

THE  
JOURNAL  
OF  
RAPTOR RESEARCH



VOLUME 21

SUMMER 1987

NUMBER 2

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The *Journal of Raptor Research* (ISSN 0892-1016) is published quarterly for \$15.00 per year by The Raptor Research Foundation, Inc., 12805 St. Croix Trail, Hastings, Minnesota 55033, U.S.A. Application to mail at second class rate is pending at Hastings, Minnesota, and additional mailing office. Printed by Allen Press, Inc., Lawrence, Kansas, U.S.A.

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# THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 21

SUMMER 1987

No. 2

*J. Raptor Res.* 21(2):49-56

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## PROPAGATION OF CAPTIVE EASTERN SCREECH-OWLS

STANLEY N. WIEMEYER

**ABSTRACT.**—A colony of captive Eastern Screech-Owls (*Otus asio*) was established at the Patuxent Wildlife Research Center in 1967. During 1981-86, birds were housed in outdoor cages and fed a commercial bird of prey diet, day-old chicks and laboratory mice. Sex was determined by laparoscopy. In 1984-86 pair assignments were made with assistance of computer generated parentage data in order to reduce the level of inbreeding. Most known causes of adult mortality were related to attacks by cage mates and to trauma. Owl weights increased with age and fluctuated with season; birds were heaviest in the fall and lightest in the summer. In 140 nesting attempts involving first clutches average clutch size was 4.63 eggs, 3.21 eggs hatched/attempt, and 3.03 young fledged/attempt. Seventy percent of eggs hatched. Infertility and embryo death were major causes of egg failure. Ninety-four percent of all nestlings fledged. Most nestling losses occurred due to unknown causes during the first week following hatching. Eighty-four percent of nesting attempts produced at least one young. Few second clutches were laid, and the success of these clutches was generally poor. Most yearling birds did not attempt to breed. Techniques for the care and breeding of this species in captivity have made it suitable as a laboratory animal for use in a variety of studies.

Many species of owls have been bred in captivity (for examples and species listings see Muller 1970; Wayre 1970; Yealland 1970; Harrison 1974; Sayers 1976), including the Common Barn-Owl (*Tyto alba*) which has been bred in large numbers (Mendenhall et al. 1983). The Eastern Screech-Owl (*Otus asio*) was bred in captivity 100 yr ago (Carpenter 1883). A colony of captive Eastern Screech-Owls was established at the Patuxent Wildlife Research Center (PWRC) in 1967. Early work on the colony involved the development of methods for managing and captive breeding followed by use of pairs to determine the effect of DDE on eggshell thickness (McLane and Hall 1972), and the effects of Aroclor 1248<sup>®1</sup> (PCBs), endrin, fluoride, and Kelthane<sup>®</sup> on reproduction (McLane and Hughes 1980; Fleming et al. 1982; Hoffman et al. 1985; Wiemeyer et al., unpubl.).

Descriptions of basic colony management and propagation methods have been very brief in earlier reports on the effects of contaminants on Eastern Screech-Owls. Herein, I describe recent techniques

for captive breeding screech-owls at PWRC and present information on reproductive success for 1981-86. Data are from birds not involved in contaminant studies, except as specifically noted.

### METHODS

**Source of Birds.** The colony was established with 20 wild owls taken in Ohio as nestlings from the area described by VanCamp and Henny (1975). Ten additional nestlings were obtained in 1980 from the same location in order to improve genetic diversity. Three additional owls obtained during the early years of the colony are presumed to have come from Maryland. The original 20 birds from the wild were not present in the colony in 1981, nor were those obtained in 1980 present in 1986.

**Facilities and Maintenance.** Most birds were housed in outdoor pens 12.2 × 2.4 × 2.1 m high. Forty pens were in the primary unit, 20 pens in each of two rows, with the backs of the rows in common. Each pen also had its long sides in common with adjacent pens. Pens were constructed of a wooden frame with top, sides and interior partitions of 2.5 cm mesh wire netting. Netting on sides and partitions was buried to prevent burrowing into pens by mammalian predators and movement of owls be-

<sup>1</sup> Use of trade names does not constitute endorsement by the U.S. Government.

tween pens. Access to each pen was provided by a 0.9 × 1.8 m door. An electric fence encircled the area in which the pens were located.

Each pen was equipped with a nest box, shelter box, wooden perches, a sheltered feeding platform and a water pan. Nest boxes were 28 × 32 cm and 37–43 cm tall with a sloping, removable roof to allow cleaning of box interiors. Each box had an 8 cm dia opening in front with an external perch directly beneath. An internal perch was placed under the entry hole about 18 cm above the floor. The back of the box had a 13 cm dia access and observation hole with hinged, wooden, 16 cm<sup>2</sup> door and a latch. Boxes were mounted on the front of pens with their backs abutting the wire, allowing for inspection of contents from outside the pens through the observation door and a hole in the wire. Several centimeters of fine hardwood chips were placed in the bottom of each box. Chips were replaced following and immediately preceding each reproductive season. Boxes were disinfected and washed with a high pressure washer following each reproductive season.

Shelter boxes were 40 cm<sup>2</sup> plywood and opened at the front and bottom; each contained a 1.8 cm dia dowel perch. One box was placed in the rear corner of each pen. A 55 × 120 cm plywood sheet was placed on the top of each of two rear abutting pens over the top of the shelter boxes. Other perches in the pens were variable, and included: swinging perches suspended from the roof by wire strands; a stationary 1.8 cm dia dowel perch, 90 cm long, attached to an interior post and shared by two adjacent pens; and one to two, 1.6–2.0 cm dia dowel perches 45 cm long attached to or through an 80 cm vertical, 4 cm<sup>2</sup> wooden post suspended from the center of a horizontal 45 cm<sup>2</sup> plywood sheet attached to the pen roof.

Sheltered feeding platforms, open on the front and back, were plywood with bases 24 × 27 cm. The sides supported a sloping roof 18–23 cm above the platform base; roofs were 29 × 40 cm. Aluminum flashing covered the top surface of each platform base and extended 11 cm up each of the interior sides. A perch (1.8 cm dia dowel, 30 cm long) supported by wooden strips extending along each side of the platform exterior was located 3 cm away from the front of the platform, and at the same level as the base. A stainless steel insert tray was placed on the platform base and was removed periodically for cleaning. Feeding platforms were mounted on a post at the front of the pens. The rear of the structure

abutted and was attached to the wire. A hinged wire door provided access to the platform from outside each pen.

Stainless steel water pans (20 cm dia × 7 cm deep) were placed on stands about 0.6 m above the ground. Pans were cleaned 2–3 times/wk. Each pen was equipped with a 110 volt electrical outlet. Electrical warmers were placed under water pans during winter so that water was always available.

Secondary units of pens measuring 14.3 × 3.0 × 1.8 or 2.0 m high housed some birds in certain years. The pens were equipped in the same general manner as those described above except each contained two shelter boxes.

Vegetation in the pens was controlled by periodic mowing, except during incubation, and in some years when nestlings were present. Short vegetation in the pens facilitated finding newly fledged young and allowed them to move to sheltered areas, reducing the likelihood of their becoming soaked during wet weather. Spot applications of a granular herbicide (Tordon®) were occasionally used to control woody vegetation and vines in some pens.

**Sex Determination and Pairing.** Sex of each owl was determined during its first winter by laparoscopy conducted under local anesthesia, except in December 1984 when no anesthesia was used. Birds were usually returned to their pens on the day of the operation. Sex determination sample included 163 ♂♂ (49%) and 170 ♀♀ (51%) for birds produced during 1981–84, which did not deviate significantly from the expected 50:50 sex ratio ( $\chi^2$ ;  $P > 0.50$ ). VanCamp and Henny (1975) reported a sex ratio in wild Eastern Screech-Owls slightly in favor of females (48:52) for the northeastern United States. Fowler (1985) reported a sex ratio of 49:51 for 127 Eastern Screech-Owls found dead on Tennessee roads. Sex ratio of 84 road killed Eastern Screech-Owls in southern Connecticut was not different from 1:1 (Devine and Smith 1985). Sex ratio of captive owls for clutches in which all eggs hatched and the sex of all young was determined was essentially even (66 ♂♂:67 ♀♀).

New pairs of owls were formed each year. Pairing was conducted on 7–27 January 1981, 2 February 1982, 27 January 1983, 16 January 1984, and 21 November 1985. All pairs in the colony during the 1985 reproductive season were used in an experimental study; therefore, no reproductive data are reported. Most individuals that had lost a mate were provided with a new one. When new pairs were

formed, rarely (<5% of pairings) did one bird kill or injure its new mate.

No special considerations appeared to have been made in pairing the owls in 1981, except that siblings were not paired nor were birds paired with their parents. In several cases, members of a pair had one or more grandparents in common. Greater precautions were taken in 1982-83 to avoid pairing closely related individuals; no members of a pair had one or more grandparents in common. All available data on parentage of birds that were or had been in the colony were compiled for computer analysis in 1984 (Miller and Barr 1981). Computer generated coefficients of inbreeding were obtained for all possible new pair combinations for unpaired birds in the colony. Those potential pair combinations with the lowest coefficients (least related) were selected. All new pairings in the years 1984-86 had coefficients  $\leq 0.05$ .

