopy 1983b). By focusing attention on open-terrain raptors, the prey captured in different parts of the habitat can be identified (e.g., Mendelsohn (*op. cit.*))).

4. The presumable clues that sympatric raptors use in choosing hunting habitats. — This is undeniably the most difficult part of the proposed research protocol. Judging from recent studies (e.g., Jaksic et al. 1981, 1982; Jaksic and Braker (*op. cit.*)); Erlinge et al. (*op. cit.*)), generalist raptors appear to take prey in about the order of their respective availabilities in the field. Within characteristic upper and lower size thresholds scaled to the sizes of the individual raptor (whatever their abundance, hares are unavailable prey for American Kestrels the same way that grasshoppers are for Golden Eagles). Because prey are taken by raptors on a one-by-one basis, numerical estimates of the abundance of individual prey may well serve as a crude estimate of their availability in the different habitat

types recognized in the study site (see Baker and Brooks 1981; and Bechard 1982, for cautionary notes). Many techniques exist that can be used (e.g., Giles 1971), and examples of their applicability and relative success can be found in USDI (1979 et seq.). An additional characteristic of the prey species which may be important in affecting their selection by — or vulnerability to — raptors is their mobility (e.g., Huey and Pianka 1981). This feature can be evaluated as the average displacement in meters per activity period, with the specifics of the measurement depending on the type of prey. Ideally, a vulnerability index for the different prey species at the study site could perhaps be devised by combining prey characteristics such as density, spatial distribution (clumped, random, regular), micro-habitat use, mobility, size, conspicuousness, etc. How to compute such a complex index I cannot figure out, because vulnerability is not an inherent feature of the prey and should vary relative to raptor characteristics (size, habitat preferences, and hunting mode).

CONCLUDING REMARKS

The study of assemblage-level correlates of hunting behavior in raptors should prove illuminating for a number of important questions in community ecology: To what extent does the trophic structure of predator assemblages reflect the hunting behaviors of the component species?, and — more specifically — provided that falconiforms and strigiforms replace each other during the daily cycle, is the similar trophic structure of these raptor assemblages (Jaksic 1983) based on behavioral similarities in the hunting modes of their respective constituent species? To what extent do the differing hunting modes of sympatric predators facilitate their coexistence through reduction of co-use of food resources (exploitative competition)? What is the influence of interspecific agonistic interactions (interference competition) in the selection of hunting habitats and of hunting modes by sympatric raptors?

Autecological studies of raptors are abundant (see Clark et al. 1978 for a bibliography; Bunn et al. 1982, and Watson 1977, for specific studies), and raptor population ecology has long reached its maturity (see Newton 1979; Mikkola 1983, and references therein). However, community ecology of raptors is still in its infancy (see Jaksic and Braker 1983 for a cursory review). Given that raptors com-

pare more than favorably to other organisms (passerine birds, lizards) as model predators, I think the time is ripe for exploring this much neglected aspect of raptor ecology.

ACKNOWLEDGMENTS

I thank Keith L. Bildstein, Tom J. Cade, John H. Carothers, Michael W. Collopy, Eduardo R. Fuentes, Harry W. Greene, Jeffrey L. Lincer, David T. Rogers, Jr., Clayton M. White, Stephen A. Nesbitt, and an anonymous reviewer for critically reading different versions of the manuscript. I acknowledge the support of grant DIUC 202/83 from the Pontificia Universidad Católica de Chile, and of grant INT-8308032 from the National Science Foundation.

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First received 7 March 1984; Accepted 20 April 1985

OWL WEIGHTS IN THE LITERATURE: A REVIEW

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ABSTRACT - Published mean body weights of 18 species of North American owls are presented and reviewed. Adequate data are lacking for virtually all species. A pattern of increased weight lability in small owl species is suggested by several studies of captive and wild birds. One source with large samples of weight data is rejected as its means deviate from virtually all other published sources.

Mean body weight is an important descriptive statistic used in many avian studies. Often, however, researchers do not handle large numbers of individual birds, and must rely on published mean weights for the species they are studying. This is especially true in the case of owls, which are difficult to capture and weigh in large numbers. In the course of compiling available weight data for all North American birds, I searched the literature for owl weights and noted some inconsistencies. The purpose of this paper is to review the published data, assess the reliability of different sources, and discuss general trends apparent from the data.

MAJOR SOURCES

Most studies reporting owl weights contain very small samples, often only a single weight. Two sources do present weights of all or almost all North American species. Earhart and Johnson (1970) (hereafter, E&J) analyzed patterns of size dimorphism and food habits in owls. They presented weights (Table 1) and wing lengths for all North American owls except the Elf Owl (*Micrathene whitneyi*). E&J included 5 subspecies of the Great Horned Owl (*Bubo virginianus*) and 8 subspecies of Eastern and Western Screech-Owl (*Otus asio* and *O. kennicottii*). These weights were compiled from various museum collections. The sample sizes were often the largest reliable weight samples available for each species. E&J used these data to calculate the degree of sexual dimorphism for each species, and examined how various ecological parameters vary with body size. Snyder and Wiley (1976) also used this same data set to examine food stress and female nest defense as factors influencing reversed sexual dimorphism in hawks and owls. The data presented in E&J included sample size, mean and range for both sexes.

The second source with a large series of owl weights was Karalus and Eckert (1974) (hereafter, K&E). This is essentially a "coffee table book" with species accounts of all North American owls. It differs from the usual book of this type by including

detailed information of species' and subspecies' range, weight, linear measurements, voice and general behavior. The measurements initially seem attractive since they are based on large samples, sometimes larger than E&J (Table 1). Unfortunately, the data in this book appear to be completely unreliable. The acknowledgments imply that most measurements were taken from museum specimens, but no sources are cited. K&E also presented sample size, mean and range for at least 1 subspecies of each species, while an "average weight" was given for most other subspecies.

SPECIES ACCOUNTS

Tyto alba — Single weights of the Common Barn-Owl are given in Imler (1937) (475g, unsexed fall bird from Kansas) and Stewart (1952) (457g, unsexed fall bird from Ohio). Jackson and Dakin (1982) gave weights of 2 ♂♂ from Mississippi (492, 512g). Poole (1938) reported the mean of 2 birds as 505g, while Haverschmidt (1948) listed the weights of 1 ♂ (485g) and 3 ♀♀ (446, 498, 558g) from Surinam. Hartman (1961) collected 4 ♀♀ ($\bar{x} = 516g$) and 4 ♂♂ ($\bar{x} = 439g$). His birds were from Panama, Florida and Ohio, so weights cannot be ascribed to any one locality with confidence. Marks and Marti (1984) gave the mean of 78 birds as 511g. All these weights were within the range given by E&J.

Large samples are in Steenhof (1983) and Marti and Wagner (1985) (Table 1). Steenhof (1983) cited unpublished data. Her means were substantially higher, but within the range presented in E&J. Marti and Wagner (1985) presented data for live (Table 1), trauma-killed, and starved owls from northern Utah in winter. Both starved ($\text{♀ } \bar{x} = 392g, N = 25$; $\text{♂ } \bar{x} = 335g, N = 28$) and trauma-killed ($\text{♀ } \bar{x} = 434g, N = 14$; $\text{♂ } \bar{x} = 361g, N = 7$) birds weighed less than live trapped owls. In addition, the starved birds weighed less than the trauma-killed, demonstrating that the manner in which weight data is collected can affect means recorded for a sample. K&E's data were similar to

Table 1. Large samples of published weights (g) for North American owls. Data are presented as: \bar{x} (sample size) range.

SPECIES	EARHART & JOHNSON 1970	KARALUS & ECKERT 1974	OTHER SOURCES
<i>Tyto alba</i>	♀ 490(21) 382-580 ♂ 442(16) 299-580	♀ 500(50) 383-573 ♂ 384(46) 312-508	♀ 571(109) Marti & Wagner 1985 ♂ 476(53) ♀ 561(50) Steenhof 1983 ♂ 461(28)
<i>Otus flammeolus</i>	♀ 57.2(9) 51-63 ♂ 53.9(56) 45-63	♀ 137(7) 122-149 ♂ 126(6) 114-143	♀ 69.2(2) 60-378.2 Johnson & Russell 1962 ♂ 55.9(11) 48.8-66.1
<i>Otus asio naevius</i>	♀ 184(36) 126-252 ♂ 160(38) 99-229	♀ 208(49) 174-222 ♂ 200(38) 166-212	♀ 194(66) 150-235 Henny & VanCamp 1979 ♂ 167(31) 140-210
<i>O. a. mecallii</i>	♀ 131(10) 115-162 ♂ 125(12) 94-154	182 ave.	
<i>Otus kennicottii myoensis</i>	♀ 155(12) 135-173 ♂ 132(10) 119-149	204 ave.	
<i>O. k. cinereascens</i>	♀ 123(18) 92-160 ♂ 111(35) 88-137	166 ave.	
<i>O. k. kennicottii</i>	♀ 186(11) 152-215 ♂ 152(14) 130-178	236 ave.	
<i>O. k. bendirei</i>	♀ 157(23) 100-223 ♂ 141(49) 100-173	216 ave.	
<i>O. k. querquedula</i>	♀ 152(10) 130-164 ♂ 134(26) 108-170	216 ave.	
<i>Otus trichopsis</i>	♀ 92.2(8) 79-121 ♂ 84.5(23) 70-104	♀ 170(7) 156-187 ♂ 161(4) 146-174	
<i>Bubo virginianus neopacathu</i>	♀ 1556(12) 1357-2900 ♂ 1239(10) 1035-1389		
<i>B. v. virginianus</i>	♀ 1768(29) 1417-2503	♀ 1597(51) 1454-1876	♀ 1758(209) 1197-2313 Langenbach & McDowell 1939
<i>B. v. virginianus</i>	♂ 1318(22) 985-1588	♂ 1449(33) 1383-1692	♂ 1343(206) 703-1703
<i>B. v. occidentalis</i>	♀ 1555(18) 1112-2046 ♂ 1154(18) 865-1460	♀ 1559(9) 1505-1652 Imler 1937 ♂ 1269(4) 1230-1360	U 1460(14) Jaksic & Marti 1984 U 1166(30) Jaksic & Marti 1984
<i>B. v. pacificus</i>	♀ 1312(23) 825-1668 ♂ 992(26) 680-1272	1384 ave.	
<i>B. v. pallidescens</i>			♀ 1142(12) 801-1550 ♂ 914(18) 724-1257.

(Table 1. Cont'd)

(Table 1 continued)

(Continuation of Table 1.)

SPECIES	EARHART & JOHNSON 1970	KARALUS & ECKERT 1974	OTHER SOURCES
<i>Nyctea scandiaca</i>	♀ 1963(30) 1550-2690 ♂ 1642(27) 1320-2013	♀ 1707(40) 1593-2003 ♂ 1613(34) 1448-1840	
<i>Strix uralensis</i>	♀ 345(14) 306-392 ♂ 299(16) 273-326	♀ 252(9) 202-274 ♂ 226(19) 194-266	
<i>Glaucidium gnoma</i>	♀ 73.0(10) 64-87 ♂ 61.9(42) 54-74	♀ 44.8(8) 36.9-50.7 ♂ 40.8(8) 34.6-46.8	
<i>Glaucidium brasilianum</i>	♀ 75.1(16) 62-95 ♂ 61.4(29) 46-74	♀ 82.2(5) 71.4-88.2 ♂ 78.5(2) 65.5-85.1	
<i>Micrathene whitneyi</i>		♀ 26.1(30) 17.3-30.6 ♂ 21.4(21) 19.5-22.3	U 41.0(20) 35.9-44.1 Walters 1981
<i>Athene cunicularia</i>	♀ 151(15) 129-185 ♂ 159(31) 120-228	♀ 25.2(11) 17.0-28.9 ♂ 20.3(18) 18.1-21.2	U 147(11) summer, Coulombe 1970 U 186(11) winter ♀ 168(10) 126-210 Thomsen 1971 ♂ 172(12) 145-191
<i>Strix occidentalis</i>	♀ 637(10) 548-760 ♂ 582(10) 518-694	♀ 502(13) 384-591 ♂ 391(11) 342-514	
<i>Strix varia</i>	♀ 801(24) 610-1051 ♂ 632(20) 468-774	♀ 506(12) 388-651 ♂ 396(9) 330-569	
<i>Strix nebulosa</i>	♀ 1298(6) 1144-1454 ♂ 935(7) 790-1030	♀ 1391(8) 1078-1524 ♂ 1289(5) 1057-1385	
<i>Aio otus</i>	♀ 279(28) 210-342 ♂ 245(38) 178-314	♀ 282(16) 227-333 ♂ 258(11) 215-299	
<i>Asio flammeus</i>	♀ 378(27) 284-475 ♂ 315(20) 206-368	♀ 336(6) 276-429 ♂ 287(3) 261-346	♀ 379(8) 323-441 Clark & Ward 1974 ♂ 325(9) 294-368
<i>Aegolius funereus</i>	♀ 140(4) 121-160 ♂ 102(5) 85-119	♀ 224(23) 109-235 ♂ 211(26) 103-227	♀ 167(96) 126-194 Glutz et al. 1979 ♂ 101(74) 90-113
<i>Aegolius acadicus</i>	♀ 90.8(18) 65-124 ♂ 74.9(27) 54-96	♀ 107(31) 87.9-124 ♂ 102(37) 84.3-119	U 91.2(68) 72-112 Mueller & Berger 1967

E&J for females, but underestimated the male weight by 13%. As is true of most other species, too few data have been published to examine geographical variation.

Otus flammeolus — Johnson and Russell (1962) presented mean weights for 13 Flammulated Owls from California and Nevada (Table 1). The mean for 11 ♂♂ is similar to E&J's mean for 56 ♂♂. The female mean in Johnson and Russell is substantially higher, but sample sizes are small. K&E's data are widely divergent from both of the above sources, deviating from E&J by 130 - 140%.

Otus asio* and *O. kennicottii — Eastern and Western Screech-Owls contain 16 subspecies combined that are widely divergent in size (A.O.U. 1957, but see Marshall 1967). The only source covering all 16 subspecies is K&E, but as has been shown for most other species, these weights are at odds with virtually all other available sources. E&J provided weights for 2 subspecies of Eastern Screech-Owl (*naevius*, *mccallii*) and 5 subspecies of Western Screech-Owl (*inyoensis*, *cinerascens*, *kennicottii*, *bendirei*, *querquinus*). A large degree of geographic variation is apparent from this data set.

Other sources of screech-owl weights are few. I found no data for *aikenii*, *asio*, *brewsteri*, *hasbrouckii*, *maxwelliae*, and *swenki*. Johnson and Russell (1962) collected 1 ♀ *macfarlanei* in California weighing 177g. Miller and Miller (1951) presented data from Arizona and California for 3 southwestern subspecies: *yumanensis* (6 ♂♂, $\bar{x} = 103g \pm 11.4S.D.$), *inyoensis* (2 ♀♀, $\bar{x} = 157g$); 8 ♂♂, $\bar{x} = 131g \pm 9.2$), and *querquinus* (7 ♂♂, $\bar{x} = 117g$). Miller and Miller's *inyoensis* data were similar to E&J, while the *querquinus* mean of Miller and Miller was less.

Clench and Leberman (1978) gave a mean of 163g (range 153-176g) for 8 *naevius* banded in Pennsylvania. Other *naevius* weights include Stewart (1937) (206, 228g unsexed adults) and Poole (1938) (2 birds averaging 178g). Kelso (1938) gave weights for *naevius* (2 ♂♂, 133, 156g; 9 ♀♀, $\bar{x} = 201g$, range 148-244g, New York, some birds starved), *floridanus* (1 ♂, 111g, Florida), and 5 starved unsexed birds from Indiana ($\bar{x} = 139g$, range 114-162g), which Kelso attributes to *swenki* but considering the range must be *naevius* (A.O.U. 1957). Finally, Imler (1937) collected 4 individuals in western Kansas ($\bar{x} = 152g$, range 153-176g) which could be either *aikenii* or *swenki*.

The only complete analysis of seasonal weight

variation in screech-owls is the Henny and VanCamp (1979) study of *O. asio naevius* in Ohio. Their means of all birds captured were slightly higher than E&J for this subspecies (Table 1). Henny and VanCamp documented a seasonal weight cycle peaking in late fall. They suggest that this weight gain reflects an increase in fat reserves which aid winter survival. They also noted a wide range of body weights within seasons, suggesting that body weight was relatively labile. The same possibility has been discussed in studies of several other small owls.

Otus trichopsis — The only additional weight published for the Whiskered Screech-Owl is an estimate of 120g (Zar 1969). This figure differs substantially from E&J. It could be that this estimate (which Zar did not make himself) was based on the incorrect assumption that Whiskered Screech-Owls should weigh approximately the same as the sympatric subspecies of Western Screech-Owl (*Otus kennicottii cinerascens*). K&E overestimated female and male means by 84 and 90%, respectively.

Bubo virginianus — With the exception of E&J, surprisingly little data have been published on Great Horned Owls. E&J presented weights for 5 of the 9 North American subspecies. Other published weights are mostly of *virginianus*, the eastern subspecies. Hartman (1955) collected 1 ♀ (1248g) and 1 ♂ (1040g) from Ohio. The female weight was substantially lower than E&J's minimum for this subspecies. Poole (1938) gave the mean of 2 *virginianus* ♀♀ as 1446g. Langenbach and McDowell (1939) reported large samples of Pennsylvanian birds (Table 1). They noted a substantial difference between specimens with full stomachs (Table 1) and with empty stomachs (♀ $\bar{x} = 1644g$, N = 94; ♂ $\bar{x} = 1263g$, N = 142). The means from birds with full stomachs closely approximates E&J. The lower means for birds with empty stomachs show the amount of error that can be introduced if this factor is not accounted for.

For the other races, only scattered data are available. Irving (1960) collected a male *lagophonus* from Alaska weighing 1445g, while Williamson (1957) reported an Alaskan female *algistus* weighed 2000g. Poole (1938) gave one unsexed *pacificus* as 1480g, Imler (1937) listed a small sample of *occidentalis* from western Kansas (Table 1), while Jaksic and Marti (1984) presented samples for both *pacificus* and *occidentalis* (Table 1). In addition, Siegfried et

al. (1975) gave the mean weight of 2 ♀♀ as 1425g. These were from zoos and unidentified to subspecies.

By far the most surprising pattern is the lack of published data. Great Horned Owls are common throughout North America, and are often among the most common birds brought to raptor rehabilitation centers and museum collections. A large amount of unpublished data must exist on the various subspecies. No reliable data were found for the subspecies *saturatus* and *heterocnemis*.

Nyctea scandiaca — Irving (1960) gave the weight of 1 Snowy Owl collected in Alaska as 2267g, while Siegfried et al. (1975) listed 1 unsexed captive from Minnesota at 1916g. Poole (1938) reported a single male weighing 1404g, while Hagen (1942) gave a mean of 2003g for 7 Norwegian birds. Gesaman (1978) gave weights of 3 captive ♀♀ during the winter as 1928, 2175 and 2392g. The largest of these lost 80g during a 5-d fast. All these weights fall within the range given by E&J.

K&E's mean for males is close to E&J, but the female mean in K&E underestimates E&J by 13%. Even considering the weight loss recorded by Gesaman (1978) in a healthy fasting bird, this difference still may be real.

Surnia ulula — Small samples of Northern Hawk-Owl weights were found in Irving (1960), Campbell (1969) and Johnson and Collins (1975). Campbell (1969) collected 3 ♂♂ (317, 319, 346g) and 1 ♀ (418g) from Alaska, while Irving (1960) collected 2 Alaskan ♂♂ (322, 350g) and 4 ♀♀ (310, 336, 350, 384g). These were slightly heavier than the ranges in E&J. However, Johnson and Collins (1975) found a single captive bird's weight varied from 293-375g. Thus the above samples agree fairly well. K&E underestimated male and female weights by 24% and 27%, respectively. The variation recorded by Johnson and Collins reflects the pattern of weight lability found in smaller owls.

Glaucidium gnoma — Several subspecies of Northern Pygmy-Owl occur in North America. Little data are available and it is impossible to determine if the wide differences reported are due to geographic variation or error. Johnson and Russell (1962) give weights of 8 ♂♂ ($\bar{x} = 62.8$ g, range 57.3-68.0g) for the subspecies *californicum*, which agrees with the *californicum* weights of E&J. K&E weights are 34-38% lower than E&J, but are from a different subspecies (*pinacula*). Zar (1969) estimated

Northern Pygmy-Owl weights at 54g, substantially under the *californicum* samples, but without reliable data for the other subspecies, this estimate cannot be evaluated.

Glaucidium brasilianum — Little additional data exist for Ferruginous Pygmy-Owls. Prange et al. (1979) gave the weight of 1 bird as 61.0g. Russell (1964) collected 2 ♂♂ (60.5, 62.6g) and 4 ♀♀ (64.4, 74.6, 77.7, 94.8g) in Belize. These data agree closely with E&J. K&E overestimate female and male means by 10 and 28%, respectively. The wide range of values given by Russell (1964) and E&J may reflect weight lability in this species.

Micrathene whitneyi — E&J gave no weights for the Elf Owl. Zar (1969) estimated mean weight as 46g, only slightly larger than the large series mean of 41.0g in Walters (1981). Lasiewski and Dawson (1967) estimated the mean as 37.7g, while Ligon (1967) gave a range of 35-55g. Johnson (1968) listed 1 ♂ and 1 ♀ averaging 37.0g. Finally, Walters (1981) published a large series of weights based on banded, unsexed Arizona birds (Table 1).

Athene cunicularia — More data exists for Burrowing Owls than for any other North American owl. Two subspecies are represented: *hypugaea* in the west and *floridana* in Florida. Some published weights cannot be safely ascribed to subspecies. For example, Marti (1974) assembled 8 weights from literature and museum specimens ($\bar{x} = 140$ g), but did not describe his sources more fully.

Most published samples are of *hypugaea*. Imler (1937) gave the mean of 7 Kansas birds as 149g (range 114-171g). Coulombe (1970) presents summer and winter weights from the same Californian population (Table 1). His samples show wide seasonal variation. Thomsen (1971) presents weights for breeding California birds (Table 1), that were heavier than E&J by less than 10%. K&E, on the other hand, overestimate E&J by 28-42%, probably a very real difference.

Of the published *floridana* weights, Prange et al. (1979) listed weights of 3 individuals (179, 182, 185g). Hartman (1955) included weights of 4 ♀♀ (130, 150, 157, 170g) and 4 ♂♂ (130, 150, 170, 170g), while Hartman (1961) listed weights of 5 ♀♀ and 6 ♂♂ (Table 1), possibly including the same data as the earlier paper. Little difference between the means for the 2 subspecies can be seen.

Strix occidentalis — Johnson and Russell (1962) collected 2 female Spotted Owls in California

weighing 616 and 648g. No other published weights were located except for E&J and K&E. K&E underestimated female weight by 21% and male weight by 33%. This difference appears very substantial, but could reflect subspecific differences. K&E's sample was based on *occidentalis*, while E&J did not give subspecific identification. Three subspecies of Spotted Owl occur in North America.

Strix varia — Weights are available for 2 subspecies of Barred Owl. For subspecies *varia*, Hartman (1955) listed weights of 2 ♀ ♀ from Ohio (681, 771g) and 1 ♂ (642g), while Poole (1938) gave the weight of 1 unsexed bird as 510g. Both E&J and K&E samples are of this subspecies. K&E again seriously underestimated the E&J weights by 37% (both sexes). Siegfried et al. (1975) gave the weight of a single captive from Minnesota as 748g.

Hartman (1955, 1961) also gave weights for *georgica* ("alleni" in the 1961 paper). Hartman (1955) listed 1 ♀ (875g) and 3 ♂ ♂ from Florida (681, 750, 800g). Hartman (1961) gave 2 ♀ ♀ weights as 850, 875g, and the mean of 6 ♂ ♂ as 718+35.1S.E. These few weights suggest that *georgica* might be heavier than *varia*, but sample sizes are much too small for firm conclusions.

Strix nebulosa — Very little data exist for the Great Gray Owl. Irving (1960) collected 1 ♀ (1092g) in Alaska, while Bent (1938) stated that weights of 4 birds ranged "from 1 lb. 15 oz. to 2 lb. 14.5 oz." K&E's male means are substantially overestimated by 38%, compared to E&J.

Asio otus — Gruber (1962) gave the weight of a captive female and a captive male from Illinois as 310g and 252g, respectively. Poole (1938) listed 2 ♀ ♀ as averaging 288g, while Hagen (1942) reported a mean of 285g for 3 Norwegian birds. Marti (1974) compiled a mean of 262g from 7 weights found in the literature and museum specimens, and Marks and Marti (1984) gave a mean of 254g for 20 birds. All these weights fall within the range reported by E&J.

Asio flammeus — A number of studies report the weight of a single Short-eared Owl. Irving (1960) collected 1 ♀ weighing 400g from Alaska. Imler (1937) found one unsexed bird in western Kansas weighed 270g. Campbell (1969) collected an Alaskan male weighing 337g. A captive in California averaged 385g over 14 d (Page and Whitacre 1975), while another captive in Illinois averaged 406g over

24 h (Gruber 1962). In addition to these single reports, Clark (1975) reported the mean of 2 ♀ ♀ as 392g and 2 ♂ ♂ as 304g, while Hagen (1942) gave the mean of 11 Norwegian birds as 371g. Clark and Ward (1974) compiled a relatively large sample for both sexes (Table 1) which agree closely with E&J.

Aegolius funereus — Irving (1960) collected an Alaskan male Boreal Owl (*A.f. richardsoni*) weighing 116g, while Campbell (1969) reported a very fat Alaskan female weighing 194g. E&J gave weights of only 9 birds. K&E have a much larger sample, but their data deviate from E&J by 60% for females and 107% for males and cannot be considered reliable. The best available sample for this species is Glutz von Blotzheim et al. (1980). Their sample (Table 1) is of the European subspecies *A.f. funereus*, however, the means and ranges overlap widely with E&J's small sample.

Aegolius acadicus — Several small samples of weights were published for Northern Saw-whet Owls. Zar (1969) estimated a weight of 124g, which is very high compared to the following. Single weights were given by Gatehouse and Markham (1970) (82.9g, 1 captive ♂), Poole (1938) (108g, unsexed), and Murray and Jehl (1964) (89.6g, 1 New Jersey migrant). Gruber (1962) weighed 2 captive birds, 1 ♀ (96g) and 1 ♂ (75g). Clench and Leberman (1978) banded 5 unsexed migrants in Pennsylvania ($\bar{x} = 86.0$ g, range 72.6-97.6g), while Walkinshaw (1965) banded 10 migrants in Michigan weighing 95.2g (range 85.1-114g). All these weights agree closely with E&J's values.

Collins (1963) reported several series of Northern Saw-whet Owl weights. Eleven birds of both sexes from the University of Michigan collection averaged 81.8g (range 54.2-124g), while 7 banded birds weighed 82.7g (range 67.5-113g). Collins also kept 2 ♀ ♀ (106, 108g) and 1 ♂ (80g) in captivity. He noted that the weight of the lighter female varied daily from 74.1g to 114g, suggesting weight lability in this species.

Mueller and Berger (1967) weighed a large series of migrants in Wisconsin (Table 1). They documented a significant weight difference between adult and immature birds, and discussed weight change after banding. Their means and ranges for the unsexed birds agree relatively well with E&J. K&E overestimated female means by 18% and male means by 36% compared to E&J.

DISCUSSION

The most apparent pattern in the preceding species accounts is the lack of published data even for common species and subspecies of owls. E&J provide a basic reference sample for most species. E&J's data were taken from specimens from several museums, and are probably adequate if a representative mean weight is needed, as in their study of owl food habits. But since individual specimens in a collection are often obtained in a wide variety of ways, the heterogeneity found in these samples precludes their use in many studies. A single sample like E&J's cannot express the seasonal (Coulombe 1970; Henny and VanCamp 1979), daily (Collins 1963) and geographic (Miller and Miller 1951) variation present in owls. Owls could provide a good test of ecotypic variation such as Bergmann's rule, as they are often permanent residents and have wide geographic ranges, but the available data simply do not allow such analyses. Published accounts typically are of small sample size or do not consider such variables as stomach content (Langenbach and McDowell 1939) or manner of collection (Marti and Wagner 1985). Thus, published series of weights within and between seasons for birds handled in a consistent manner are needed for virtually every species.

This situation is not unique to owls. In a compilation of weight data for all North American birds (Dunning 1984), I found that adequate data are lacking for a surprising number of species. This is especially true for western and southwestern species. However, I often found that pertinent data existed in some bander's log or researcher's notebook, but remained unpublished. A single example of the value of more published data will suffice. Henny and VanCamp (1979) proposed that the increase in mean body weight recorded in the fall reflects an increase in fat reserves allowing greater winter survival for a population of Eastern Screech-Owls in northern Ohio. One way to test this hypothesis would be to examine seasonal weight cycles in more southerly screech-owl populations. If a similar fall peak in body weight were found in screech-owls that lived in a more mild climate, an alternative explanation might be required. However, this test is presently impossible to do, as I could find no weights at all for the more southerly subspecies in the eastern United States, *O. a. asio*!