Since the end of the 1981 reproductive season, reductions in the number of birds in the colony have been conducted periodically. The level of inbreeding in the colony in 1981 was considered unacceptable, and there was the occasional appearance of an eye defect which could have had a genetic basis. Several birds with the defect had a common male parent or grandparent. Many birds with common lines of parentage were used in non-reproductive studies (Serafin 1984; Franson et al. 1985; Wiemeyer et al. 1986; Beyer et al., in press) or in the establishment of a new captive colony in Canada to increase the average heterozygosity of the colony.

**Adaptation to Pens and Adult Mortality.** Owls produced in the colony readily adapted to their pens. Fledglings, however, were often seen with minor injuries to their cerea. Eye injuries were most common, and in severe cases involved the rupture of the eyeball or tearing of the lid. Some eye injuries appeared to result from attacks by cage mates, whereas others may have resulted from striking objects in the pens. Some birds that became blind in one eye were used in non-reproductive studies. Others remained as members of productive pairs. Some torn eyelids were sutured and healed well. Bumble foot was seen infrequently.

Unpaired owls were often housed in groups of three to four/pen. Owls of both sexes were combined in pens prior to sex determination. Thereafter, only birds of like sex were housed in a given pen. A few owls died due to fighting when housed together as non-pairs, especially shortly after their assignment

to pens with new pen mates; however, the rate of loss was unsubstantial.

Mortality of adults and fledglings during April 1981-June 1986 resulted from a variety of causes. Data on causes of mortality were primarily based on gross necropsies. Ten owls were euthanized: two had suffered trauma, two were unable to fly, two had eye defects, and one each had a slipped tendon of the leg, eye deterioration, eye injury and an eye infection. Fifteen birds died of unknown causes during this period, and seven died from injuries that apparently resulted from attacks by cage mates. Two birds died of trauma and two appeared to have been killed by predators. Two birds died of emaciation and one bird each died of cardiac hemorrhage, visceral gout and an overdose of anesthesia during surgery. Mortality appeared to be heaviest during May and June (five deaths each month), followed by November and January (four), December and March (three) and July and September (two). No owls died during October and February and only one each died in April and August. Recoveries of banded wild Eastern Screech-Owls, in comparison, were lowest during August and September and highest in March (VanCamp and Henny 1975). Most road kill mortality of Eastern Screech-Owls in southern Connecticut occurred during October-March, with the highest number recorded in March (Devine and Smith 1985).

**Diet.** From 1981 through the 1982 breeding season, the owls were fed day-old chicks (supplemented with calcium phosphate or calcium carbonate, Vionate® and thiamine) and laboratory mice. Nebraska Brand Birds of Prey Diet® was used in summer 1982 to replace the mice; chicks and the commercial diet were each fed three to four d/wk, alternating days. This diet was continued into the 1983 reproductive season until the first egg hatched in each clutch; chicks were then fed daily. Commercial diet was earlier found to be nutritionally inadequate for nestlings or adults were unable to adequately feed it to them (M. Anne R. McLane, pers. comm.). Commercial diet also became coated with wood chips in nest boxes. Day-old turkey poult were often substituted for chicks. Chicks or poult were fed four d/wk and Nebraska Brand Birds of Prey Diet three d/wk in 1984 until hatching began, when chicks, poult and mice were fed. The same regimen was followed in 1986 except that poult were not substituted for chicks. Mice were used about two d/wk because of their expense. Owls were fed slightly more

Table 1. Mean weights (g) of captive Eastern Screech-Owls in relation to age and season.

AGE AND DATES OF WEIGHING	MALES				FEMALES			
	N	$\bar{x}$	SE	RANGE	N	$\bar{x}$	SE	RANGE
<b>&lt;One year<sup>a</sup></b>								
9 Nov 1981–20 Jan 1982	52	173.6	2.4	(146–215)	55	193.1	2.4	(152–238)
7 Dec 1982–21 Jan 1983	18	186.2	4.8	(156–222)	26	210.5	4.3	(178–262)
18 Oct–15 Nov 1983	31	170.5	1.7	(150–187)	33	187.8	3.3	(154–258)
7–28 Dec 1984	54	180.8	2.1	(148–210)	49	201.9	2.8	(170–252)
<b>≥One year</b>								
30 Nov 1981 <sup>b</sup>	33	216.2	3.8	(158–256)	33	247.5	4.8	(188–300)
2 Feb 1982 <sup>c</sup>	25	182.6	3.7	(160–222)	25	198.4	4.2	(169–244)
27 Apr 1983 <sup>d</sup>	—				18	196.9	3.3	(180–228)
18 May 1983 <sup>e</sup>	—				13	183.1	4.0	(167–215)
22 Jun 1983 <sup>e</sup>	—				13	180.5	3.4	(168–214)
12 Oct 1983 <sup>e</sup>	—				13	201.9	5.7	(176–250)
28–29 Nov 1984 <sup>f</sup>	16	204.9	7.3	(158–254)	16	260.7	8.6	(210–310)
8–9 Jan 1985 <sup>f</sup>	16	211.1	5.8	(167–245)	16	264.1	7.6	(212–310)
8–9 Jan 1985 <sup>g</sup>	25	190.1	3.1	(153–225)	30	221.3	5.0	(173–264)
21 Nov 1985 <sup>h</sup>	34	210.4	3.2	(170–246)	36	232.0	3.9	(192–282)
27 Feb–3 Mar 1986 <sup>h</sup>	34	168.7	1.7	(145–190)	36	203.9	3.5	(163–263)

<sup>a</sup> Weights for birds <one yr old were taken at the time laparoscopies were conducted. Birds were housed three to four/pen.

<sup>b</sup> Paired birds.

<sup>c</sup> Weights at time of pairing; previously one to three birds/pen.

<sup>d</sup> Unpaired; two to three birds/pen.

<sup>e</sup> Same females weighed repeatedly; all hatched in 1982.

<sup>f</sup> Previously paired birds hatched in 1982 or earlier. Birds remained in same unit of pens before first weighing and between weighings. Same birds weighed on both dates.

<sup>g</sup> Birds paired in 1984; all hatched in 1983. They were housed in a different unit of pens than the older birds weighed on the same date.

<sup>h</sup> Birds paired on 21 November 1985; all hatched in 1984. The same birds were weighed on both dates.

than they would eat; each was provided  $\geq 35$  g of food/d. Leftover food items were removed from trays daily and from nest boxes, where much food was cached, especially when nestlings were present, at least twice weekly. One or two fresh food items were left in nests when nestlings were present. Food was placed on food tray inserts on the water warmers to prevent freezing before consumption during winter months.

**Weights of Birds.** Owls were weighed when laparoscopies were conducted and occasionally at other times, although not on a systematic basis (Table 1). Young birds generally weighed less than older birds during October–January. Males ( $N = 42$ ) averaged 181.1 g ( $SE = 2.4$ ) when <one yr old in December 1984 and 212.0 g ( $SE = 3.0$ ) on 21 November 1985, a significant increase ( $P < 0.001$ ; paired *t*-Test). Females ( $N = 50$ ) of the same cohort averaged 202.8 g ( $SE = 2.7$ ) in December 1984 and 230.1 g ( $SE = 3.1$ ) on 21 November 1985 ( $P < 0.001$ ; paired *t*-Test).

The average weight gain for this period for males and females was 17% and 13%, respectively.

Weights also fluctuated with season. Owls were heaviest in October–November, but weights declined by January or February. Sixteen older pairs had similar weights on 28–29 November 1984 and 8–9 January 1985 (Table 1;  $P > 0.10$ ; paired *t*-Test). More than 30 paired birds of each sex that hatched in 1984 weighed significantly less in February 1986 than on 21 November 1985 (Table 1;  $P < 0.001$ ; paired *t*-Test). Males lost nearly 20% and females 12% of their weight during the winter.

Weights were the lowest in summer, but increased significantly by October. No significant change in weight was noted for 13 females between 18 May and 22 June 1983 (Table 1;  $P > 0.10$ ; paired *t*-Test), but they were significantly heavier on 12 October than on 22 June (Table 1;  $P < 0.001$ ; paired *t*-Test), an increase of 12%. Although the annual weight cycle of wild Eastern Screech-Owls is not

well defined, Henny and VanCamp (1979) also reported a weight gain between the spring (April–May) and fall–winter (October–February) months with a peak in October–December and suggested that weight loss occurred in January and February. However, no major weight loss occurred during the spring and early summer (mid-April to mid-June). Their weights during April–June were primarily of breeding birds, whereas the limited data for the captive owls were from paired, but nearly all, non-breeding females. The weight cycle of captive Eastern Screech-Owls may be somewhat different than that of wild birds due to their access to a constant food supply. Captive owls tended to be heavier than wild owls in Ohio as reported by Henny and VanCamp (1979) and those reported by Earhart and Johnson (1970) for museum collections. Captive females weighed an average of 15.8% more than males, which is similar to the 15.3% and 16.4% differentials between sexes reported for wild screech-owls (Earhart and Johnson 1970; Henny and VanCamp 1979).

#### RESULTS

**Clutch Size.** Captive owls laid first clutches of 2–8 eggs (Table 2). Five-egg clutches were most common, followed by four- and six-egg clutches. Frequency distribution of clutch sizes for captive females was significantly different ( $\chi^2$ ;  $P < 0.05$ ) from that of wild females in Ohio where the mean clutch size ( $N = 91$ ) was 4.43 eggs (VanCamp and Henny 1975). Murray (1976) reported a mean clutch size ( $N = 96$ ) of 4.06 based on eggs in museum collections for the region and latitudinal area encompassing northern Ohio. Captive birds laid more six-egg clutches and fewer four-egg clutches than wild birds in northern Ohio (VanCamp and Henny 1975). Seven- and eight-egg clutches were not observed in the wild population but were seen on a few occasions in captivity. However, one brood of seven young was observed in northern Ohio (VanCamp and Henny 1975). Some unpaired females laid eggs while housed in pens with other females; data from these birds were not included in the above analysis.