A second pattern of great interest is that of increased weight lability in small owl species. Collins

(1963) reported that the weight of a single captive female Northern Saw-whet Owl varied from 74.1g to 114g, a variation of 30% from the median. Similarly, Johnson and Collins (1975) reported weight of a female captive Northern Hawk-Owl varied from 293g to 375g "without apparent ill effect." In comparison, Gessaman (1978) found that a female Snowy Owl lost only 80g (3.3% of this individual's mean weight of 2392g) during a 5-d fast. If this weight loss had been in the same proportion as the Northern Saw-whet Owl reported by Collins, the female Snowy Owl could have lost up to 718g. With these captivity studies in mind, the wide within-season range of Eastern Screech-Owl weights reported by Henny and VanCamp (1979) and the large between-season variation in Burrowing Owl weights reported by Coulombe (1970) suggest that weight lability may be common in many smaller owls.

Finally, it is apparent from this review that Karalus and Eckert (1974) is totally unreliable. The mean weights presented in this work deviate from virtually all other samples by as much as 140%. The weight lability just discussed could lead to widely divergent weights sometimes being reported for a small owl. But the K&E data are supposedly based on large samples, and the deviations are present in both large and small species. A spot check of some of the linear measurements presented for each species shows that these, too, deviate from published references by as much as 20%. Since other reviewers have found fault with the text, terminology, bibliography (Martin 1976) and maps (Bock 1976) in this work, it is apparent that this book cannot be used as a reliable source of any information on owls.

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Received 26 December 1983; Accepted 15 April 1985

EVAPORATIVE WATER LOSS OF CAPTIVE COMMON BARN-OWLS

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ABSTRACT — Evaporative water loss of the Common Barn-Owl (*Tyto alba*) was examined at temp experienced by these owls during incubation. Water loss increased ($P < 0.001$) with increasing ambient temp; however, it appeared that Common Barn-Owls in Utah would not be heat-stressed during incubation.

The Common Barn-Owl (*Tyto alba*) readily uses man-made structures (i.e., barns, haylofts, abandoned water towers) as roosting and nesting sites and adapts quickly to the use of nestboxes (Otteni et al. 1972; Marti et al. 1979). The use of nestboxes as nesting sites provides the barn owl with the advantageous effects of the sheltered nestboxes (i.e., decreased forced convection, less direct exposure to precipitation, and higher than ambient temp) during incubation (Hamilton 1982). While there may be advantages for birds to conduct incubation within nestboxes, higher ambient temp may be a potential stressor. Birds may mitigate the effects of heat stress by panting, gular fluttering, or by postural thermoregulatory behavior (Bartholomew et al. 1968; Weathers 1972; Bartholomew and Dawson 1979; Dawson 1982).

The objectives of this study were to examine evaporative water loss of barn owls, and to determine whether water loss plays a crucial role during incubation at ambient temp below 32°C.

MATERIALS AND METHODS

Two adult owls were captured in April 1980 at Welder Wildlife Foundation (Sinton, San Patricio Co., Texas) and a third adult owl was obtained from a local raptor rehabilitator (S. Ure, Salt Lake City, Utah). All birds were transported to the Environmental Physiology Laboratory at Utah State University, Logan, Utah. In 1981, three additional adult owls were captured post-incubation (April-May, Brigham City, Box Elder Co., Utah) and likewise transported to the laboratory facilities. All owls (♀) were housed in separate 3 x 3 x 2.5 m walk-in environmental chambers. Owls were fed a laboratory House Mouse (*Mus musculus*) diet and maintained on a 12L:12D photoperiod during all experimental trials.

Evaporative water loss of 6 captive barn owls was measured at temp that simulated nesting temp (2-30°C). An owl was equilibrated to the test temp for 2-3 d before an experiment and fasted for 6 h prior to the experiment. Each owl was weighed to the nearest 1.0 g on a platform balance and placed in a metabolism chamber. Owl weights ranged from 527.0-584.4 g with a mean value of 561.3 g (± 27.8 , S.D.). Metabolism chambers (56 x 46 x 43 cm) were constructed of plywood (1.3 cm) with a plexiglass sliding door unit (30 x 22 cm, inside dimensions). All edges of the chamber and door were sealed airtight with liquid plastic to prevent extraneous air flow. The wood was varnished and the inner surface of the chamber was covered with a plastic coating to prevent water vapor from being bound hydroscopically to the walls of the metabolism chamber. Condensation was never noted

on the walls of a chamber. Air inlet and outlet valves were positioned on opposite sides of the chamber to allow airflow through the chamber.

After closure of the sliding door of the metabolism chamber, a diaphragm pump (dynapump) was started and respiratory gases were pulled through plastic tubing and then through a series of preweighed U-tubes which were filled with Drierite and weighed to the nearest 0.01 g, analytical balance. The weight change in the Drierite equalled the water vapor expired by the owl plus the atmospheric water vapor. A second set of Drierite U-tubes was connected in parallel to measure atmospheric water vapor (same pump). The rates of air flow from the metabolism chamber and the second set of tubes were equal. Water vapor expired by the owl (mg H₂O/g.h) was calculated as the difference in weight between the experimental and control tubes.

Air temp inside the metabolism and environmental chambers was monitored with thermistors (Model No. 1331, Control Equipment Co., Salt Lake City, Utah) and copper-constantan thermocouples and recorded on Rustrak chart recorders (Model No. 2133, Control Equipment Co.) and Wescor thermometers (Model No. TH50 TC, Wescor Co., Logan, Utah), respectively. Thermistors and thermocouples were calibrated with a glass mercury thermometer. Temp was recorded every 15 min.

Statistical analysis of data presented here included curvilinear regression analysis and paired t-Test.

RESULTS AND DISCUSSION

Evaporative water loss of barn owls was examined over a temp regime (2-30°C) which simulated ambient temp experienced by incubating barn owls (Hamilton 1982).

To test the physical effect of the metabolism chamber in altering the temp experienced by an owl, ambient (environmental chamber) temp and temp of the metabolism chamber were monitored during each experimental trial. Experimental temp was separated into 3 temp ranges: 0-10°C, 11-20°C and 21-30°C. In each temp range, the temp of the metabolism chamber was significantly higher ($P < 0.001$, paired t-Test) than the temp of the environmental chamber. The temp difference between the metabolism chamber and the environmental chamber was greatest ($P < 0.001$, 2.0°C) at temp which ranged between 0-10°C, and also was significantly higher for temp between 11-20°C (0.7°C) and 21-30°C (0.6°C). Therefore, owls utilizing nestbox metabolism chambers experience higher temp than would be seen if using open sites.

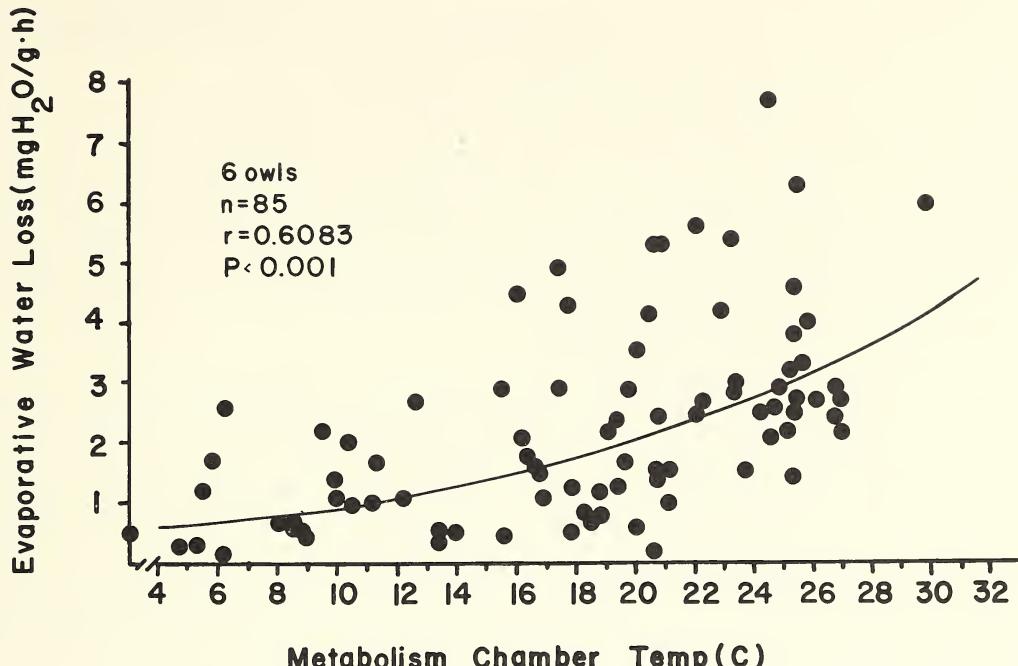


Figure 1: Water loss (mg H₂O/g.h) of 6 captive barn owls.

Eighty-five measurements from 6 captive barn owls showed that water loss (mg H₂O/g.h) increased significantly ($P < 0.001$) as ambient temp increased (Fig. 1). Recent studies by Wunder (1979), Weathers (1979, 1981), and Dawson (1982) have examined climatic adaptation, physiological thermoregulation and water loss from birds and the data exhibited by the barn owl does not deviate from established patterns. Water loss of barn owls at ambient temp from 0-20°C is not different than data for non-incubating pigeons (*Lophophops ferruginea*) (Dawson and Bennett 1973) or Burrowing Owls (*Athene cunicularia*) (Coulombe 1970).

Coulombe (1970), Dawson and Bennett (1973) and Weathers (1981) have shown that the pattern of evaporative water loss of birds is an exponential function. However, water loss is essentially linear until approximately 35-40°C at which time birds become heat-stressed (Dawson 1982) and the water loss increased exponentially. This is also seen in Figure 1; at temp that mimics incubation temp (up to 30°C) water loss of barn owls is fairly linear and not very substantial. However, barn owls in Utah do not experience nestbox temp greater than 32°C during incubation (Hamilton 1982); therefore, the

barn owl in Utah may be able to conduct incubation without an apparent heat stress.

In summary, birds must contend with numerous environmental stresses during incubation, one of which is heat stress. Some birds utilize roost sites with low heat loads (Barrows 1981), while other incubating birds use postural thermoregulatory behavior to reduce heat stress (Lustick et al. 1978, 1979; Bartholomew and Dawson 1979). The barn owl may escape heat stress problems during incubation by using nestboxes and by choosing a location where high ambient temp does not occur.

ACKNOWLEDGMENTS

This paper is part of a dissertation submitted to the Department of Biology at Utah State University in partial fulfillment of the requirements for the Ph.D. degree. I thank members of my graduate committee: Drs. J.A. Gessaman, K.L. Dixon, R.T. Sanders, R.P. Sharma and L.C. Ellis. I also thank Dr. A.B. Hamilton for her help and support through the years. Thanks to Drs. H.E. Dziuk, J.A. Mosher and one anonymous referee for reviewing an earlier version of this manuscript. Thanks to Ms. P. Hornbeck and Ms. J. Thorp for secretarial assistance. This study was funded in part by an Edwards H. and Winnie H. Smith Fellowship from the Welder Wildlife Foundation (Dr. J.G. Teer, Director), a Sigma Xi Grant-in-Aid of Research award, and the Ecology Center, Utah State University (Dr. F. Wagner, Director). This is Welder Wildlife Foundation Contribution No. 282.

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Received 18 December 1984; Accepted 20 March 1985

PEREGRINE FALCON SEMEN: A QUANTITATIVE AND QUALITATIVE EXAMINATION

JOHN Hoolihan and William Burnham

ABSTRACT — Collection frequencies and certain characteristics of Peregrine Falcon (*Falco peregrinus*) semen were investigated using semen from a falcon trained to copulate on a specially designed hat. Semen volume increased significantly when collections were increased from two to three times/day, but cells/ejaculate decreased. No significant difference in number cells/ejaculate or cells/microliter was detected between morning and evening samples with two collections/day. Three collections/day resulted in decreasing total cell numbers/collections and numbers/microliter with the most cells collected during the initial morning collection. Semen showed a high motility, with estimated 80 - 100% of sperm cells alive.

The Peregrine Falcon (*Falco peregrinus*) continues to be a focal point of captive propagation efforts (Cade and Dague 1981). An important technique used in captive propagation is artificial insemination, since many captive falcons do not copulate (Boyd 1978). The technique of artificial insemination has been described by Boyd et al. (1977), but little attention has been directed toward quantitative or qualitative examination of falcon semen. We report here the affect of increasing frequency of semen collection upon semen volume and upon certain characteristics of peregrine semen, including concentration of sperm cells, total cells/ejaculate, motility and percent of viable sperm cells.

MATERIALS AND METHODS

We wished to know if daily semen volume could be increased significantly by collecting semen 3 times/d vs 2 times/d. Two periods were designated near the midpoint of the semen production cycle (Table 1). Period I comprised 9 d when semen was collected 2 times/d, between 0800 H and 1015 H, and between 1715 H and 1745 H. A third collection was accomplished between 1300 H and 1345 H in Period II. Three days separated the two 9-day collection periods.

All semen in this study was collected from a 10-year-old peregrine. The falcon was behaviorally imprinted to humans and copulated on a specially constructed hat (Cade and Dague 1981). The falcon was handled and raised as described by Boyd and Schwartz (1981). The falcon was given the opportunity to copulate on the hat only during the period when semen was needed for artifi-

Table 1. Means (ranges in parentheses) of semen volume and sperm counts of a 10-year-old Peregrine Falcon.