**Hatching Success.** Seventy percent of all eggs laid in first clutches hatched (Tables 2 and 3). Hatching success of yearling females exceeded that of older females; every yearling female that laid hatched at least one egg. Hatching success by yearling females averaged 84%, whereas that of older pairs never exceeded 76% in any year and averaged somewhat lower ( $\bar{x} = 69\%$ ).

Table 2. Frequency of clutch and brood sizes for captive Eastern Screech-Owls, 1981–86.

CLUTCH OR BROOD SIZE	EGGS LAID (%)	EGGS HATCHED (%)	YOUNG FLEDGED (%)
0	—	19 (14)	22 (16)
1	0 (0)	7 (5)	10 (7)
2	5 (4)	17 (12)	16 (11)
3	20 (14)	28 (20)	27 (19)
4	36 (26)	31 (22)	31 (22)
5	46 (33)	29 (21)	27 (19)
6	26 (19)	8 (6)	7 (5)
7	5 (4)	1 (1)	0 (0)
8	1 (1)	0 (0)	0 (0)
Mean	4.63	3.21	3.03

A number of factors were involved in the failure of eggs to hatch. No embryo was detected in 42% of unhatched eggs, but small embryos may have gone undetected. Dead embryos were found in 15%, while eight percent of the eggs disappeared. Some of the latter may have hatched, but died shortly thereafter and were removed or consumed by the parents. Ten percent of eggs that failed were cracked or broken; some were also infertile or had dead embryos, but were not included above. Breakage in many cases was caused by struggles of females (kicking of eggs) when nest box contents were being examined. Boxes of pairs that had completed clutches were normally examined only once/wk until hatching was expected. Boxes were examined daily during egg laying in most years. Eleven percent of egg failures were due to abandonment during incubation, four percent were not examined for embryo development, and nine percent were not incubated. Egg abandonment and failure to incubate were most severe in 1986 (nine clutches).

Broods of three, four and five young were most common at hatching (Table 2). Broods of five young were predominant in 1984, broods of three and four were the most common in 1981 and 1986, and broods of two were most frequent in 1983.

**Fledging Success.** Ninety-four percent of all known hatchlings fledged during 1981–86 (Tables 2 and 3). Some early loss of young could have been undetected and attributed to egg disappearance. An average of 3.03 young fledged/laying pair and 3.59 fledged/successful attempt. VanCamp and Henny (1975) reported that 3.80 young fledged/successful

Table 3. Reproductive success of captive Eastern Screech-Owls, 1981-86.

YEAR AND GROUP	NO. PAIRS			EGGS LAID		EGGS HATCHED			YOUNG FLEDGED			% LAYING PAIRS SUC-CESS-FUL <sup>a</sup>
	TO-TAL	WITH EGGS	%	N	MEAN/CLUTCH	N	MEAN/CLUTCH	%	N	MEAN/CLUTCH HATCHED	% OF EGGS	
<b>1981</b>												
Yearlings <sup>b</sup>	14	9	64	33	3.7	29	3.2	88	28	3.1	97	100
>One yr old												
Previously productive	10	10	100	53	5.3	37	3.7	70	34	3.4	92	80
Not previously paired <sup>c</sup>	18	17	94	82	4.8	50	2.9	61	48	2.8	96	82
Miscellaneous	6	4	67	17	4.3	7	1.8	41	3	0.8	43	75
<b>1982</b>												
Yearlings <sup>d</sup>	7	2	29	8	4.0	7	3.5	88	7	3.5	100	100
Older	9	8	89	40	5.0	29	3.6	73	28	3.5	97	88
<b>1983</b>												
Yearlings <sup>d</sup>	14	1	7	5	5.0	2	2.0	40	2	2.0	100	100
Two yr olds <sup>e</sup>	6	6	100	23	3.8	16	2.7	70	14	2.3	88	67
>Two yr olds <sup>f</sup>	15	15	100	70	4.7	50	3.3	71	47	3.1	94	100
<b>1984</b>												
Yearlings <sup>b</sup>	6	1	17	5	5.0	5	5.0	100	5	5.0	100	100
Two yr olds	14	13	93	63	4.8	48	3.7	76	47	3.6	98	100
>Two yr olds <sup>g</sup>	20	18	90	98	5.4	70	3.9	71	69	3.8	99	83
<b>1986</b>												
Two yr olds	43	36	84	146 <sup>h</sup>	4.2	99	2.8	68	92	2.6	93	72

<sup>a</sup> A successful pair is one fledging one or more young.<sup>b</sup> Both members of all but one pair were yearlings; one yearling female paired with older male.<sup>c</sup> No record of previous pairing.<sup>d</sup> Both members of each pair were yearlings.<sup>e</sup> One female had a yearling mate.<sup>f</sup> Some females had mates that were at least two yr old.<sup>g</sup> One female with a two-yr-old mate.<sup>h</sup> Clutch size unknown for one pair; broken eggs found on ground long after laying.

nest in Ohio, only slightly in excess of captive production, and estimated that 2.63 young fledged/nesting attempt, a value somewhat lower than the production of captive owls. The number of young fledged/captive pair was higher in 1982 and 1984 than in 1983 and 1986. Fledging success was variable in 1981 in relation to age and past reproductive history (Table 3).

Cause of most nestling deaths was unknown, because in many cases young disappeared. Most losses occurred during the first week post-hatch. Documented causes of nestling deaths involved the loss of one young each to aspergillosis, pneumonia, umbil-

ical hemorrhage, possible food compaction in the ventriculus and a fractured leg resulting in septicemia.

**Second Clutches.** Ten second clutches were laid after 19 first clutches failed to hatch. Nine were laid after the first clutch was abandoned during incubation or the female failed to initiate incubation. Eight eggs hatched in three second clutches and all nestlings fledged. However, three were hand-reared following the death of a female parent and failure of the male to feed the young in one brood. One female died while incubating a second clutch. One third clutch was laid in 1984 following the aban-

donment of two earlier clutches. Four of six pairs laid a second clutch in 1983 after their first clutches were removed immediately before hatching.

Second clutches have also been laid following death or removal of hatchlings from first clutches. A second clutch was laid following the death of a single first clutch young within 24 hr of hatching in 1986; the second clutch failed. Two control pairs in a contaminant study (Hoffman et al. 1985) laid second clutches in 1982 after their first clutch young were removed at seven days of age; one second clutch failed and the other produced three fledglings.

Average size of the first clutch (4.35 eggs) was significantly greater ( $P < 0.005$ ; paired *t*-Test) than that of the second clutch (3.06 eggs) in 17 cases where second clutches were laid. Greater declines in size between first and second clutches tended to occur when first clutches were incubated full term. VanCamp and Henny (1975) suggested that Eastern Screech-Owls in northern Ohio renested based upon their observations of small young in nests during the first week of June.

**Proportion of Females Laying.** The proportion of females that laid eggs varied among ages and years. Eight of 13 (62%) yearling pairs produced eggs in 1981; four of six (67%) females taken from Ohio as nestlings and four of seven (57%) captive produced females. Two pairs that involved a yearling bird (one of each sex) paired with an older mate were both successful in producing young in 1981, one being two yr old. Three females (one each two, four, and five yr old) that were paired with males three to seven yr old failed to lay. Two of seven (29%) yearling pairs produced eggs in 1982 and two of three (67%) two-yr-old females laid; one female from Ohio did not lay eggs until 1983 when she was three yr old. Only one of 14 (7%) yearling pairs laid in 1983, although six of six (100%) two-yr-old pairs laid. One additional pair comprised of a yearling male and an older female successfully produced young. One of five (20%) yearling pairs laid eggs in 1984; one yearling female paired with a two-yr-old male did not lay. Thirteen of 14 (93%) of the two-yr-old pairs laid in 1984. Two of 20 older pairs failed to lay in 1984 which included 12-yr- and 8-yr-old females. Only 36 of 43 (84%) two-yr-old pairs laid in 1986. Decline in the proportion of yearlings that laid in 1983–84 compared to 1981–82 could have been due to change in diet made in 1983. The oldest banded wild Eastern Screech-Owl recovered in the northeastern United States and Ontario for 1915–64 was 12–13 yr old (VanCamp and Henny

1975). One captive 13-yr-old female laid eggs and produced young in 1982 while in a contaminant study (Hoffman et al. 1985); she was sacrificed at the end of the study.

The proportion of females laying as yearlings and when two yr old may also be an indication of age of sexual maturity. Sixty-two of 72 (86%) two-yr-old females laid during 1981–86, compared to 13 of 41 (32%) yearling females. VanCamp and Henny (1975) estimated that 77–83% of wild yearlings attempted to nest. Although captive yearling females from Ohio nested at near this rate, captive-produced yearling females nested at a much lower rate, especially after 1981.

#### DISCUSSION

Development of techniques to breed Eastern Screech-Owls in captivity on a large scale has made the species available as a laboratory animal for use in a variety of studies. The species' response to exposure to environmental contaminants can be considered representative of the Order Strigiformes.

Eastern Screech-Owls have several characteristics that make them a desirable laboratory species. They are not readily disturbed by routine maintenance activities around their cages, remaining perched unless closely approached. To date they have not succumbed to disease outbreaks; annual mortality rate was estimated to be well under 10%. They are relatively small and thus easily handled, and space requirements are somewhat lower than for larger species, such as the Common Barn-Owl.

The species also has several characteristics that may be considered disadvantages for a laboratory species. The species exhibits little sexual dimorphism, therefore laparoscopies are required to determine sex, a procedure that causes minor risk to the owls. However, an experienced veterinarian can conduct at least 10 Eastern Screech-Owl laparoscopies per hour if assisted by additional personnel in handling and restraining the birds. Captive owls did not reproduce well until their second year and did not flush readily from their nests, making it difficult to examine eggs or young without attacks on the observer, increasing the risk of accidental injuries to the nestlings by their parents.

Additional research should aid in making the species more desirable as a laboratory animal. The feasibility of artificial insemination should also be investigated. Proper artificial incubation techniques have not been determined. Eggs incubated at 37.6°C and 55% relative humidity experienced high mor-

tality (Bunck et al. 1985). Additional knowledge regarding nutritional requirements and disease would be helpful.

Several contemplated modifications to our facilities should improve care to birds and result in lower maintenance costs. First, new facilities should be constructed with heavily galvanized steel pipe frame and with vinyl bonded welded wire, which should reduce injuries from striking the pen frame and limit damage to cerea from striking rough wire. The life of such a facility should be much greater than those constructed with wooden frames and galvanized wire. All wooden materials used for nest and shelter boxes and feeding stations should be sealed to aid in cleaning and improve sanitation; alternatively such items should be constructed with nonporous materials. Additional shelter, a variety of perch sizes and types and a water delivery system for bathing are also being considered.

#### ACKNOWLEDGMENTS

I thank Laurel F. VanCamp for providing birds from Ohio for the captive colony. M. Anne R. McLane established the basic protocol for management of the colony. Henry C. Bourne provided valuable technical assistance, especially in maintaining records of parentage, entering the data on the computer system and selecting new pairs from computer output data. Dwight G. Smith participated in the collection of weight data in November 1985 and February–March 1986. Denise Clearwater, John Czajkowski, Robert Prettyman, Eric Hill, Bryan Watts, Val Urban, Mario Dance, Todd Erlandson, Mark McGarigal and Kelly Campbell provided care for the birds during 1981–86. F. Joshua Dein, Christian E. Grue, Dwight G. Smith, Charles J. Henny and Brian Walton provided critical reviews of the manuscript, and Marcia Holmes typed the paper.

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Received 23 December 1986; Accepted 12 March 1987

## BEHAVIOR AND HABITAT USE OF BREEDING NORTHERN HARRIERS IN SOUTHWESTERN IDAHO

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**ABSTRACT.**—Radiotelemetric and visual monitoring of four breeding pairs of the Northern Harrier (*Circus cyaneus*) in predominantly shrub-steppe habitat of the Snake River Birds of Prey Area, Idaho, indicated that harriers used riparian and cultivated habitats disproportionately. As alfalfa growth approached 46 cm height, males shifted from predating voles (*Microtus* sp.) in alfalfa fields to the Western Whiptail (*Cnemidophorus tigris*) in open shrub-steppe habitat. Mean minimum home ranges of males were estimated at 15.7 km<sup>2</sup> while those of females were estimated at 1.13 km<sup>2</sup>. Males ranged up to distances of 9.5 km from nests. Males hunted most intensively in the second week after hatching. Females did not hunt until the third week after hatching. During most of the day, both sexes rested or preened <0.5 km from nests. Varying home range sizes in this and other studies may be a function of harrier responses to differing habitat structures and prey availability or vulnerability to capture.

Breeding behavior of the Holarctic Northern (Hen) Harrier (*Circus cyaneus*) has been studied and discussed by Breckenridge (1935), Bent (1937), Brown and Amadon (1968), Hamerstrom (1969) and Watson (1977). These and other studies showed that male participation in the breeding effort is limited primarily to provisioning prey for their mates and young, with incubation or care of young rarely recorded (Bildstein 1979; Thompson and Cornely 1982). Male abandonment of the breeding effort prior to fledging of young is not uncommon and is usually associated with increased hunting activity by females (Hamerstrom 1969; Watson 1977).

Few studies have attempted to quantify male and female harrier behavior and activities related to habitat utilization in upland areas. This study was conducted from March through July 1981 with the objective of determining breeding activities in a habitat type not typically associated with harriers.

### STUDY AREA AND METHODS

Four nesting pairs of harriers were selected in the Snake River Birds of Prey Area (BOPA) in southwestern Idaho, a 338 778 ha sanctuary within the Upper Sonoran life zone of the Great Basin Region characterized by a cold desert physiognomy and climate (Odum 1971; USDI 1979). Nesting or pair-bonded harriers were located using methods discussed by Hamerstrom (1969, 1986). Emphasis was placed on determining behavior and activities of breeding male harriers occurring within the BOPA. Precautions were taken to avoid investigator disturbances near nests [i.e., trampling vegetation and creating paths for predators to follow (Fyfe and Olendorff 1976)].

Habitats were categorized into six types: water, riparian, shrub-steppe, cultivated fields, abandoned fields, and barren soils. Water habitats were open waters of the Snake River, reservoirs, and irrigation systems. Riparian habitat consisted primarily of pampas grass (*Phragmites communis*), bulrush (*Scirpus* sp.), stinging nettle (*Urtica* sp.), will-

low (*Salix* sp.), and tamarisk (*Tamarix pentandra*). Greasewood (*Sarcobatus vermiculatus*) formed a transitional zone between riparian and shrub-steppe habitats and was included in the riparian habitat category. Shrub-steppe was the dominant upland habitat, consisting primarily of big sagebrush (*Artemesia tridentata*), cheatgrass (*Bromus tectorum*), and shadscale (*Atriplex confertifolia*) associations. A variety of crops made up cultivated fields, primarily alfalfa (*Medicago sativa*), wheat (*Triticum aestivum*), and sugar beets (*Beta vulgaris*). Cultivated fields were dependent on water through sprinkle or flood irrigation. Abandoned fields were dry fallow cultivated fields invaded by halogeton (*Halogeton glomeratus*), cheatgrass, and Russian thistle (*Salsola kali*). Barren soils were a variety of mine tailings, gravel pits, cliffs, and lava beds.

Habitat analyses were made by overlaying 1:24 000 USGS topographic maps with a grid. Each square size represented 0.405 ha and was assigned a habitat type determined from aerial photographs, vegetation maps provided by the Boise District Office of the Bureau of Land Management, and from field observations. A circular area of approximately 200 km<sup>2</sup> was analyzed surrounding each of the study nests. On this basis, habitat percentages were calculated in order to detail harrier habitat utilization.

Selected alfalfa fields in the study area where harriers were observed hunting were measured for height from the ground along linear transects of 10 points. Cutting schedules were observed and recorded.

Six harriers were captured using a variety of techniques. Two males and two females were captured using a noose-halo (Scharf 1968) and a mounted Great Horned Owl (*Bubo virginianus*) on a portable one m high, placed 3–10 m from the suspected nest. One male was captured using an octagonal bal-chatri (Erickson and Hoppe 1979) with a Montane Vole (*Microtus montanus*) as bait. Another male was captured using a mist net set ≥1 m behind a mounted owl. A dho-gaza and mounted owl (Hamerstrom 1963) attracted several adult harriers but failed to result in any captures. Harriers may have detected dho-gazas or mist nets due to motion caused by prevalent winds. A wire dome with monofilament nooses (Burke 1979) or bownet (Hamerstrom 1969) placed over the nest was not used due to possible abandonment of eggs or young (Hamerstrom 1969).

Each individual captured was measured, weighed, and aged (Hamerstrom 1968). Colored plastic and USFWS bands were placed on the legs of each harrier, and a radio transmitter was attached to a central rectrix using techniques described by Dunstan (1973), Beske (1978), and modified by Martin (unpubl.). Transmitters used were AVM SM-1 units operated at 164 MHz weighing about five g when encased in dental acrylic. Transmitter whip antennas were trimmed to about 200 mm. Receivers were AVM LA-12 units with 10 subchannels, used alternately with three-element Yagi or Adcock antennas.

Prior to capture efforts, monitoring of harrier activities began in March during courtship and nest building. Distinctive markings and plumages (such as moulting or color patterns) were used to distinguish individuals. After radio-tagging harriers, behavior and habitat use were sampled instantaneously (Altmann 1974) at 10-min intervals from 0500–2200 H (MST). Monitoring was conducted in 17-hr blocks rotating once every seven d to each of the nests. The sampling effort was equal through all time periods of the day for the length of the study. Emphasis was placed on tracking males of a given nest as I assumed they would be far ranging, hunting for themselves and their mates, while females remained at the nests (Watson 1977). When a repeated direction of travel to and from the nest could be determined, alternate tracking days were spent in the suspected hunting areas and the nest. When possible, contact between two investigators was maintained by two-way radios. One investigator always remained near a given nest in the event that visual or radio contact was lost. In this manner, lost contact could be regained as the male harrier returned to a nest with prey and female behavior and activities could be monitored concurrently with males.