TIME	VOL/DAY	CELLS/ μ L $\times 10^3$	CELLS/EJACULATE $\times 10^6$
Period I	150 (116 - 185) (n=9)	52.86 (38.12 - 81.12) (n=8)	4.46 (2.55 - 5.84) (n=8)
0800 - 1015 H		59.06 (45.62 - 81.12) (n=4)	4.97 (3.51 - 5.84) (n=4)
1715 - 1745 H		46.66 (38.12 - 55.88) (n=4)	3.95 (2.55 - 4.97) (n=4)
Period II	192 (175 - 208) (n=11)	37.12 (26.25 - 60.62) (n=15)	2.46 (1.27 - 3.88) (n=15)
0800 - 1015 H		47.54 (40.00 - 60.62) (n=3)	3.32 (2.76 - 3.88) (n=3)
1300 - 1345 H		36.47 (30.38 - 39.88) (n=7)	2.61 (1.77 - 3.23) (n=7)
1715 - 1745 H		31.78 (26.25 - 37.38) (n=5)	1.72 (1.27 - 1.90) (n=5)

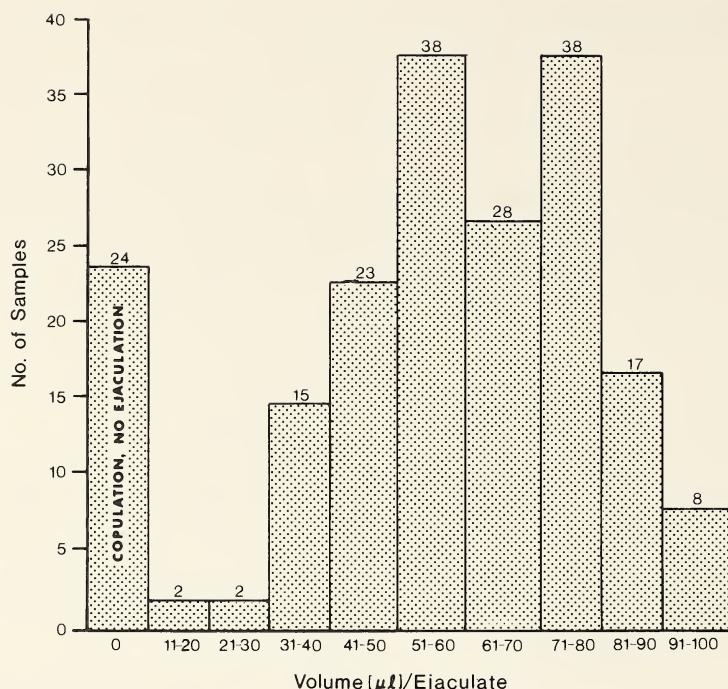


Figure 1. Semen production of a 10-year-old Peregrine Falcon.

cial insemination. The semen was retrieved from the hat by use of blood capillary tubes. The capillary tubes were initially calibrated for volume by using a micropipette. Each millimeter (mm) of tube length represented 1 micro-liter (μl) of semen. Volume was therefore easily calculated by measuring the length of semen in the tube with a metric rule.

Concentration of spermatozoa per sample was calculated by the use of a phase contrast hemocytometer. Separate means were calculated for the morning and evening collections since the collections were not evenly spaced over each 24 hr period.

Standard poultry science methods for determining the percent of viable sperm were inadequate for peregrine semen quantification. Use of a live-dead stain was not helpful in determining fertilization capacity. The nigrosin, eosin blue stain (Ernst 1970) which is intended to darken only dead cells, permeated both live and dead cells of the falcon semen. This technique needs to be perfected for falcons.

Motility score of the semen was judged qualitatively. Samples were taken immediately to the laboratory once collected and mixed thoroughly in small vials pre-warmed to 37°C. Semen samples were then placed on pre-warmed slides which were kept at 37°C in a microscope stage incubator and viewed through a phase contrast microscope. Motility was judged qualitatively by the progressive motion and speed of the sperm cells, as well as the estimated percent of moving cells.

RESULTS AND DISCUSSION

The 10-year-old male peregrine commenced copulation on 5 March and continued on a daily basis through 1 June when the opportunity to copulate was no longer made available to him, thus representing a semen production period of 95 d. Semen produced per copulation ranged from 0 (copulation, but no ejaculation) to 93 ml. Figure 1 compares the volume produced/ejaculate with frequency of ejaculation for periods of both 2 and 3 collections/d. Semen volume rose significantly (28%, $P < 0.001$, Mann-Whitney U-test) when collections were increased from 2 to 3 times/d, but cells/ejaculate decreased significantly ($P < 0.01$) when collection frequency was increased (Table 1).

During Period I, no significant difference ($P = 0.20$) in number of cells/ μl or cells/ejaculate between morning or evening samples was observed (Table 1). In contrast, in Period II a significant difference ($P < 0.025$) existed in number of cells/ μl and cells/ejaculate between the 3 collection times. The mean number of cells/ μl for the morning collection of Period II of 47.54×10^3 shows a decrease of 19% compared

with the same time in Period I (Table 1). The midday and evening collections for Period II had mean values of 36.47×10^3 and 31.78×10^3 cells/ μl , respectively, the latter showing a decrease for the evening collection times. Total sperm cells/ejaculate (in the morning collections of Period I) averaged 4.97×10^6 (Table 1), and evening collections averaged 3.95×10^6 cells/ejaculate. Together, these figures represent a daily total average of 4.46×10^6 spermatozoa/ejaculate for Period I. In contrast, the mean for the morning, midday and evening collections of Period II were 3.32×10^6 , 2.61×10^6 and 1.72×10^6 , respectively (Table 1). We initially presumed that Period II would show a decrease in spermatozoa/ejaculate and an overall daily total greater than Period I. However, fewer total cells were produced in Period II.

The semen collected showed a high motility value for more than 92% of the samples ($n = 41$) analyzed with an estimated 80 - 100% of the sperm cells alive and moving in a progressive motion. The speed with which the sperm cells move is difficult to evaluate with respect to their apparent fitness. It should be possible to correct this problem through the examination of samples from other captive and wild falcons. In this way, comparisons could be made and the normal speed could be ascertained. Semen from the peregrine tested fertilized eggs at a level equal to other donors of varying ages.

ACKNOWLEDGMENTS

This research was conducted at The Peregrine Fund's Western Facility

located near Fort Collins, Colorado. Financial support was provided by The Peregrine Fund, Inc. (T.J. Cade, President). Technical advice was supplied by R. Amen, Colorado State University Animal Reproduction Laboratory. D. Konkel, W. Heinrich and C. Sandfort trained the semen donor and performed most collections. J. Enderson and T. Cade reviewed the manuscript and provided statistical assistance.

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First Received 1 April 1982; Accepted 22 April 1985



Adult male Prairie Falcon and young at a typical Mojave Desert nest-site. Artwork by N. John Schmitt.

PRAIRIE FALCON PREY IN THE MOJAVE DESERT, CALIFORNIA

DOUGLAS A. BOYCE, JR.

ABSTRACT — Twenty-five species of birds, 9 species of mammals, 5 species of reptiles and 1 species of insect were represented in prey remains and castings from 19 Prairie Falcon (*Falco mexicanus*) nests in the Mojave Desert, California, during 1977 and 1978. Reptiles represented a greater proportion in the diet than is reported in most other Prairie Falcon food studies in the western United States. The Horned Lark (*Eremophila alpestris*), Mourning Dove (*Zenaidura macroura*), Valley Pocket Gopher (*Thomomys bottae*) and Desert Woodrat (*Neotoma lepida*) were found in over 50% of the nests. Eighty-four percent of the prey weighed less than 150 g. The mean prey weight was 107 g and equals 20% of the weight of male Prairie Falcons.

The Prairie Falcon (*Falco mexicanus*) is considered a generalist in prey selection (Bent 1938: Part 2). Mammals and birds are the most common prey taken, with specific prey frequencies varying regionally (Tyler 1923; Fowler 1931; Enderson 1964; Brown and Amadon 1968; Leedy 1972; Osgden 1973; Denton 1975; Haak 1982). Reptiles and insects are rarely recorded as prey (Table 1), although Snyder and Wiley (1976) reported an unusual reliance on insects for food. Types of prey selection by Prairie Falcons nesting in the Mojave Desert contrast sharply with prey previously recorded for this area. Pierce (1935) and Fowler (1935) reported a nest in the Mojave Desert where young Prairie Falcons were raised entirely on a diet of reptiles — mainly Chuckwalla (*Sauromalus obesus*) and occa-

sionally Collared Lizard (*Crotaphytus collaris*), while Bond (1936) reported exclusively mammalian prey in 41 castings at another Mojave Desert nest. Because little is known about food habits of Prairie Falcons in the Mojave Desert, I studied this aspect of their biology.

METHODS

Prey remains and castings were collected from 19 falcon nests throughout the Mojave Desert (34° N 116° W) between March and June 1977 and 1978 in order to provide a qualitative summary of Prairie Falcon food habits. Prey remains and castings were also collected from immediately below the nest site when known to have come from no other raptor. Prey remains were identified in the field or compared with specimens at Humboldt State University, Arcata, California. Fresh weights for prey items were obtained from the Museum of Vertebrate Zoology, University of California, Berkeley, California. I used an adjusted weight

Table 1. Frequency (%) of birds, mammals, reptiles and insect prey remains in Prairie Falcon nests in the western United States.

SOURCE	LOCATION	MAMMALS	BIRDS	REPTILES	INSECTS
Fowler (1931)	California	30 ^c	70	0	0
McKinley unpubl. ^a	Colorado	55	45	0	0
Marti and Braun (1975)	Colorado	39	61	0	0
Ogden (1973)	Idaho	53	33	14	trace
S.R.B.P. ^b (1979)	Idaho	22	72	6	0
Platt (1974)	New Mexico	37	54	9	0
Voelker unpubl. ^a	Oklahoma	8	92	0	0
Porter and White (1973)	Utah	8	92	0	0
Smith and Murphy (1973)	Utah	31	50	0	19
This Study	Mojave Desert	52	38	10	trace

^adata from Sherrod (1978:96, 97)

^bSnake River Birds of Prey annual report 1979

^crounded to nearest 1%

of 500 g for rabbit species in Table 2 because, from the available information, it is unlikely Prairie Falcons are capable of carrying anything heavier (see discussion below).

Quantifying prey remains and castings collected from hawk nests during the nesting season is biased and unreliable (Errington 1932; Craighead and Craighead 1956). Some castings and prey remains may be deposited by falcons before nesting begins and persist until collection during the nesting season. Furthermore, Fowler (1931) reported that adult Prairie Falcons remove uneaten prey and castings from nests. Haak (1982) reported that a larger variety of prey was found at nests than was hunted, suggesting over-representation of uncommonly used prey at nests; however,

observations of encounters with some prey species may be difficult to make. Prey remains may also underestimate the numbers of small rodents and birds actually captured (Cade 1960). Because of numerous potential biases, food habits reported here are qualitative not quantitative.

Delineation of the Mojave Desert boundaries closely parallels the outer distributional limits of the Joshua Tree (*Yucca brevifolia*) (Jaeger 1957). Cresote (*Larrea divaricata*) and Burro Bush (*Fanseria dumosa*) are also characteristic desert flora. Alkali sinks, creosote bush scrub, shadscale scrub, Joshua Tree woodland, and Pinyon-Juniper woodland form the major Mojave Desert floral communities (Munz and Keck 1959).

Table 2. Prey items identified at Prairie Falcon nests in the Mojave Desert.

SPECIES	No. ^a NESTS	% ^b NESTS	ESTIMATED WEIGHT (g)
MAMMALS			
California Ground Squirrel (<i>Spermophilus beecheyi</i>)	2	10.5	565
Mojave Ground Squirrel (<i>Spermophilus mohavensis</i>)	5	26.0	177
Whitetail Antelope Squirrel (<i>Ammospermophilus leucurus</i>)	4	21.0	113
Valley Pocket Gopher (<i>Thomomys bottae</i>)	12	63.0	88
Pocket Mouse (<i>Perognathus</i> sp.)	5	26.0	19
Kangaroo Rat (<i>Dipodomys</i> sp.)	5	26.0	41
Deseret Woodrat (<i>Neotoma lepida</i>)	11	58.0	105
Black-tailed Jack Rabbit (<i>Lepus californicus</i>)	2	10.5	500
Desert Cottontail (<i>Sylvilagus audubonii</i>)	2	10.5	500
BIRDS			
Chukar (<i>Alectoris chukar</i>)	3	15.8	500
Western Sandpiper*			
(<i>Calidris mauri</i>)	1	5.3	27
Rock Dove (<i>Columba livia</i>)	2	10.5	393
Mourning Dove (<i>Zenaida macroura</i>)	8	42.1	109
White-throated Swift (<i>Aeronautes saxatalis</i>)	1	5.3	36
Western Kingbird (<i>Tyrannus verticalis</i>)	2	10.5	41

(Table 2 continued)

(Continuation of Table 2)

BIRDS (cont'd)

Say's Pheobe*			
(<i>Sayornis saya</i>)	1	5.3	25
Horned Lark			
(<i>Eremophila alpestris</i>)	12	63.2	28
Cactus Wren*			
(<i>Campylorhynchus brunneicapillus</i>)	1	5.3	37
Rock Wren			
(<i>Salpinctes obsoletus</i>)	3	15.8	11
Sage Thrasher*			
(<i>Oreoscoptes montanus</i>)	1	5.3	44
LeCont's Thrasher*			
(<i>Toxostoma lacontei</i>)	1	5.3	62
Mountain Bluebird			
(<i>Sialia currucoides</i>)	1	5.3	2.7
Loggerhead Shrike			
(<i>Lanius ludovicianus</i>)	1	5.3	45
European Starling			
(<i>Sturnus vulgaris</i>)	2	10.5	77
Black-headed Grosbeak*			
(<i>Pheucticus melanocephalus</i>)	3	15.8	46
White-crowned Sparrow			
(<i>Zonotrichia leucophrys</i>)	1	5.3	2
Western Meadowlark			
(<i>Sturnella neglecta</i>)	5	26.3	103
Red-winged Blackbird			
(<i>Agelaius phoeniceus</i>)	2	10.5	56
Brewer's Blackbird			
(<i>Euphagus cyanocephalus</i>)	3	15.8	58
Scout's Oriole*			
(<i>Icterus parisorum</i>)	2	10.5	38
Northern Oriole*			
(<i>Icterus galbula</i>)	1	5.3	27
Western Tanager			
(<i>Piranga ludoviciana</i>)	4	21.1	31
House Sparrow			
(<i>Passer domesticus</i>)	4	21.1	27
House Finch			
(<i>Carpodacus mexicanus</i>)	1	5.3	20

REPTILES

Desert Iguana*			
(<i>Dipsosaurus dorsalis</i>)	1	5.3	56
Chuckwalla			
(<i>Sauromalus obesus</i>)	4	21.0	235
Zebra-tailed Lizard*			
(<i>Callisaurus draconoides</i>)	1	5.3	2
Desert Horned Lizard			
(<i>Phrynosoma platyrhinos</i>)	4	21.0	22
Western Whiptail			
(<i>Cnemidophorus tigris</i>)	2	10.5	1

^aThe number of nests in which a species was recorded.^bThe number of nests in which a species was found divided by the number of nests examined (N = 19); times 100 and reported as a percentage.

*Species not previously recorded in the literature as Prairie Falcon prey.

RESULTS AND DISCUSSION

Thirty-nine species representing 3 vertebrate classes were present in prey collections from 19 nests (Table 2). Twenty-five species of birds, 9 species of mammals and 5 species of reptiles were identified. Insect parts were rarely noted and only 1 species, Armored Stink Beetle (*Eleodes armata*) was identified. The Horned Lark, Valley Pocket Gopher and Desert Woodrat were present in over 50% of the nests. The Mourning Dove was present in 48% of the nests.

Although the number of avian species captured outnumbered mammals by almost 3 to 1, the mean weight for birds (76 g) was half of the mean weight for mammals (179 g) suggesting greatest energetic return results from capturing mammals. Analysis of 214 pellets provides further evidence that mammals might be captured more often than birds or reptiles. Mammals were present in 72%, birds in 24% and reptiles in 4% of the pellets examined.