Home ranges were determined using the non-statistical minimum polygon method (Mohr 1947; Jennrich and Turner 1969). Radio telemetry was used primarily to assist in visually locating a harrier within a given habitat type, then observe its behavioral activities as suggested by Craighead et al. (1963) and Mech (1983). Radio triangulated positions (Mech 1983) were used to clarify harrier locations when necessary. All missed data points were eliminated from statistical analyses.

Harrier activities were placed into classes based on a scheme similar to those used by Linner (1980), Schipper (1977), and Bildstein (1982) [i.e., loafing (perching, resting, or preening), feeding, agonistic interactions (both intra- and interspecific), soaring or gliding, hunting flights (either border following or quartering), and other flights (including powered transit or high flights)]. Starting, ending, and duration of flights or activities, prey deliveries, prey items identified, and compass directions of travel to and from the nests were recorded.

Nesting chronology of each nest was determined by backdating the first prey taken into the nest, indicating hatch of eggs (Hamerstrom 1969). Due to the close proximity of two of the study nests, it was possible to observe harrier behavior and activities concurrently, noting initial prey deliveries to newly hatched young, without interfering with the established monitoring schedule. In addition, two of the nests occupied by radio-tagged harriers were examined to determine the age of young by weight and

length of primary feathers (Munoff 1963; Hamerstrom 1968; Scharf and Balfour 1971).

Activities and habitat utilization of individuals were combined after synchronizing nesting chronologies into similar composite categories for statistical analyses. Statistical methods used are from Snedecor and Cochran (1967). A breeding effort was assumed to commence with the laying of eggs (through incubation of about 30–32 d), and ending about 35 d after hatching (with the young capable of flight), or about 70 d total (Hammond and Henry 1949; Hamerstrom 1969). After hatching of eggs, activities and behavior were broken into seven-d units for analysis. For some analyses, sample sizes were inadequate to list in weekly increments and were grouped into three major phases of breeding: incubation, brooding (from hatch to the end of the second week), and post-brooding (from the start of the third week to the end of the fourth week or as young fledged) (Watson 1977).

## RESULTS

**Activities and Behavior—Males.** Males were observed hunting at first light ( $\pm 30$  min prior to sunrise). No prey deliveries were recorded before 0530 H (MST) and only one prey delivery was observed after 1900 H (MST). Prey deliveries/d peaked from 0900–1200 H (MST) and this pattern remained constant throughout the breeding season (Fig. 1). Copulations associated with prey given to females were observed for 15.6% of the total prey deliveries by males ( $N = 96$ ), 48.0% occurring prior to 0900 H (MST), 35.0% from 0900–1200 H (MST), and 17.0% from 1200–1500 H (MST). All copulations observed were in association with prey deliveries and continued until day 15 of incubation.

The number of prey items delivered/d by male harriers to the nest or females peaked during the second week post-hatching. Concurrently, intervals between prey deliveries shortened and observed hunting activities increased (Fig. 2). For the entire season, the males delivered an average of 3.5 prey items/d to the female or nest. Prey deliveries ranged from one to three items/d during courtship and incubation, to a maximum of seven items/d during brooding, and decreasing to two to three items/d as chicks approached fledging. Male harriers were in flight during 52% of total observations. Only 20% of male flight activities could be classed as hunting behavior (Table 1).

Early in the season males spent most of their time loafing near nests (Tables 1 and 2). If monitoring had been conducted on a 24-hr basis, it is probable that the number of observations of males near nests would have been greatly reduced. At least one male

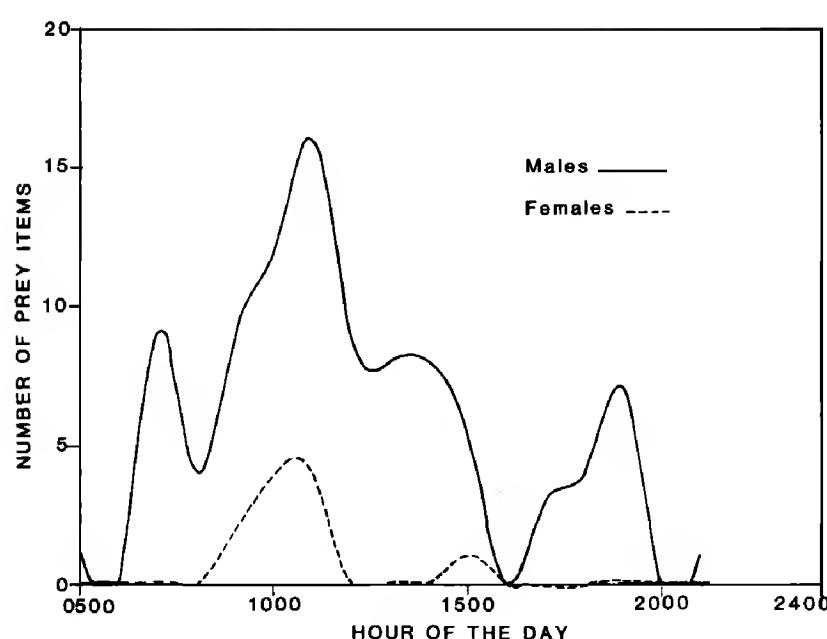


Figure 1. Number of prey deliveries/hour of the day for males and females.

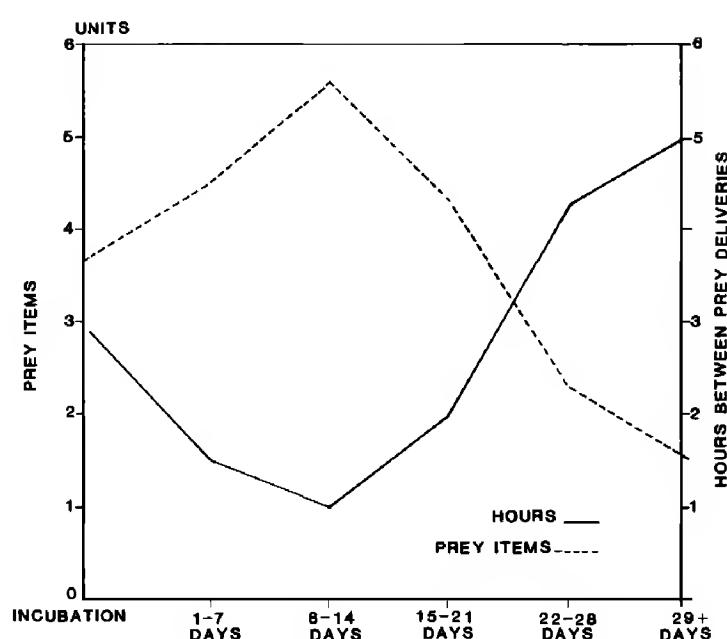


Figure 2. Frequency and number of prey items delivered to nest or female by male Northern Harriers

did not roost within two km of the nest from the onset of incubation. After eggs hatched, the time males spent near nests decreased more rapidly than females. Foraging sorties by male harriers of 4.5–9.5 km were routinely observed. As the breeding season progressed, harriers tended to range farther, but these observations could not be quantified before the study terminated.

Flights to and from nests followed certain compass bearings that were traveled repeatedly throughout the nesting season at at least two of the study nests. Flight patterns were established during the courtship and nest building period, prior to radio-tagging. Due to nesting failures, observations were not completed for the other two nests.

Male agonistic interactions observed were pri-

marily with other male harriers near nests (73.1%, N = 82). Most of these interactions occurred early in the season as territories were being established. Interactions with neighboring males and females declined through the breeding season. However, reaction to other harriers approaching the nest territory, even from nearest neighbors, always resulted in vigorous pursuit. Males defended an area of about 0.78 ha with the nest at the center. Borders between territories were often defined by vegetation changes or height differences, fence lines, or topographic features. Aerial talon-grappling described previously by Craig et al. (1982) was observed three times and these were the only intraspecific interactions observed away from nests.

Interspecific encounters included the pirating of

Table 1. Activities of male harriers in relation to nesting events.

NESTING EVENTS	PERCENT TIME <sup>a</sup>					OTHER FLIGHTS <sup>c</sup>
	LOAFING	HUNTING <sup>b</sup>	FEEDING	AGGRESSION	SOARING	
Incubation	53	15	2	2	10	18
Brooding	30	34	2	2	8	24
Post-brooding	55	12	2	2	3	28
Total for season	46	20	2	2	7	23

<sup>a</sup> Based on 688 visual or radio contact locations at 10-min intervals from a total of 2256 tracking intervals spent in the field (29.6% actual) and excludes observations of male activities between intervals.

<sup>b</sup> Hunting activities included edge following and quartering flights.

<sup>c</sup> Other flights were all flights determined not to be hunting or soaring (i.e., gathering nest materials, courtship, and high or transit flights).

Table 2. Harrier activities in relation to distance from nests for the total breeding season.

DISTANCE FROM NESTS	PERCENT ACTIVITIES <sup>a</sup>	
	MALES	FEMALES
<0.5 km	42.3	85
0.5–1.0 km	23.9	11
1.0–2.0 km	7.7	4
2.0–3.0 km	11.3	0
3.0–6.0 km	8.5	0
>6.0 km	6.2	0

<sup>a</sup> All activity categories combined, based on 688 male and 250 female instantaneous samples at 10-min intervals, plotted on topographic maps.

a large unidentified prey item from a flying Red-tailed Hawk (*Buteo jamaicensis*). Males appeared most aggressive towards intruders early in the breeding season, just prior to or just after start of incubation.

**Activities and Behavior—Females.** Hunting by female harriers was not observed prior to the third wk post-hatching (Table 3). Females were observed routinely for 10–15 min from 0700–0730 H (MST) in preening bouts or low flights near nests (<100 m) from the start of incubation through the second wk post-hatching. The only other time females were observed away from the nests was for food transfers from mates or to assist mates or neighboring harriers in attacking intruders (Powers et al. 1984). After the beginning of the third wk post-hatching, females were observed hunting from 0600–2120 H (MST). Female prey deliveries tended to follow the male prey delivery pattern from mid-morning to mid-afternoon (Fig. 1). Frequency or number of prey

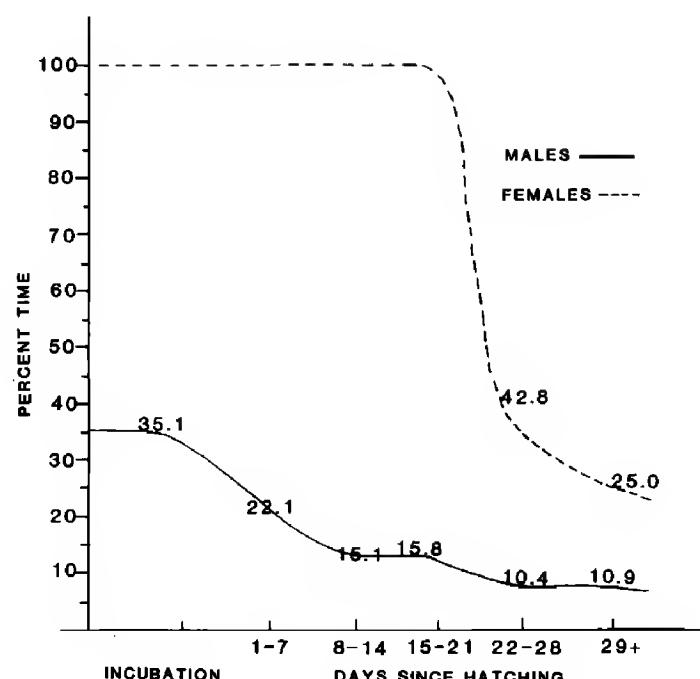


Figure 3. Time male and female harriers spent <0.5 km from nest site.

deliveries by females could not be determined quantitatively due to emphasis on monitoring male activities. Additionally, female activities during the incubation period were not determined (Fig. 3).

From the beginning of the third wk post-hatching, females ranged progressively farther from nests but never as extensively as males (Fig. 3). The longest flight observed by a female harrier was 600 m.

Flights to and from nests followed specific compass bearing, in patterns similar to males; however, female direction of travel differed from that of males. One harrier pair was observed flying to and from the nest in opposite directions. Females continued these flight patterns during courtship and nest building, and while hunting for themselves and young.

Intraspecific interactions involving females were oriented more towards other females (43.3%, N =

Table 3. Activities of female harriers in relation to nesting events.

NESTING EVENTS	PERCENT TIME <sup>a</sup>					
	LOAFING	HUNTING <sup>b</sup>	FEEDING	AGGRESSION	SOARING	OTHER FLIGHTS <sup>c</sup>
Incubation	—	—	—	—	—	—
Brooding	79	0	2	1	1	17
Post-brooding	64	8	3	1	2	22
Total for season	46	4	3	1	2	19

<sup>a</sup> Based on 250 visual or radio contact locations at 10-min intervals from a total of 264 tracking intervals spent in the field (94.7% actual) and excludes observations of females' activities between intervals.

<sup>b</sup> Hunting flights included edge following and quartering flights.

<sup>c</sup> Other flights were all flights determined not to be hunting or soaring (i.e., gathering nest material, courtship, and high or transit flights)

Table 4. Habitat types surrounding study nests in the Snake River Birds of Prey Area, and male harrier habitat utilization.

DISTANCE FROM NESTS	HABITAT TYPES <sup>a</sup>					
	WATER <sup>b</sup>	RIPARIAN	SAGE	CULTIVATED	ABANDONED FIELD	BARREN SOILS
% Habitat Types						
Nest-0.5 km	26.6	22.6	46.7	1.0	3.1	—
0.5-1.0 km	11.3	27.1	42.2	13.7	2.9	2.8
1.0-2.0 km	37.7	16.2	25.3	20.8	—	—
2.0-3.0 km	16.1	12.7	45.5	20.8	2.6	2.3
3.0-6.0 km	2.5	3.1	74.9	17.2	1.2	1.1
>6.0 km	1.1	1.0	77.9	18.0	1.0	1.0
Total habitat types	6.9	5.9	67.5	17.9	1.4	0.3
% Male Habitat Use by Distance <sup>c</sup>						
Nest-0.5 km	5.5	81.8	—	1.8	10.9	—
0.5-1.0 km	2.0	25.8	6.5	36.7	29.0	—
1.0-2.0 km	20.0	10.0	50.0	20.0	—	—
2.0-3.0 km	6.6	20.0	66.7	6.7	—	—
3.0-6.0 km	—	—	45.5	54.5	—	—
>6.0 km	—	—	12.5	87.5	—	—
Total habitat use <sup>d</sup>	4.5	43.9	17.7	21.3	11.5	—
Male Habitat Use Related to Nest Events						
Incubation	3.0	48.0	7.0	21.0	21.0	—
Brooding	4.0	18.0	42.0	24.0	12.0	—
Post-brooding	4.0	27.0	38.0	23.0	4.0	—
Total activities per habitat type for season <sup>d</sup>	4.9	33.3	28.5	22.8	10.6	—

<sup>a</sup> Percentage based on 200 km<sup>2</sup> area surrounding study nests determined from aerial photos, vegetation maps, and on-site inspections.

<sup>b</sup> Harrier use of water habitat limited to over water flights to and from terrestrial habitats.

<sup>c</sup> Male harrier habitat use determined from 688 instantaneous samples, using radio triangulation or visual contacts.

<sup>d</sup> Error in total male harrier habitat use and activities due to differences in computation and is not statistically significant.

90) than males (21.7%, N = 90). Most intraspecific encounters occurred early in the season and females defended identical areas as males. Male-female interactions of mated pairs were excluded from consideration.

Females were most aggressive towards interspecific intruders, such as the Great Blue Heron (*Ardea herodias*) (6.5%, N = 90), Canada Goose (*Branta canadensis*) (4.3%, N = 90), and American Coot (*Fulica americana*) (2.1%, N = 90). Encounters with Coyotes (*Canis latrans*) (10.8%, N = 90) have been previously reported (Powers et al. 1984). Females of several closely grouped nests (seven nests within 100 m rad) were observed to defensively dive at Coyotes and Mule Deer (*Odocoileus hemionus*). Males, when present, would join in such defense but were never as vigorous (i.e., did not dive as low or

as prolonged) as females after eggs hatched. Deer were suspected of trampling one nest in the study area.

**Habitat Use—Males.** Due to problems in visual and radio-tracking, home ranges for male harriers could only be approximated. Enderson and Kirven (1983) discuss problems in radio-tracking Peregrine Falcons (*Falco peregrinus*), similar to those encountered during this study. The estimated minimum mean home range for males of the four study nests was 15.7 km<sup>2</sup> (range 9.7–17.7 km<sup>2</sup>).

Chi-square ( $\chi^2$ ) analyses were made for each habitat type occurring at various distances from the nests in order to compare expected habitat use by males to available habitat in the study area (after Nicholls and Warner 1972). Male harriers used riparian habitats significantly more ( $P = 0.01$ ) and shrub-

steppe habitat significantly less ( $P = 0.01$ ) than expected. The dominant habitat type in the study area was shrub-steppe (67.5%) with riparian habitat relatively uncommon (5.9%), but males frequented riparian habitat most often (43.9%) (Table 4). If irrigated cultivated fields are considered similar to riparian habitats based on availability of free water (Thomas et al. 1979), male activities in riparian-like habitats increases to 66.2% of total observations. Male activity in shrub-steppe habitat were limited to 17.7% of total observations (Table 4).

A total of 20 observations of males with identifiable prey items were recorded. An apparent shift from mammalian prey to reptilian prey appeared to be associated with alfalfa growth. All voles delivered by males to the nest or female (30% of total prey items) were observed prior to alfalfa growth of 46 cm. Following alfalfa growth to 46 cm in height, males delivered mostly Western Whiptails (*Cnemidophorus tigris*) (35% of total prey items). Other prey items identified included the Kangaroo Rat (*Dipodomys* sp., 15%), Deer Mouse (*Peromyscus maniculatus*, 5%), juvenile Nuttall's Cottontail (*Sylvilagus nuttallii*, 10%), Red-winged Blackbird (*Agelaius phoeniceus*, 5%) and showed no patterns associated with changes in vegetation height.

Male harrier activities in alfalfa fields were negatively correlated with vegetation height ( $r = -0.857$ ,  $P < 0.05$ ). However, activities in shrub-steppe habitat were positively correlated with alfalfa height ( $r = 0.914$ ,  $P < 0.05$ ). These relationships suggest a shift in habitat preference by hunting male harriers to more open shrub-steppe habitats as alfalfa growth approached an average height of 46 cm. Further, a distinct increase can be observed in harrier activities in shrub-steppe habitat after hatching of young (Table 4). Male harriers from three of the four study nests were observed in this apparent habitat and prey shift. The first cutting of alfalfa fields occurred about 1 June when alfalfa growth reached an average height of 61 cm. Following cutting of alfalfa, males appeared to return to the fields to hunt, but this could not be quantified before the study terminated. No other significant patterns were observed between harrier activities and habitat types.