In contrast to Pierce (1935) and Bond (1936) I found no instance where all or nearly all prey items were from just one vertebrate class. No single species appears as primary prey on a desert-wide basis (Table 2). Some species were infrequent in prey remains desert-wide but were locally frequent. For example, the Black-headed Grosbeak (*Pheucticus melanocephalus*) was collected from 3 nests located along the east side of the Sierra Nevada Mountains but nowhere else in the desert. One nest had 8 grosbeaks present.

Mammals. The Valley Pocket Gopher and Desert Woodrat were found in over 50% of the nests. They were seldom seen except very early in the morning or late in the evening when temperatures were cooler. Their high abundance in the prey remains suggests that they were captured at these times. Harmata et al. (1978) found that Prairie Falcons forage primarily during early morning and late afternoon in the Mojave Desert.

Blacktailed Jackrabbit (*Lepus californicus*) and Desert Cottontail (*Sylvilagus audubonii*) feet were found in falcon nests. Adult Blacktailed Jackrabbit (2,590 g) and Desert Cottontail (1,700 g) weigh 3 to 5 times as much as adult male Prairie Falcons (554 g, Enderson 1964), making it unlikely that they carried them to their nests. It is probable that only very young rabbits or portions of them were carried to nests. Porter and White (1973) noted that Prairie Falcons prey on White-faced Ibis (*Plegadis chihi*, 519 g) in Utah. However, since White-faced Ibis were

not found at Utah nests, they concluded that White-faced Ibis were too heavy for Prairie Falcons to carry. Adult Chukar (*Alectoris chukar*) and California Ground Squirrel (*Spermophilus beecheyi*) weigh between 500-565 g and were the next largest prey items found in eyrie samples and may have been brought to the nest by the female (863 g, Enderson 1964).

Birds. The Horned Lark and Mourning Dove were found in 63 and 42% of the nests, respectively. The presence of a Western Sandpiper (*Calidris mauri*) (Table 2) demonstrates the opportunistic hunting nature of Prairie Falcons. The Mojave River flows through the desert but is subterranean for much of its length. Sandpiper remains were found at a falcon nest 3.2 km from one of the few points where the river surfaces. The sandpiper was the only prey item not observed in the field.

Reptiles. Most Prairie Falcon food studies show that reptiles are infrequently reported as prey (Table 1); however, reptiles did constitute a relatively high proportion of the prey in this study (9.5%). Desert Horned Lizard (*Phrynosoma platyrhinos*) and Chuckwalla were found at 20% of the nests. Reptile remains, however, were recorded in only 4% of the pellets. Reptile scales were found mixed with mammal hair in castings but no castings contained both scales and feathers. It seems likely most reptile scales are so thin that they are digested and not cast. Usually, the only indication that reptiles were being used was the presence of heads and tails found around the margin of the nest. Although only lizards were represented in prey remains I did observe a male falcon leave its perch on a power pole and capture a snake.

The 20% Rule. Male falcons usually hunt for family groups during the nesting season (Newton 1979). Harmata et al. (1978) found that male Prairie Falcons hunted more frequently than females in the Mojave Desert. In this study 84% of prey captured weighed less than 150 g and the mean weight was 107 g, or 20% of the weight of male Prairie Falcons. A mean prey weight 20% of mean adult male falcon weight is also common in other species of falcons. I noted a high correlation ($r = 0.98$) between mean prey weight during the breeding season and male falcon body weight for 5 species of falcons (Table 3). Because male falcons are restricted to a definite nesting territory during the breeding season, and are less restricted in movement during the remainder of the year, it seems

Table 3. Mean weight (g) of male falcons selected to show a weight range and the mean weight of their prey captured during the nesting season.

SPECIES	MALE WEIGHT	PREY WEIGHT (\bar{x})	SOURCE
<i>Falco columbarius</i>	187	26	Laing 1984
<i>Falco eleonorae</i>	350	62	Walter 1979
<i>Falco mexicanus</i>	554	143	This Study
<i>Falco peregrinus pealei</i>	750	199	White 1973
<i>Falco rusticolus</i>	1,170	475	Roseneau 1972

probable that characteristics of prey vulnerability and density (during the breeding season) have evolutionarily dictated male falcon size. To test this hypothesis one needs to compare weight of prey captured by females when they begin to hunt after brooding is completed with that caught by males. An alternative hypothesis is that selection pressure is highest during winter months and not during the breeding season. If this were true male and female falcons should show significant differences in the weight of prey captured during winter.

ACKNOWLEDGMENTS

This manuscript benefited from comments by J. Enderson, S. England, B. Haak, A. Harmata, J. Hodges, K. Kertell, D. Mindell, S. Platt, J. Sedinger and C. White. Anne Jacoberger, assistant curator for the Museum of Vertebrate Zoology, Berkeley, California and T. Lawler, Humboldt State University, Arcata, California provided specimens. Bill Lehman and B. Hipp assisted in the field and J. Schmitt helped in identification of prey remains. The study was supported partially by the U.S. Bureau of Land Management and U.S. Fish and Wildlife Service.

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Received 15 March 1985; Accepted 1 June 1985

PERCHING AND ROOSTING PATTERNS OF RAPTORS ON POWER TRANSMISSION TOWERS IN SOUTHEAST IDAHO AND SOUTHWEST WYOMING

JOHN C. SMITH

ABSTRACT — As part of an ongoing raptor management program, 45 km of 345 kilovolt (kv) transmission lines were surveyed from 5 June to 31 September 1983 to determine diurnal and nocturnal raptor use patterns. The Golden Eagle (*Aquila chrysaetos*) and Red-tailed Hawk (*Buteo jamaicensis*) perched mostly on upper, outer sections of transmission towers during the day and roosted on lower, inner sections at night. Daytime surveys alone may not accurately represent raptor use of these structures.

In many treeless areas where availability of nest, perch and roost sites may limit raptor populations, electrical powerline structures are readily utilized by many raptor species (Stahlecker 1979; Olen-dorff et al. 1981). In recent years utility companies have become more aware that the raptor/powerline association is sometimes detrimental to both man and bird, and have initiated studies to examine raptor use of powerlines. The most commonly used technique is daytime aerial surveying (e.g., Wilder 1981; Hansen 1982). Relatively little information has been gathered concerning raptor roosting behavior on powerlines and how it may compare to perching behavior (Craig and Craig 1984). This

paper presents results of a study funded by Idaho Power Company in spring and summer of 1983 (Smith 1983), which was designed to collect information on nocturnal and diurnal behavior of raptors on electrical transmission towers in southeast Idaho and southwest Wyoming.

STUDY AREA AND METHODS

The study area is located 30 km north of the convergence of the Idaho/Wyoming/Utah borders (Fig. 1). Three 345 kv transmission lines transmit electrical power through the study area from a coal-fired generating plant near Rock Springs, Wyoming to 3 separate substations bordering the Snake River plain in southern Idaho.

The 45 km study section is situated on the Idaho/Wyoming border and traverses mostly rolling, arid, treeless terrain 1800-2100 m in

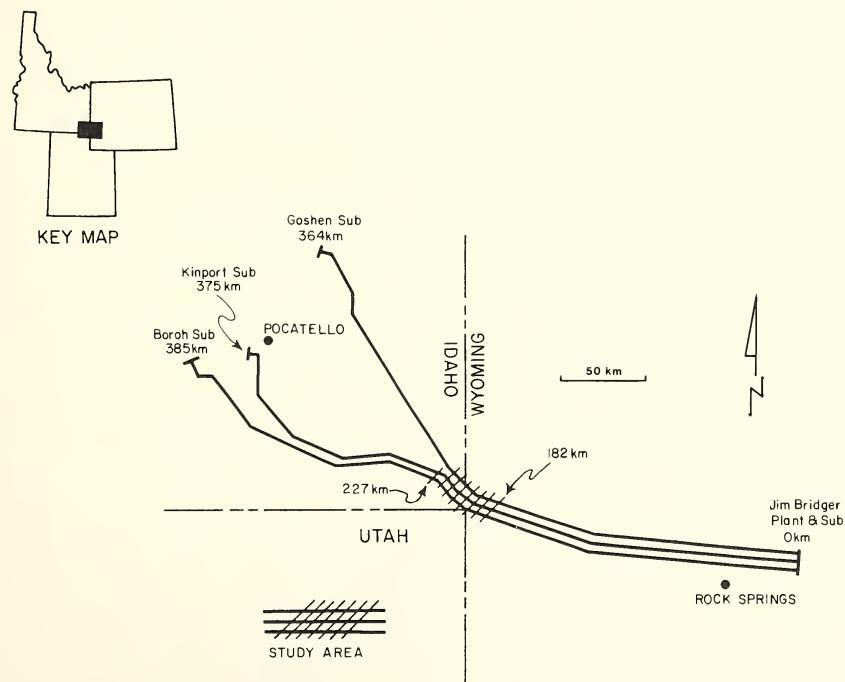


Figure 1. Transmission line route and study area.

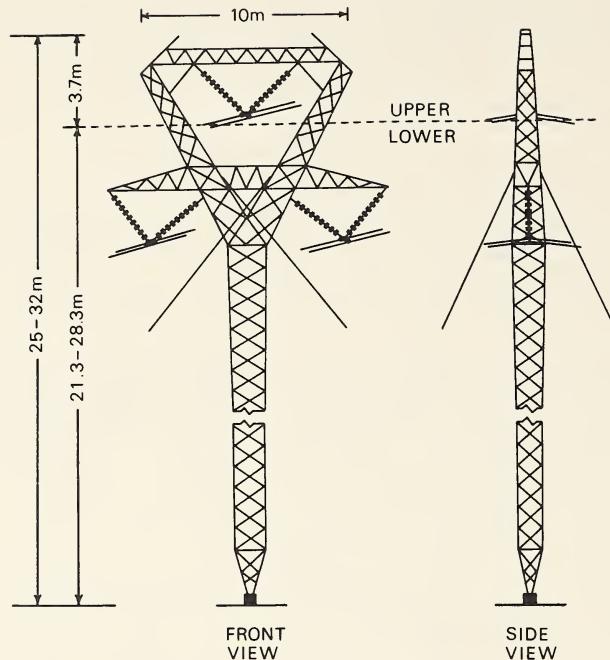


Figure 2. Configuration of 345kv transmission tower.

elevation. Three lines in the study area contain a total of 348 guyed aluminum towers, 25-32 m in height (Fig. 2). Dominant plant species for most of the area is big sagebrush (*Artemesia tridentata*).

Raptors most commonly sighted on towers were the Red-tailed Hawk (*Buteo jamaicensis*) and Golden Eagle (*Aquila chrysaetos*). During the post-fledging period (10 July to 31 September), an observed maximum of 28 fledgling and adult Red-tailed Hawks and 8 fledgling and adult Golden Eagles used the towers in this area for roost and/or perch sites. Seven Red-tailed Hawk nests and 2 Golden Eagle nests were the only occupied raptor nests present on transmission towers within the study area in 1983.

The study area was surveyed from a vehicle on 45 nights between 5 June and 31 September 1983. Surveys began at dusk and usually terminated 1-2 h before dawn. Each tower was examined using a hand-held spotlight and binoculars. The reflective property of the raptors' retinae aided in locating birds at night. A light amplification device, or nightscope, was found to be unsuitable for this task due to inadequate magnification when used alone and poor resolution when used in conjunction with binoculars or spotting scope. Observations of birds at specific roost sites were made on 24 nights between 24 June and 9 September, to determine if movement to and from roost sites took place during the night. In all cases, Golden Eagles ($n = 19$ nights at 14 locations) and Red-tailed Hawks ($N=5$ nights at 5 locations) did not move from their roost towers at any time during the night.

Lines were also surveyed from the ground on 15 d between 21 July and 31 September. Day surveys began at 0700 H and were completed by 1400 H.

Perching/roosting observations were classified according to time of day, species, and position on tower. "Inside" refers to any position on the tower that is surrounded on at least 4 sides by tower members (referring to the 6 sides of a cube). Upper/lower position

designation used in data analysis (Fig. 2) was chosen because very little perching/roosting occurred in the slanted portions of the towers (Red-tailed Hawks — less than 10% of all observations, Golden Eagles — zero observations). Birds were observed perched mainly in 2 regions of the transmission towers, the uppermost horizontal crossbridge area and the lower horizontal crossarm area (Fig. 2).

RESULTS AND DISCUSSION

Most significant observed differences between diurnal and nocturnal use patterns were as follows:

1. Eagles and hawks showed a significant shift from using *outer* tower sections during the day to using *inner* tower sections at night.
2. Both species exhibited a shift from using *upper* sections of the towers during the day to using *lower* sections at night.

Data for Red-tailed Hawks consisted of 99 perch and 236 roost observations. Data for Golden Eagles consisted of 46 perch and 124 roost observations. Frequencies of observations in each category were used to generate 2x2 chi-square contingency tables to test the null hypothesis that time of day was independent of observed perch/roost location on the towers. Chi-square values (Fig. 3) indicate that

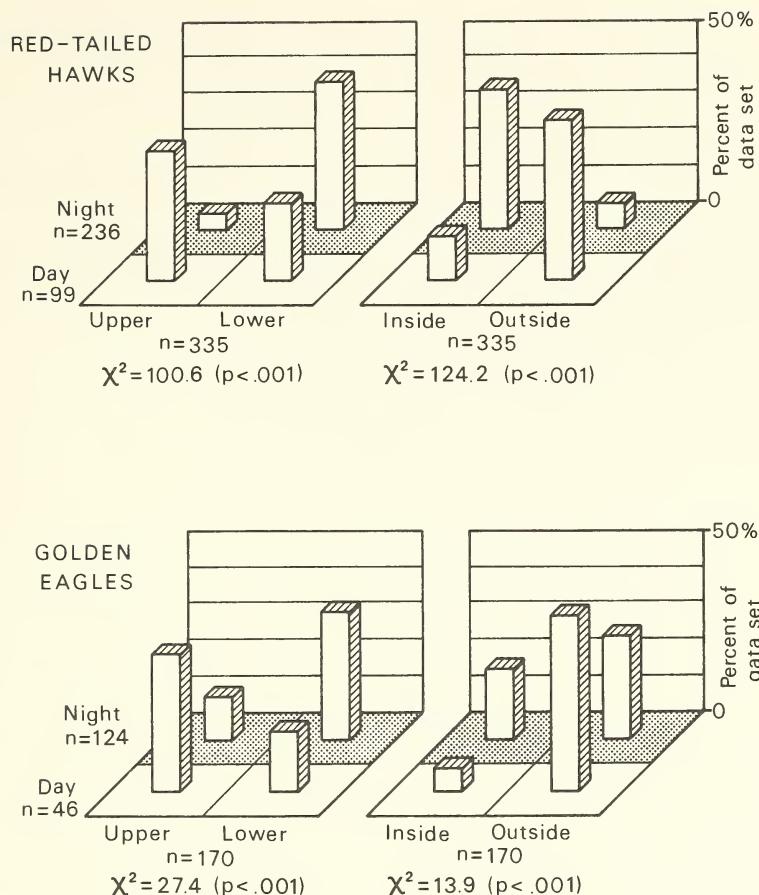


Figure 3. Relative frequencies of perch and roost observations on transmission towers in southeast Idaho and southwest Wyoming for the period 5 June to 31 September 1983. Chi-square (χ^2) values were generated from observed frequencies in each category. Day = 0700-1959 H. Night = 2000-0659 H.

diurnal use patterns differed significantly from nocturnal use patterns for both species. Results indicate that daytime surveys alone may not accurately represent overall use of towers as perch/roost structures, and should be supplemented by nocturnal observations.

Red-tailed Hawks exhibited larger day-outside/night-inside differences than did Golden Eagles ($\chi^2 = 78.8$, $P < 0.001$), possibly due to differences in body size and mobility. The hawks could land and take off directly from inner tower members, whereas eagles were required by girder spacing to walk and hop into and out of some inner locations.

Both Red-tailed Hawks and Golden Eagles ap-

peared to react behaviorally to transmission towers much as they do to natural substrates such as trees or cliffs. Upper, outer portions of the towers, used for diurnal hunting and resting perches, provided the advantages of an elevated viewpoint and unobstructed takeoff and landing flight paths. Lower, inner portions of the towers afforded what little cover there was in the area and were used for roost sites.

ACKNOWLEDGMENTS

Special thanks go to Kelly Fulcher for assistance in data collection, Leon Powers and Morlan Nelson for discussions on raptor behavior, and Allan Ansell for initiating and supporting the study, which was funded by Idaho Power Company, Boise, Idaho.

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Received 20 November 1984; Accepted 20 April 1985

Relationship Between Prairie Falcon Nesting Phenology,
Latitude and Elevation

RICHARD N. WILLIAMS

The relationship between timing of reproduction, latitude and elevation is a well known biological phenomenon: birds in northern areas breed later than birds in southern ones (Alee et al. 1949; Johnston 1954; Morton 1978). The Peregrine Falcon (*Falco peregrinus tunidius*) showed delayed nesting in North America with increasing latitude (White 1964). The Prairie Falcon (*Falco mexicanus*) in New Mexico (Platt 1974) and Oregon (Denton 1975) showed delayed nesting with increasing elevation. However, the cumulative effect of latitude and elevation on reproductive phenology has not been examined

for any of the large falcons. It would be of general interest to know to what extent the variation in timing of reproductive phenology can be influenced by latitude and elevation. Additionally, an analysis of this phenomenon may elucidate general trends and/or physical limitations that determine the breeding range of large falcons.

The Praire Falcon presents an ideal study case for an examination of this phenomenon. It breeds over a wide range of latitudes, from 25.5° N (Lanning and Lawson 1977) to 54° N (Fyfe pers. comm.), and elevations, from near sea level (D. Boyce pers. comm.) to 3688 m (Marti

Table 1. Mean values for latitude and clutch completion date, sample size, and source study for 20 local populations of the Prairie Falcon.

°N LATITUDE	CLUTCH COMPLETION	BREEDING PAIRS	SOURCE
25.5	23 March	5	Lanning and Lawson 1977
32	10 March	1	Mader pers. comm.
32.5	29 March	1	Porter pers. comm.
34.2	9	1	Porter pers. comm.
35	26 March	24	Boyce pers. comm.
37	14 April	15	Platt 1974
40	13 April	10	Porter and White 1973
40.5	25 April	36	Enderson 1964
40.5	17 April	17	Olendorff 1973
41	17 April	9	Craig pers. comm.
41	3 May	23	Williams 1980
42.5	13 April	68	Ogden and Hornocker 1977
43	12 April	5	Johnstone 1980
44.5	16 April	49	Denton 1975
45.5	27 April	66	Becker and Ball 1981
47	6 April	6	Monk 1981
48	28 April	38	Leedy 1972
51	3 May	7	Edwards 1968
52.5	26 April	17	Fyfe pers. comm.
54	10 May	1	Fyfe pers. comm.
GROUP (X ± S.D.)			
43.1° ± 4.5°	18 April ± 10d	n = 401	

Table 2. Mean values for elevation and clutch completion date, sample size, and source study for 20 local populations of the Prairie Falcon.

ELEVATION (m)	CLUTCH COMPLETION	BREEDING PAIRS	SOURCE
700	6 April	8	Monk 1981
700	13 April	68	Ogden and Hornocker 1977
700	26 April	17	Fyfe pers. comm.
700	10 May	1	Fyfe pers. comm.
1030	26 March	24	Boyce pers. comm.
1100	27 April	66	Becker 1981
1180	29 March	1	Porter pers. comm.
1200	10 March	1	Mader pers. comm.
1200	¹⁶ April	49	Denton 1975
1200	3 May	7	Edwards 1968
1500	12 April	5	Johnstone 1980
1500	13 April	10	Porter and White 1973
1500	28 April	38	Leedy 1972
1700	17 April	17	Olendorff 1973
1700	14 April	15	Platt 1974
1800	25 April	36	Enderson 1964
2000	17 April	9	Craig pers. comm.
2510	9 April	1	Porter pers. comm.
2720	3 May	23	Williams 1980
2800	23 March	5	Lanning and Lawson 1977
GROUP (X ± S.D.)			
1320 ± 540 m	18 April ± 10 d	N = 401	

and Braun 1977). However, observations of Prairie Falcons nesting at elevations greater than 3000 m are few and do not permit analysis of the effects of high elevation on nesting phenology. Nevertheless, the Prairie Falcon has been well-studied and data are available from local nesting populations for latitudes 25.5° - 54° N (Table 1) and elevations 700 - 2800 m (Table 2). Data from the source studies (Tables 1 and 2) were reported in highly varied forms, therefore it was not possible to calculate standard deviations or standard errors for many of the mean values listed. The sequential events in the reproductive phenology of large falcons (e.g., territory establishment, copulation, hatching and fledging) are difficult for the researcher to observe and to record accurately with regards to time. It is relatively easy, however, to age young nestlings in the eyrie (see Fowler 1931; Moritsch 1983) and establish hatch dates. Traditionally, clutch completion dates have been calculated by backdating 30 days from hatching dates (Olendorff 1973). I employed this method for studies listed in Tables 1 and 2, unless specific data or different methods were provided by individual authors. In this study, therefore, mean clutch completion dates

(Tables 1 and 2) were used as the data base for statistical analysis and were assumed to be representative of the timing of the Prairie Falcon's reproductive phenology in each locality reported.

On this basis, I tested the prediction that Prairie Falcons nest at higher elevations in southern latitudes and at lower elevations in northern latitudes by dividing the reported breeding range (25.5° - 54° N latitude, Table 1) into quartiles. Weighted mean elevations for the quartiles were compared using ANOVA (SAS 1982) with the southernmost quartile ($\bar{x} \pm s.d. = 2340 \pm 786$ m) differing significantly ($F = 10.5$, $P < 0.0001$) from the 3 more northern quartiles. Although the mean elevation of the northernmost quartile ($\bar{x} \pm s.d. = 1177 \pm 376$ m) was the lowest of the means, it did not differ significantly (Duncan's Multiple Range, $P < 0.05$) from the central 2 quartiles (south-central $\bar{x} \pm s.d. = 1344 \pm 567$ m).

Multiple regression techniques (SAS 1982) for linear and non-linear models were applied to the combined data from Tables 1 and 2. A linear model (clutch completion = $5.361 + 2.036$ latitude + 0.012 elevation) provided the best fit ($R = 0.85$, $P < 0.001$) with latitude accounting for

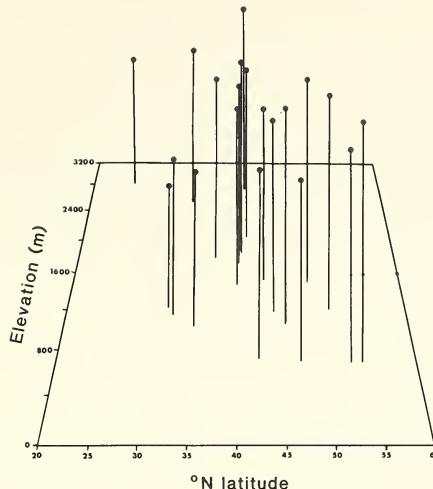


Figure 1. Clutch completion dates by latitude and elevation for 20 breeding populations of the Prairie Falcon. Clutch completion dates (range 10 March - 10 May) are depicted by circles atop vertical lines where height of line increases with increasing date. See Tables 1 and 2 for date.

64% of the variation in clutch completion dates and elevation an additional 21%. A general trend is observable in Figure 1 in which the mean elevation of nesting Prairie Falcon populations decrease with increasing latitude. The strong relationship of clutch completion date with latitude is easily seen in Table 1. Two studies (Lanning and Lawson 1977; Williams 1980) that do not appear to conform to the relationship had mean elevations greater than 2700 m (Table 2), which may have delayed clutch completion date.

The relationship of clutch completion date with elevation is not as apparent (Table 2). It is interesting to note that the 2 populations nesting north of 52° N latitude (Fyfe pers. comm.) (Table 1) both nested at 700 m (Table 2), the lowest nesting elevations considered in this study. Conversely, the southernmost population (25.5°N latitude (Table 1)) nested at 2800 m, the highest elevation considered in this study. It seems, therefore, that these patterns may represent the extremes of the Prairie Falcon's breeding range and nesting phenologies, with birds in the south using the cool mountain tops in Mexico (Lanning and Lawson 1977) and Canadian prairie birds utilizing escarpments along low-lying prairie river systems (Fyfe pers. comm.). In both situations, specific nesting localities may provide a climate more equitable for breeding Prairie Falcons than the prevailing climate at that latitude. Falcons in northern regions may be utilizing behavioral and ecological adaptations to augment their nesting attempts, such as choosing south and/or east facing eyries (see Williams 1984) rather than being restricted to nesting on low-elevation escarpments along river systems. Such diversity in nesting phenology could provide a means of range expansion or a means of utilizing a variety of habitats to accomplish reproduction.

ACKNOWLEDGMENTS

I am grateful to Clayton M. White for his guidance and assistance in this study. I would like to thank J.R. Parrish and Joseph E. Scheiring for their insightful reviews of the manuscript. Partial funding was provided by the Department of Zoology, College of Biological Sciences and the Associated Students of Brigham Young University and the Frank M. Chapman Fund. The Colorado Division of Wildlife provided historical data, lodging and financial assistance through Federal Aid in Wildlife Restoration Project W-124-R.

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Received 15 October 1984; Accepted 15 February 1985

Recapture of a Non-breeding Boreal Owl Two Years Later

THOMAS W. CARPENTER

On 22 April 1984, while mist-netting owls at Whitefish Point, Chippewa County, Michigan, I recaptured a Boreal Owl (*Aegolius funereus*) that was banded at this location by Warren A. Lamb on 3 May 1982. There are no known summer or breeding records for this species in Michigan, though fair numbers are captured at Whitefish Point during most springs (Payne 1983). Thus, this bird was apparently moving north during both years it was captured following a southward movement during the preceding fall or winter.

Periodic southward movements of the Boreal Owl have received previous attention (Anweiler 1960; Bent 1961; Mysterud 1970; Catling 1972; Evans and Rosenfield 1977). However, to my knowledge this is the first time a Boreal Owl has been recaptured in North America in a subsequent year following a southward movement. Recapture in a subsequent year of owls banded during migration is not a common occurrence as shown by the low recapture rate of the highly migratory Northern Saw-whet Owl, *Aegolius acadicus* (Woodford 1959).

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Received 20 March 1985; Accepted 20 April 1985.

Fall Raptor Concentration on Henrys Lake Flats

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In the early 1970's we became aware of raptor concentrations of primarily *Buteo* spp. on Henrys Lake Flats in late summer and early fall. A concentration of large numbers of raptors on a high mountain meadow intrigued us, and from 1974 to 1983 we conducted annual roadside surveys to monitor raptor abundance and gain insight into why they were concentrating in this area.

Henrys Lake Flats is located between 1,950 and 2,000 m in

elevation in Fremont County in the northeast corner of Idaho. The flats extend from 1 to 8 km from Henrys Lake and are characterized by large, wet meadows and gently rolling plain dominated by big sagebrush (*Artemesia tridentata*). Most of this land is moderately grazed by cattle with at least a short grass/herb cover over practically all the land during the period of our surveys. The flats are surrounded by coniferous stands of primarily lodgepole

Table 1. Total raptor sightings on a 32 km automobile transect around Henrys Lake, Idaho, for the period 1974-1983. All transects conducted between 28 August and 4 September of each year.

SPECIES	YEAR										
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	MEAN
Red-tailed Hawk (<i>Buteo jamaicensis</i>)	12	10	6	14	28	32	114	135	136	39	52.6
Ferruginous Hawk (<i>Buteo regalis</i>)	46	28	16	7	16	48	67	21	34	31	31.4
Swainson's Hawk (<i>Buteo swainsoni</i>)	11	12	3	3	4	15	34	17	19	14	13.2
Unidentified Buteo		2				3		4	1	9	1.9
Sub-total	69	52	25	24	48	98	215	177	190	93	99.1
Northern Harrier (<i>Circus cyaneus</i>)	11	11	5	9	3	2	6	2	4	5	5.8
Sharp-shinned Hawk (<i>Accipiter striatus</i>)	2	2	5	2	2		1			1	1.5
Cooper's Hawk (<i>Accipiter cooperii</i>)				2			1		1		0.4
Goshawk (<i>Accipiter gentilis</i>)			2			2					0.4
Osprey (<i>Pandion haliaetus</i>)		5	2	2	2					8 1	1.2
Bald Eagle (<i>Haliaeetus leucocephalus</i>)				1	1	3	2	1	2	2	1.2
Golden Eagle (<i>Aquila chrysaetos</i>)		1	2		1		1		1		0.6
American Kestrel (<i>Falco sparverius</i>)	33	12	8	9	5	9	5	4		9	9.4
Prairie Falcon (<i>Falco mexicanus</i>)	2		2			3	4	3		1	1.5
Total	119	83	49	51	62	115	235	187	198	112	121.1

pine (*Pinus contorta*) extending down from surrounding mountains.

We drove a 32 km automobile transect route around Henrys Lake once annually in the last few days of August or first week of September. Heading north, the route started in Section 24, Range (R) 43 East (E), Township (T) 14 North (N) on a secondary road which parallels U.S. Highway 20/191. We detoured approx. 1.5 km onto the road to Henrys Lake State Park, where we parked and walked about 100 m north to a bluff and surveyed the surrounding area with a 30 X spotting scope. We returned to U.S. Highway 20/191 and continued north until turning west on U.S. Highway 287. We traveled on U.S. Highway 287 until turning south on a gravel road in Section 32, R 42 E, T 13 N, where we continued around the lake and reunited with U.S. Highway 20/191. The route traveled was mainly through open meadow or sage plain with the exception of the last few km before rejoining U.S. Highway 20/191. Using USGS quadrat maps, we estimated surveying about 68 km² of open country.