**Habitat Use—Females.** Minimum home range size for the two study females was estimated at 1.13 km<sup>2</sup>. Females were observed only in riparian and cultivated habitats directly adjacent to nests.

Females were observed with only two prey items:

a vole, and a Red-winged Blackbird caught in mid-air from a mobbing flock as it passed below the female's plane of flight. A similar response by female harriers to mobbing has been reported by England (1986).

## DISCUSSION

**Habitat Use and Foraging Behavior.** Habitat use by harriers has been discussed by Nieboer (1973), Schipper (1973, 1977) and Watson (1977), mostly in reference to sympatric occurrence with other harrier species. Northern Harriers in North America are typically associated with lowlands, brackish or fresh water marshes, and mesic grasslands (Bent 1937; Brown and Amadon 1968; Apfelbaum and Seelbach 1983). Additionally, harriers are found in upland habitats distant from water sources (Rees 1976; Duebbert and Lokemoen 1977; Call 1978; Thurow et al. 1980; Thompson-Hanson 1984; Rysser 1985). In the Palearctic the Hen Harrier usually occupies drier open grasslands (Cramp 1908; Harrison 1982). Watson (1977) suggests that harriers secondarily occupy lowlands in North America due to a lack of competition with other harrier species.

Although the few prey items observed in this study are peripheral to the initial objective of determining habitat utilization, they collaborate with previous studies showing breeding harriers to be highly dependent on certain prey species, principally voles (Craighead and Craighead 1956; Hamerstrom 1969, 1979, 1986; Barnard 1983; MacWhirter 1985), and indirectly indicate foraging patterns and habitat use.

When temporal changes occur in prey densities, predators have been observed shifting to the second highest prey density (Taylor 1984). MacWhirter (1985) found nesting harriers at Tantramar Marsh, New Brunswick, principally predating voles but observed a significant shift to fledgling passerines in late-June and early-July. Barnard (1983) also observed a significant prey shift, from voles to passerines. Errington (1933) and Errington and Breckenridge (1936) observed prey shifts, resulting in a succession of prey species appearing in the diet of harriers through the breeding season. However, Watson (1977) implies that any abundant population readily accessible to harriers may be substituted as prey. If voles are rare or absent, harriers prey on birds, primarily passerines (Schipper 1973, 1977; Watson 1977; Picozzi 1978; Barnard 1983; MacWhirter 1985). Rees (1976) observed nesting

harriers in shrub-steppe habitats of eastern Washington preying exclusively on vole populations.

Data collected by Diller and Johnson (1982) indicate that riparian habitats support the greatest number of vertebrate species. Montan (1977) observed the greatest rodent numbers in the BOPA in riparian zones, with microtine species found only in wet sites such as riparian or irrigated cultivated habitats. It may be assumed that voles are limited in the BOPA due to the predominantly xeric environment. I found evidence of voles (i.e., runways, cuttings, and actual observations) only in riparian habitats including adjacent greasewood understory. Diller and Johnson (1982) observed only moderate numbers of Western Whiptails in greasewood and riparian habitats, and low numbers in big sagebrush habitats. However, they predicted that whiptails had the greatest potential as a prey species due to their ubiquity and relatively high mean biomass (g/ha). I observed Western Whiptails only in shrub-steppe habitats, but no effort was made to determine numbers in this or other habitat types.

Craighead and Craighead (1956) found raptor numbers directly related to prey vulnerability but not related to prey density. Wakeley (1979), Bechard (1982) and Janes (1985) suggest that factors other than prey availability or density, such as vegetative cover or structure, may influence foraging patterns by raptors. Errington and Breckenridge (1936) noted that alteration of vegetation structure, such as mowing, increased vulnerability of some prey species to predation by harriers. Montan (1977) noted that irrigated wheat fields attracted breeding deer mice and voles, but wheat is harvested only once and grows to a height which renders prey less vulnerable to predation. In contrast alfalfa is harvested several times during its growing season, continually altering vegetation structure and density. As indicated in this study, voles were predated in alfalfa fields prior to vegetation height of 46 cm and after cutting of alfalfa fields. The shift to Western Whiptails is probably a response to the reduced vulnerability of voles. Diller and Johnson (1982) observed that habitats with high lizard densities had relatively low percent ground cover with many areas of open ground or rocks. Such habitat characteristics would probably increase vulnerability of Western Whiptails to predation by harriers.

Rice (1982) demonstrated that harriers depend heavily on auditory cues to locate prey. Harriers

may be at a disadvantage in locating or capturing prey in high, dense vegetation similar to alfalfa >46 cm. Difficulty in plunging through dense vegetation to capture prey may also be a major disadvantage, allowing escape time for potential prey. Both vole and lizard movements were highly audible in natural habitats to 2.0 m (pers. observ.).

Harriers appeared to prey upon high density, vulnerable vole populations in riparian-like habitats. When vole vulnerability to predation decreased, harriers shifted to low density, relatively high biomass Western Whiptail populations vulnerable to predation in open shrub-steppe habitats.

Temeles (1986) observed partitioning of foraging behaviors and habitat utilization between sexes in wintering harriers. Observations of males and females foraging in different directions from nests suggests that foraging behavior and habitat differences between sexes may continue during the breeding season, except when females are dependent on mates provisioning prey.

**Home Range.** Previous studies have observed male harriers hunting 4.0–7.0 km from the nest and may range even farther (Schipper 1973, 1977; Watson 1977; Barnard 1983; Thompson-Hanson 1984). Home range sizes observed in the BOPA differ considerably from those observed by Breckenridge (1935), who estimated 2.49 km<sup>2</sup> to be an individual home range for harriers in mesic habitats of Minnesota. Craighead and Craighead (1956) estimated home range for breeding harriers at 2.1 km<sup>2</sup> (range 0.6–6.3 km<sup>2</sup>). Hamerstrom and De La Ronde Wilde (1973) and Picozzi (1978) estimated a home range for a breeding pair to be 8.8 km<sup>2</sup> and 14.0 km<sup>2</sup>, respectively. Schipper (1977) observed home ranges of males sympatric with other harrier species varying from 1.8–12.3 km<sup>2</sup> ( $\bar{X} = 4.97$  km<sup>2</sup>). Balfour (1962) estimated harrier hunting ranges in Orkney with no sympatric competitors to be 66.4 km<sup>2</sup>. Thompson-Hanson (1984) found male home ranges in the shrub-steppe of eastern Washington varied from 72.1–366.0 km<sup>2</sup>.

Minimum home ranges estimated for females in this study are similar to those observed by Craighead and Craighead (1956) and Schipper (1977). Watson (1977) noted that females usually hunt a smaller area than males, but Balfour (1957) observed a female at eight km from a nest with young.

Thompson-Hanson (1984) critically reviewed field methods and various analyses of radiotelemetric data

for determining home range size for harriers, concluding that the minimum convex polygon method underestimates home range sizes. Swihart and Slade (1985) determined that nonstatistical methods, such as those used in estimating home ranges for harriers in this and other studies are valid, and that some statistical analyses may overestimate home range depending on the sampling interval of radio locations. However, large home ranges observed by Balfour (1962), Thompson-Hanson (1984) and this study may result from differences in habitat type and structure, or prey availability or vulnerability to capture. MacArthur and Pianka (1966), Schoener (1971, 1983) and Hixon (1980) predicted that the most probable response to a decrease in prey density is an increase in the foraging area.

**Conclusion.** Presuming the rationale of optimal foraging theory (Krebs et al. 1983), harriers may have visited relatively uncommon riparian and riparian-like (cultivated) habitats as long as foraging efforts were successful. When foraging efficiency declined, harriers shifted to common shrub-steppe habitat. After alteration of vegetation structure, increasing foraging efficiency of voles, harriers returned to riparian-like habitats. Rather than shifting specific search images of prey species (voles to lizards), harriers may have shifted foraging locations (riparian to shrub-steppe), each with differing prey species compositions. Such shifts in foraging location have been discussed by Royama (1970, 1971), Krebs et al. (1983) and Taylor (1984), or as a predator response to patchy or intermittent resources (MacArthur and Pianka 1966). Male harriers selectively foraging in habitat types with an associated prey species easily captured may have been observed during this study. Additionally, with male harriers preferentially foraging a select percentage of available habitat types, large home ranges were observed.

#### ACKNOWLEDGMENTS

I am grateful for the field assistance of W. V. Sykora. I thank K. L. Bildstein, S. H. Broadbent, A. and J. Comer, F. Hamerstrom, M. N. Kochert, C. D. Marti, B. and J. Martin, and K. Steenhof for their assistance, encouragement, and support. Also thanks to F. E. Andersen, P. E. Barnard, J. T. Flinders, M. N. Kochert, J. S. Marks, J. R. Parrish, L. R. Powers, C. L. Pritchett, R. E. Simmons, K. Steenhof, and C. M. White for reviewing and commenting on drafts. Special thanks go to M. Martin who patiently followed this study through to its completion, and E. Abram and J. R. Parrish who typed or edited earlier drafts. Research was supported by the Snake River Birds of Prey Research Project, U.S. Bureau of Land

Management, and the Zoology Department and Associated Students of Brigham Young University.