Surveys were conducted on calm, clear mornings and were generally completed before 1030 H. At least 2 competent observers conducted each survey. The transect route was traveled at speeds < 35 kph, and frequent stops were made at good vantage points or when raptors were sighted. Traffic was minimal on the route, except sometimes U.S. Highway 20/191 had moderate traffic.

An average of 121.1 raptors/yr were sighted for the 10-yr period (Table 1), of which 99.1 (83%) were buteos, resulting in 4 raptors sighted/km traveled. Sightings in 1974-75 were near the 10-yr average, but sightings in 1976-77 were low. Buteos were particularly low in 1976-77. A severe drought in 1976-77 resulted in a reduction in raptor productivity in the Birds of Prey Natural Area, near Boise, Idaho (Snake River Birds of Prey Environmental Statement, 1980, B.L.M., Boise, pp. 2-11), which corresponds with an ebb in our observations. Perhaps the build-up in subsequent years is a reflection of raptor recovery from the 1976-77 drought.

The Red-tailed Hawk (*Buteo jamaicensis*) was the most common raptor sighted, averaging 53 birds/survey (Table 1) with a range of 6 - 136 birds. Such a large range for sightings could reflect annual productivity in the region, since > 90% of red-tail sightings were of birds in immature plumage. Adult red-tail sightings were confined to small meadows and clear-cuts surrounding the main flats. Adults may have limited themselves to peripheral areas to avoid harassment from immatures who often congregated around kills. Once we observed up to 11 immature red-tails fighting over a single prey.

The Ferruginous Hawk (*Buteo regalis*) was the next most frequently sighted raptor, averaging 31.4 birds/survey (Table 1) with a range of 7 - 67. Most Ferruginous Hawks sighted were also in immature plumage. Except for 2 birds perched on the edge of a clear-cut in 1983, all Ferruginous Hawks were sighted on the main flats. The observation bluff was a particularly good concentration spot, with less vegetation, allowing excellent views from ground level.

Ferruginous Hawks have been known to move to Henrys Lake Flats from the Raft River Valley along the Utah-Idaho border, about 250 km to the southeast (Thurow et al. 1980. Raptor Ecology of Raft River Valley, Idaho, E.G. and G., Inc., Idaho Falls, Idaho, and pers. obs.). In late summer food availability becomes limited in Raft River Valley since Black-tailed Jackrabbits (*Lepus californicus*) become less diurnal to avoid heat (Thurow et al. 1980). The Ferruginous Hawks apparently respond by drifting on pre-

vailing wind currents, which move primarily towards the Henrys Lake area.

The Swainson's Hawk (*Buteo swainsoni*) sightings averaged 13.2 birds/survey for the 10-yr period (Table 1) with a peak of 34 in 1980. Unidentified buteos and 9 other diurnal raptors sighted accounted for an average of 23.9 more sightings/survey.

The heavy concentration of raptors at Henrys Lake Flats is probably due to the abundance of Richardson's Ground Squirrels (*Spermophilus richardsoni*). Ground squirrels at lower elevations are known to estivate in late summer and fall, when hot, dry weather eliminates or drastically reduces succulent vegetation (Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, California). The high elevation of Henrys Lake Flats keeps vegetation green, and the ground squirrels are active and available as prey. There may be a general tendency for raptors to move up-slope as ground squirrels estivate and rabbits become more nocturnal. We have observed similar concentrations of buteos in early fall from 2,000 to 3,000 m elevation on Steens Mountain in southeast Oregon, where Belding's Ground Squirrels (*Spermophilus beldingi*) were still active. In addition to an abundant food supply, the Henrys Lake area lies just west of the Continental Divide and may act as a corridor for migrating birds in general (Larrison, E. 1981. Birds of the Pacific Northwest: Washington, Oregon, Idaho and British Columbia. University Press of Idaho, Moscow).

Our automobile surveys indicate that high mountain meadows are important late summer concentration areas for buteos, especially those in immature plumage. The Henrys Lake Flats and other high meadows of the intermountain west have become increasingly popular recreation areas. Recreation and other forms of land use may affect high meadow ground squirrel populations, which in turn may affect raptor concentrations in those areas.

ACKNOWLEDGMENTS

M. DeLate, T. Reynolds, M. Reynolds, S. Trost and C. Webb helped to conduct surveys. Earlier drafts of this paper were improved by comments from M. Collopy and J. Gessaman.

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Received 6 March 1984; Accepted 22 April 1985

Bald Eagle (*Haliaeetus leucocephalus*) Consumption of Harbor Seal (*Phoca vitulina*) Placenta in Glacier Bay, Alaska

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This note reports on the frequent consumption of Harbor Seal (*Phoca vitulina*) placenta by the Bald Eagle (*Haliaeetus leucocephalus*) and a fluctuation in numbers of Bald Eagles in Muir Inlet, Alaska, in relation to the availability of this food source.

From 30 May to 23 August 1982 and 8 to 13 June 1984, we spent 41 d in our study area in the northern portion of Muir Inlet, located in the northeast corner of Glacier Bay in southeast Alaska. This recently (within the last 20 yr) deglaciated area is about 20 km long and an average of 2 km wide. The shoreline rises steeply on both sides of the inlet and consists of loose rock and glacial debris. There are no trees and vegetation is extremely sparse. Up to 1,000 Harbor Seals rest and give birth to young on small icebergs formed by an active tidewater glacier at the head of Muir Inlet. Our research was focused on the biology and behavior of Harbor Seals in this area. Our regular censuses and observations of seals required us to scan the entire inlet with binoculars and spotting scopes and consequently observe eagles and their interactions with seals.

On 9 occasions in early June, we observed Bald Eagles feeding on Harbor Seal placenta; these were the only times we saw eagles feeding in our study area. In one instance we saw 6 eagles either feeding on the placenta, chasing after an eagle with placenta, or perching near a feeding eagle. At each of 3 Bald Eagle perches visited in early June 1982, we found from 2 to 15 clumps of lanugo hair (the fetal coat of Harbor Seal pups that is shed before birth and is expelled with the placenta).

Bald Eagle numbers in our study area changed through the season and corresponded to the time of Harbor Seal pupping. We saw a minimum of 4-7 eagles on 5 d between 31 May to 17 June 1982 and a minimum of 5 on 2 d between 8 and 13 June 1984. We saw fewer eagles during visits later in the season. During the latter part of June we saw up to 2 eagles. In 16 d of observation in July and August 1982, we had only one eagle sighting. Bald Eagles in Muir Inlet consisted about equally of mature and immature birds, 4 of the 7 seen at one time in June 1982 and 3 of the 5 seen at one time in June 1984 were mature. The majority of Harbor Seal pups in Muir Inlet are born in late May and early June, the same period we saw the largest numbers of Bald Eagles. In both 1982 and 1984, over 300 Harbor Seal pups were born in this portion of Muir Inlet. Given a minimum weight of 1 kg for a Harbor Seal placenta, this would mean an excess of 300 kg of food available to eagles.

We concluded that Bald Eagles in this area during late May and early June subsist largely or entirely on placenta of Harbor Seals because: 1) our frequent observations of eagles feeding on placenta and not on other food, 2) the abundance of this food source and the scarcity of other food sources in this deglaciated area, 3) the presence of seal lanugo hair found at eagle perches, and 4) the close parallel between the number of eagles in our study area and the Harbor Seal pupping season. Eagles appear to use this area for only a short period; we found no evidence of eagle nesting.

Sherrod et al. (Living Bird 15:143-182, 1976) reported that Bald Eagles on Amchitka Island, Alaska consume northern Sea Lion (*Emetopias jubatus*) afterbirth. It is the only other report we know that mentions Bald Eagles feeding on placenta of pinnipeds. We have observed Bald Eagles feeding on seal placenta and

scavenging on dead seal pups in other parts of Glacier Bay and Puget Sound, Washington.

ACKNOWLEDGMENTS

Funding was by the School for Field Studies, Cambridge, MA. The National Park Service provided permits and Gary VeQuist was instrumental in this regard. Staff and students with the School for Field Studies aided in data collection. Sue Carter and Robin Butler made additional contributions. Al Harmata and Jon Gerrard critically reviewed the manuscript.

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Received 22 January 1985; Accepted 1 May 1985

Barred Owl Hunting Insects

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Although the Barred Owl (*Strix varia*) is partially insectivorous (Bent, U.S. Natl. Mus. Bull. 170, 1938) its methods of hunting and capturing insects have not been described. From 1924-2000 H we observed a Barred Owl hunting insects on 4 April 1984 at Blue Springs Stake Park, Orange City, Florida. The Barred Owl was apparently hunting noctuid moths (Lepidoptera) and large vein-winged insects on the lawn of an historic house in the park. The owl hunted these insects from a small stump or on a sandy stretch of lawn beneath a lighted area. In hunting, the owl sat motionless except for slight head movements to watch the insects. Captures were attempted only after the insects landed. Capture attempts were a combination of 3 movements: 1) a bound initiated from a partially forward leaning position, 2) a single wing flap and 3) a short glide. Attempts covered 1-2 m distances and the owl was twice observed to follow missed attempts with 2 or 3 immediate additional pounces. Insects were captured with the talons and consumed by bringing the head down to pick the insect from the talons. One insect not immediately consumed was transferred to the beak before the owl flew to a nearby tree. At 1949 H the Barred Owl returned to its hunting perch on the lawn where it unsuccessfully attempted two more captures before leaving the area at 2000 H. During the time observed, the Barred Owl was successful in 2 of 18 capture attempts.

Forsman et al. (Wildl. Mongr 87, 1984) reported that the Spotted Owl (*Strix occidentalis*) diet also includes insects and that these owls used pounces to capture insects on the ground or on tree limbs. Also, mid-air captures of flying insects were not observed.

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Received 22 March, 1985; Accepted 20 May 1985

Northern Harrier Predation on Greater Prairie Chickens in Southwest Missouri

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Although habitat preferences of the Northern Harrier (*Circus cyaneus*) and the Greater Prairie Chicken (*Tympanuchus cupido*) are quite similar (Berger et al. 1963), harriers are rarely reported to prey upon these galliformes (Yeatter 1943; Schwartz 1945; Grange 1948; Weller et al. 1955; Ammann 1957; Berger et al. 1963). Other similar-sized avian prey such as Ring-necked Pheasant (*Phasianus colchicus*), Sharp-tailed Grouse (*T. phasianellus*), American Bittern (*Botaurus lentiginosus*), ducks and the Domestic Chicken (*Gallus* spp.) are, however, not infrequently taken (Fisher 1893; Peabody 1900; Errington and Breckenridge 1936; Bent 1937; Brown and Amadon 1968) although usually as juveniles (Peabody *op. cit.*; Saunders 1913; Randall 1940; Hecht 1951).

This note reports harrier predation on adult and young Greater Prairie Chickens in the tall-grass prairie region of southwest Missouri during spring and summer 1984. The study area of 850 ha consisted of Prairie State Park and surrounding private lands. Prairie State Park is 1 mi southwest of Liberal, Missouri, in Barton County. Vegetation consists of bluestem grasses (*Andropogon* spp.), Indian grass (*Sorghastrum nutans*) and other native grasses and

forbs, as well as invading cool season grasses such as fescue (*Festuca* sp.). Old and reclaimed strip mines and deciduous woody growth are scattered throughout the area. Neighboring lands are mostly crops and fescue (Larson 1982).

A total of 325 h were spent observing harriers and prairie chickens from 7 April - 7 August 1984. Using techniques described by Hamerstrom (1969), I found 7 harrier nests (density of 1 pair/121 ha) clumped in 3 loose aggregations in undisturbed grasslands.

Approximately 150 prairie chickens were concentrated around 4 booming grounds on the study area during early spring (April-May) and later scattered throughout the area during nesting (May-July). At least 2 prairie chicken nests were located within 200 m of 2 harrier nests.

Visits to Northern Harrier nests during the nestling stage were made to collect prey remains and/or pellets. I calculated frequency of occurrence of prey types from fresh pellets and identified prey remains. Percent composition of each prey species was calculated from the number of each type divided by the total. Percent biomass was estimated by weights given in Schwartz and Schwartz (1959), Terres (1980) and Steenhof (1983).

Analysis of food items revealed a catholic diet (Table 1). The diet of nesting Northern Harriers in other regions has been of a similar euryphagus composition (Randal *op. cit.*; Hecht *op. cit.*; Craighead and Craighead 1956; Brown and Amadon 1968; Smith

Table 1. Prey of nesting Northern Harriers at Prairie State Park in southwest Missouri, 1984.

PREY	FREQUENCY OF OCCURRENCE	% COMPOSITION	AVERAGE WEIGHT (G)	ESTIMATED % BIOMASS
BIRDS				
Greater Prairie Chicken (<i>Tympanuchus cupido</i>)	8	6.6	624	22.6
Adults	3		908	12.3
Juveniles	5		454	10.3
Mourning Dove (<i>Zenaida macroura</i>)	3	2.5	134	1.8
Eastern Meadowlark (<i>Sturnella magna</i>)	6	4.9	95	2.6
Common Grackle (<i>Quiscalus quiscale</i>)	2	1.6	112	1.0
Red-winged Blackbird (<i>Agelaius phoeniceus</i>)	6	4.9	50	1.4
Brown-headed Cowbird (<i>Molothrus ater</i>)	3	2.5	41	0.5
Unidentified passerines	11	9.0	75	3.7
Total birds (Table 1 continued)	39	32.0		33.6

(Continuation of Table 1)

MAMMALS

Prairie vole (<i>Microtus ochrogaster</i>)	24	20.0	8	4.1
Fulvous harvest mouse (<i>Reithrodontomys fulvescens</i>)	6	4.9	21	0.5
Deer Mouse (<i>Peromyscus maniculatus</i>)	2	1.6	20	0.2
Cotton rat (<i>Sigmodon hispidus</i>)	1	0.8	120	0.5
Eastern wood rat (<i>Neotoma floridana</i>)	1	0.8	255	1.2
Unidentified rodents	7	5.8	30	0.9
Eastern cottontail (<i>Sylvilagus floridanus</i>)	9	7.4	1200	49.0
Total mammals	50	41.3		56.4

REPTILES

Plains garter snake (<i>Thamnophis radix</i>)	1	0.8	109	0.5
Unidentified snakes	11	9.1	190	9.5
Total reptiles	12	9.9		10.0

INSECTS

Coleopterans	12	9.9	0.5	tr ¹
Orthopterans	8	6.6	1	tr
Total insects	20	16.5		tr

TOTAL PREY ITEMS	121	100.0		100.0
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¹tr = trace.

and Murphy 1973; Snyder and Wiley 1976). A total of 7 prairie chicken remains were collected from the 2 harrier nests closest to prairie chicken nests. Of these 7 remains, 5 represented half-grown juveniles and 2 represented adults.

An eighth prairie chicken was captured by an adult female harrier on 25 July at 0700 H. The hawk hovered briefly 4 m above a dense stand of bluestem grasses and fescue, before diving into the vegetation. After waiting about 10 min, I approached the site and the hawk flushed when I was about 20 m away. I discovered a dead adult female prairie chicken that was partly deplumed and still warm. I was unable to find a prairie chicken nest in the immediate vicinity, but numerous droppings and matted vegetation (form) indicated that the prairie chicken had been on its roost. I left the site and watched from a distance of ca 300 m until the

harrier returned to her kill after nearly 20 min. Berger et al. (1963) observed prairie chickens being captured by raptors (including 1 female Northern Harrier) early in the morning. Campbell (1950) reported an unsuccessful capture attempt of a Lesser Prairie Chicken (*T. pallidicinctus*) during evening hours. Poor light during early morning and late evening hours may make approaching raptors more difficult for prairie chickens (or other quarry) to spot (Berger et al. 1963).

All prairie chicken prey was brought to harrier nests during the last half of the nestling stage. During this time female harriers spent as much time hunting for their young as did males. It is probable that the larger females (50% heavier than adult males) caught the adult prairie chickens (Berger et al. 1963). I observed several adult male harriers feeding on mammalian prey among

displaying prairie chickens at booming grounds just prior to the nesting season. The prairie chickens seemed oblivious of these male harriers. Female harriers, however, usually evoked a response from prairie chickens, ranging from a brief squat to an all out flush. Berger et al. (1963) reported that over a 4-year sample of harrier-prairie chicken reactions, prairie chickens flushed nearly 70% of the times female harriers approached, but only 30% of the times males approached. Of the 33 times that prairie chickens completely ignored approaching harriers, 94% were male hawks and 6% were females. Female Hen Harriers (*C. c. cyaneus*) take significantly more Red Grouse (*Lagopus lagopus*) and other gamebirds than do males (Marquiss 1980).

I have found no evidence of Northern Harriers preying on Greater Prairie Chickens during winter or on booming grounds in early spring. However, prairie chickens did comprise a significant proportion of Northern Harrier diets (22.6% biomass; Table 1) during the nesting season when female and juvenile prairie chickens in close proximity to harrier nests may be more vulnerable to raptor predation.

ACKNOWLEDGMENTS

Toney Chiles contributed invaluable field assistance. The Missouri Department of Natural Resources provided funding and technical assistance for this study through a state park research grant. Nancy Thompson-Toland helped with expenses and field work. Keith Bildstein, Clayton White and an anonymous referee made editorial suggestions which improved the manuscript.

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Received 8 April 1985; Accepted 15 July 1985.

The Migration of Birds of Prey in the Northern Red Sea Area: Report of the 1982 Suez Study by David Wimpfheimer, Bertel Bruun, Sherif M. Bahael Din and Michael C. Jennings with contributions by William S. Clark, Carsten Jensen, Donald Parr and Ib Petersen, and forward by Dean Amadon. Arabic summary by Assad Serhal. 80 pp., 6 Tables, 24 Figures, 2 Appendices, 10 plates. Available from the Holy Land Conservation Fund, 1825 Eye Street Northwest, Suite 400, Washington, DC 20006. \$20.00 U.S.

Whenever the nation of Egypt is mentioned, thoughts come to mind of the pharaohs, the great pyramids and the sphinx. One also remembers Egypt's biblical and more recent history, both closely tied to the nation of Israel. Thoughts of migrating raptors do not immediately come to mind. Yet this report has made it apparent that a spring migration of raptors does occur over the lands of Egypt, and undoubtedly has done so since before the great pyramids were built.

The report describes the initial results of the Holy Land Conservation Fund's expedition to Suez, Egypt, in the spring of 1982. As a result of many individual efforts and outstanding support from numerous individuals and agencies, both in the United States and Egypt, the authors have provided students of raptor migration with a data base for reference and future comparison for the Middle East. All of the authors except one have previous experience with Eurasian raptors. Observational data are reported for 124,996 raptors, representing 28 species, sighted during the period 23 February - 16 May 1982. The primary goal of the study was to learn more about the spring migration of raptors at or near Suez, Egypt, and towards that goal the authors have a good start. However, there is some question as to whether the report effectively establishes the Suez area as a concentration point as stated. Certainly there is a substantial spring overfly in the region, but the evidence supports the idea that raptors do not initiate migrations in the immediate vicinity of the city of Suez, and thus do not concentrate themselves in the area.

A species by species account of sightings by time period and a seasonal total is provided for each of the 28 species tallied. Comparisons by species are made with other regions, particularly Eliat, Israel. Six species, *Buteo b. vulpinus*, *Aquila nipalensis*, *A. pomarina*, *Milvus migrans*, *Circaetus gallicus* and *Neophron percnopterus* accounted for 90% of total sightings. Sightings of *B. b. vulpinus* alone accounted for almost 65% of total numbers, but the *vulpinus* tally is biased by the inclusion of all *B. buteo* sightings with the *vulpinus* totals, as pointed out by the authors. Less than 10 individuals were tallied for 12 species. Observational data for 214 non-raptors are provided in Appendix A, which includes 3 new sightings for Egypt. Histograms of related species are provided depicting total numbers versus date. The figures could have been combined in many cases, especially Figures 14 and 15 and Figures 17 and 18. Analysis by 5-day interval would have been most helpful and welcome, but such was provided only for accipiters, which represented 0.2% of total sightings.

At least 2 observers were present on most days, and there was a gap in continuous coverage during early April when no observations were made. In order to compensate for these gaps, the authors extrapolated data for observations both before and after periods of no coverage. On this basis, adjustments were calculated for selected species, including *Aquila* sp., *A. pomarina* and *A. nipalensis*. Adjustments were made with the assumption that the proportions of identified *Aquila* is the same as unidentified, which is confusing. However, these adjustment figures do not appear in final tallies and conclusions. Virtually every individual raptor sighted was identified at least to genus, and no "unidentified" category appears in the final tallies. As one who has observed North American migrations over the years, it is simply not possible to always pinpoint an individual, though worthy a goal such identification may represent.

Intermittent observations made in areas adjacent to Suez were also accomplished. Brief summaries are provided for Hurghada and surrounding area, for northern Sinai between El Arish and Nakhl, for Ismailia north of Suez (all observations accomplished by one or more of the authors), and summaries of previous reports in the literature for the region and for Eliat, Israel. Previous reports and more recent studies indicate the migration at Eliat is substantially greater than reported for Suez and surrounding areas (W.S. Clark, pers. comm.). Also included is a chapter on raptor migration in the Middle East which provides the reader with a nice comparison as well as a substantial reference list.

As the authors point out, their attempts to correlate meteorological factors with their observations needs further study. Purely qualitative evaluations of wind direction, wind strength(?) (only for surface winds), and cloud cover are provided with species tallies. Qualitative assessment carries over into observations, where individuals are grouped under the heading of being either an "active" or "passive" migrant based upon convection current utilization (Table 6) (after studies of raptor migration in Denmark by B. Bruun and O. Schelde, 1957, Efteraarstrækker pa Stigsnaes, S.V. Sjaelland, D.O.F.T. 51:149-167). The usefulness of such categorization seems questionable, since any individual of any species may either actively or passively utilize convection currents at any given time.

Appendix B summarizes human threats to migrating raptors. Although there is little evidence of direct persecution such as shooting (Plate 4 of a "hunter" displaying 2 recently shot Steppe Eagles notwithstanding), potential for harm from chemical dumping and industrial pollution does exist in the Suez area. No mass kills have been reported, but as with most chemical contaminants, raptors that feed, bathe, or drink while enroute through the region probably pick up harmful compounds which would be transported back to breeding territories.

Overall, the report provides valuable data to the ever-growing worldwide raptor migration picture. Sherif Ben el Din's illustrations evidence a keen familiarity with migrant raptors enroute through Suez. A more comprehensive assessment of observations would have been a welcome addition. Nevertheless, an 82-item literature section is provided which helps to substantiate the report as a basis for comparison with future raptor migration studies in the Middle East. — Jimmie R. Parrish.

ERRATUM — Volume 18(4), page 159. Paul Springler should be Paul Springer. The Editorial Staff apologizes to Paul for failing to catch the misspelling before final printing.

ANNOUNCEMENT

LIT — a Literature Retrieval System Using dBASE II — is a literature cataloguing system for use with personal computers. While the LIT System (\$30.00) can be used for literature on any subject, a prepared Keyworded Data Base is available including all publications (783 items) of the Raptor Research Foundation, Inc. (\$20.00 on disk or hard copy). New Data Bases are being prepared for all raptor references in Auk, Condor, Wilson Bulletin, etc. Also available is the LIT Ornithological Keyword List of nearly 900 Keywords (\$15.00 on disk or hard copy for use with other systems).

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Proceedings of the Southeastern United States and Caribbean Osprey Symposium — published by The International Osprey Foundation, Inc., edited by Mark A. Westall. Eleven papers, 132 pages. Copies can be ordered from The International Osprey Foundation, Inc., P.O. Box 250, Sanibel, FL 33957 USA. Price: \$16.00 U.S.

The Southwestern Raptor Management Symposium and Workshop will be held on the University of Arizona Campus, Tucson, 22-25 May, 1986. The Symposium will focus on raptors in the southwestern United States and adjacent Mexico. Sessions will cover raptor biology, management and research techniques, impact mitigation, and population status. There will also be a workshop on research and management priorities. For more information, or if you are interested in presenting a paper, contact Brian A. Millsap, Raptor Information Center, Institute for Wildlife Research, National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036.

Bird Banding by Elliott McClure, The Boxwood Press, Pacific Grove, California. 341 pp., 5½ x 8½, paper: **\$15.00**. — While this is a general book on bird banding there are several sections concerning raptors. McClure spent a large portion of his active professional life in Southeast Asia and much of the material is drawn from his experiences there. There are 13 distinct sections varying from the geological background of migration routes (the example is from Southeast Asia), nets and snares, banding nestlings, to the art of record keeping. There are 35 index entries for birds of prey (11 of those are for owls). Under the section, "The Bird and its Banding Idiosyncrasies," there is a page and a half devoted to owls and 2 pages to falconiforms. Most of the standard trapping methods used on hawks are discussed (many variations of the Bal-chatri). An interesting method of snaring the buzzard (*Butastur*) is discussed at some length. This book has some valuable tips for raptor banders and it is well worth looking at. — C.M. White.

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A more detailed set of instructions for contributors appeared in *Raptor Research*, Vol. 18, No. 1, Spring 1984, and is available from the Editor.

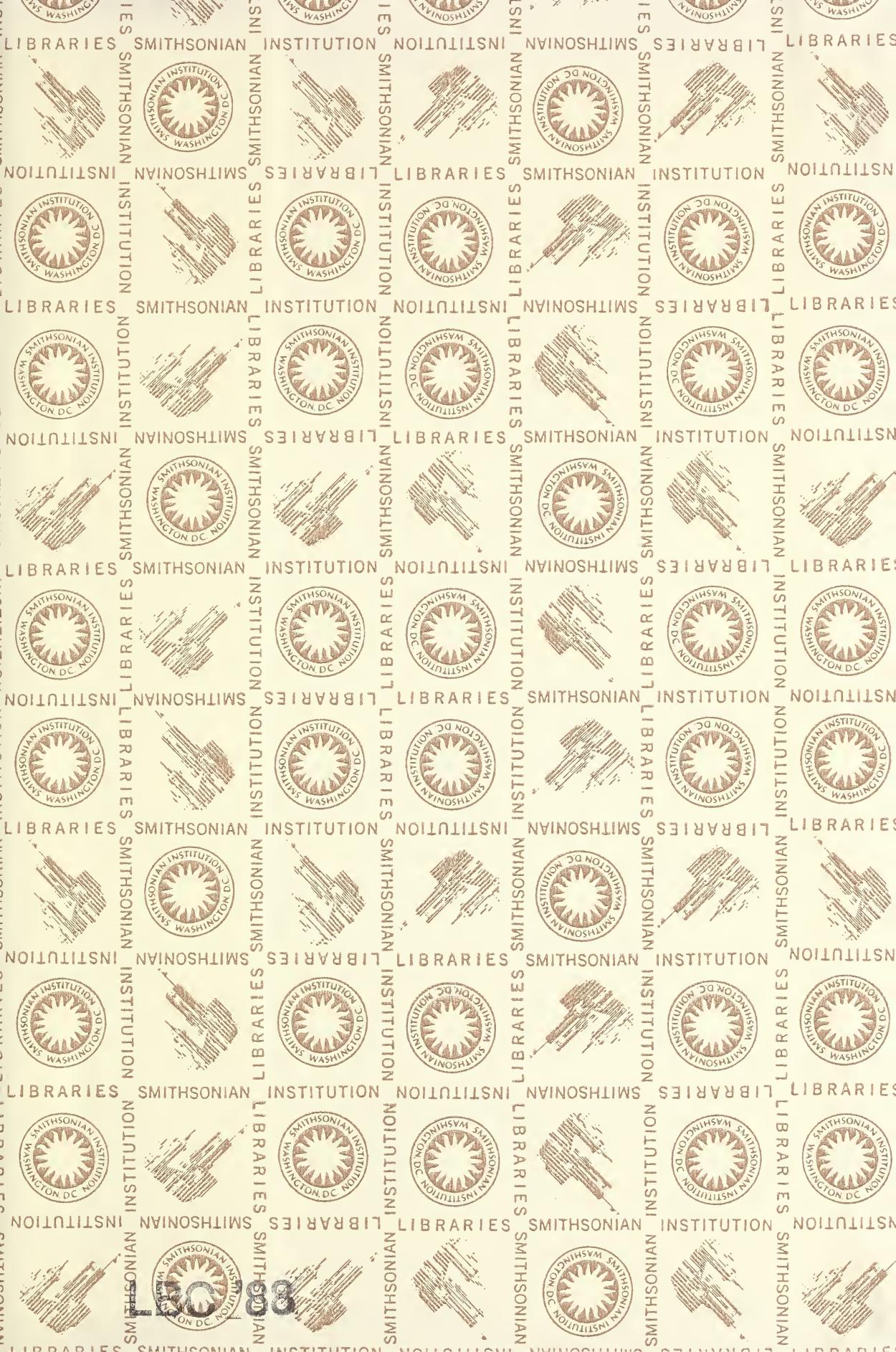
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