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Received 1 January 1986; Accepted 5 January 1987

**22nd Annual Meeting of The Raptor Research Foundation, Inc.**—The Raptor Research Foundation, Inc., will hold its annual meeting **28-30 October 1987** at the Red Lion Riverside Hotel, Boise, Idaho. The meeting will feature a symposium on migration of raptors in western North America. Karen Steenhof, Bureau of Land Management, 3948 Development Avenue, Boise, Idaho 83705, is the Program Committee Chairperson. **Deadline for abstracts is 31 July.** For more information contact the **Conference Committee Chairman, Rich Howard, U.S. Fish and Wildlife Service, 4696 Overland Road, Room 576, Boise, ID 83705, telephone (208) 334-1888.**

*J. Raptor Res.* 21(2):67

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## SHORT COMMUNICATIONS

### PEREGRINE FALCON NEST DEFENSE AGAINST A GOLDEN EAGLE

LARRY L. HAYS

In the southern portion of the Colorado Plateau, the Peregrine Falcon (*Falco peregrinus*) shares canyon nesting sites and hunting areas with Golden Eagle (*Aquila chrysaetos*), the Prairie Falcon (*Falco mexicanus*), the Turkey Vulture (*Cathartes aura*), the Red-tailed Hawk (*Buteo jamaicensis*) and the Common Raven (*Corvus corax*). It is not uncommon to see these species flying in the vicinity of Peregrine eyries in Zion National Park. All species listed above nest within a ½ km rad of a Peregrine eyrie where the incident reported herein occurred.

The canyon in which the eyrie defense took place is oriented east-west with the base of the cliff at an elevation of 1798 m. The cliff is 688 m in height. The Peregrine eyrie was located about 50 m below the top of the cliff.

By early May Peregrine Falcons in the park are well into incubation activities. The pair at the eyrie of interest followed a fairly regular incubation pattern. The male arrived at the eyrie between 0930 and 1000 H. The female left the nest-site, flew up to the cliff top, preened briefly and departed to hunt. She returned to the eyrie between 1400 and 1430 H and relieved the male.

At 0950 H on 8 May 1985 an adult Golden Eagle passed slightly below the Peregrine eyrie soaring west along the cliff face. The female Peregrine left the nest-site and attacked the eagle, striking it heavily on the back between the wings. The male Peregrine appeared over the top of the cliff and joined in the attack. During the attack, the eagle rolled over and attempted to use its feet in defense but was not able to react quickly enough to the stoops from both falcons. The simultaneous attacks caused the eagle to collide with the cliff wall several times, after which the eagle had difficulty regaining its balance and in reorienting itself.

Finally, the female Peregrine stooped and struck the eagle in the head or neck. The eagle dropped inert with no attempt to fly and fell approximately 184 m into trees on one of the ledges on the cliff face. The female Peregrine circled the spot where the eagle had disappeared while the male entered the eyrie. It was not possible to retrieve the eagle since the trees were located on a ledge 244 m above the canyon floor. It is not known whether the Golden Eagle was killed but it never reappeared during the remainder of the observation period. The female Peregrine flew back to the top of the cliff and perched. Every few minutes for the next 40 min she left her perch and flew

back over the area where the eagle had fallen. The female finally left and flew south disappearing over the top of the cliff. She returned to the eyrie at 1420 H and the male flew to the top of the cliff and perched. He stayed for a short time and then flew down the canyon west out of sight. Neither falcon was again seen to circle the site where the Golden Eagle had disappeared. Observations were continued during the remainder of the day until 1900 H.

The following observations during the eyrie defense were noted. The female Peregrine vocalized during the entire incident but the male did so only a few times. The female was particularly persistent in her attacks and several times struck the eagle hard enough to force it to fall two-three m before regaining flight. The male's attack consisted of a series of swift strikes to the eagle's back and wings. The male always maneuvered to attack from the direction of the sun while the female's attack did not demonstrate any pattern.

Interspecific interactions between Peregrine Falcons and the other raptors using the same nesting areas are not unusual. (Nelson, M. W. The status of the Peregrine Falcon in the northwest. In J. J. Hickey, Ed. *Peregrine Falcon populations: their biology and decline*. Univ. Wisconsin Press, Madison, 1969; Nelson, R. W. Some aspects of breeding behavior of Peregrines on Langara Island, British Columbia. Ph.D. Dissertation, Univ. Calgary, Alberta, 1970; Porter, R. D., and C. M. White, The Peregrine Falcon in Utah, emphasizing ecology and competition with the Prairie Falcon. Brigham Young Univ. Bull., 1973; Ratcliffe, D. Breeding density in the Peregrine Falcon (*Falco peregrinus*) and Raven (*Corvus corax*) *Ibis* 104, 13–39, 1962; Walton, B. *Raptor Res.* 12(1/2):46–47, 1978) Generally, observations in Zion National Park reveal that Golden Eagles and Prairie Falcons receive more serious attacks from Peregrines when encounters occur. Attacks on these species are prolonged and usually continue until the intruding bird is driven from the area. Other species mentioned at the beginning of this paper elicit a few stoops from Peregrines but the aggressive behavior is less intense and shorter in duration.

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Received 3 April 1986; Accepted 1 April 1987

*J. Raptor Res.* 21(2):68–70  
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## OBSERVATIONS OF A RADIO-TAGGED GOLDEN EAGLE TERMINATING FALL MIGRATION

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On 26 November 1974 a Golden Eagle (*Aquila chrysaetos*) was trapped at Cedar Grove, Wisconsin, 60 km north of Milwaukee, and a 2 g radio transmitter was affixed to the ventral side of an outer rectrix feather (Cochran 1975). The eagle was banded with a U.S. Fish and Wildlife Service leg band, released and tracked throughout each day until 7 December. After 7 December the bird was tracked for all or part of eight additional d until 2 January.

Haugh (1972:21) notes that Golden Eagles at Hawk Mountain, Pennsylvania, reached maximum numbers about 20 September–23 November. Observations at Hawk Ridge, Minnesota (Hofslund 1966:82, Table 2) show Golden Eagles passing in September, October, and November but not in December. The data suggest that Golden Eagles migrate conventionally in fall (i.e., move south toward a wintering area). Bent (1937:314), on the other hand, asserts that the fall migration of Golden Eagles resembles a wandering rather than a migratory movement. Our observations are consistent with both views with wandering limited to a wintering phase after conventional migration ends.

From release at 0600 H on 26 November until 29 November the eagle covered a total of 215 km at an average rate of 43 km/d (rates are based on distance between roost sites). On 27 November the eagle shifted course from southerly to westerly (Fig. 1). After 29 November, and during 29 days of intermittent observation, the eagle's rate of movement slowed to an average of 3 km/d. We believe a shift from a migratory to a wintering phase occurred between 27 and 29 November when course and average daily rate of travel changed.

Activity during the wintering phase consisted of 1) flying from a roost to carrion and back to the same roost, 2) some hunting ( $\bar{x} = 1.7$  kill attempts/d), and 3) flights to search for carrion when carcasses became depauperate of food (2, 8, and 12 December). No other eagles were observed throughout the study, probably due to a low density in northern Illinois (see Millsap and Vana 1984). Only the American Crow (*Corvus brachyrhynchos*) was observed competing with the eagle for carrion; the crows always left when the eagle approached. Our observations of the Golden Eagle suggest exploitation of carrion to offset low prey abundance or hunting success; further, there was little competition for carrion. Utilization and preference for live prey by breeding Golden Eagles has been documented (Brown and Watson 1964; O'Gara 1982; Tigner and Larson 1982; Nette et al. 1984). Greater abundance of food during the nesting season would permit a different pattern of food preference.

During winter wandering, 11 kill attempts were recorded in 19 d of close observation (1.7 kill attempts/d). The Golden Eagle has been reported to have a 20% success rate of prey capture (Collopy 1983). The radio tagged eagle attacked and injured a Ring-necked Pheasant (*Phasianus colchicus*), but our presence aborted the attack and permitted the pheasant to escape. Interference with the natural outcome of kill attempts was not our only problem in observing the eagle's hunting of live prey. In some instances we tracked the eagle to an area where it had perched, possibly on prey, but flushed the bird before we were able to identify the location accurately enough to look for prey remains. In other instances the eagle took flight again before we were close enough to determine if small prey had been captured or eaten.

Our observations of the Golden Eagle and those for the Bald Eagle (*Haliaeetus leucocephalus*) indicate that both species rely heavily on carrion as a winter food but employ different search strategies (Hansen et al. 1984; Stalmaster and Gessaman 1984; Fischer 1985). Golden Eagles may wander over large areas in search of carrion, whereas Bald Eagles achieve the same end with much less movement. In the case reported here, inter- and intraspecific competition was virtually absent, and an average of 4% of each 24-hr day was spent flying. Longer flights ended when carrion was located. In contrast Bald Eagles are reported to spend only 1% of their time in flight (Stalmaster and Gessaman 1984) and face considerable competition for carrion (Hansen et al. 1984; Fischer 1985).

### ACKNOWLEDGMENTS

We wish to thank B. Pastor, D. Pastor, D. Morpurgo, P. Lowery, and J. F. Harper for assistance in monitoring the eagle. R. E. Warner, C. D. Burnett, and G. C. Sanderson critically reviewed the manuscript. C. R. Griffin, A. Harmata, and an anonymous reviewer provided useful comments.

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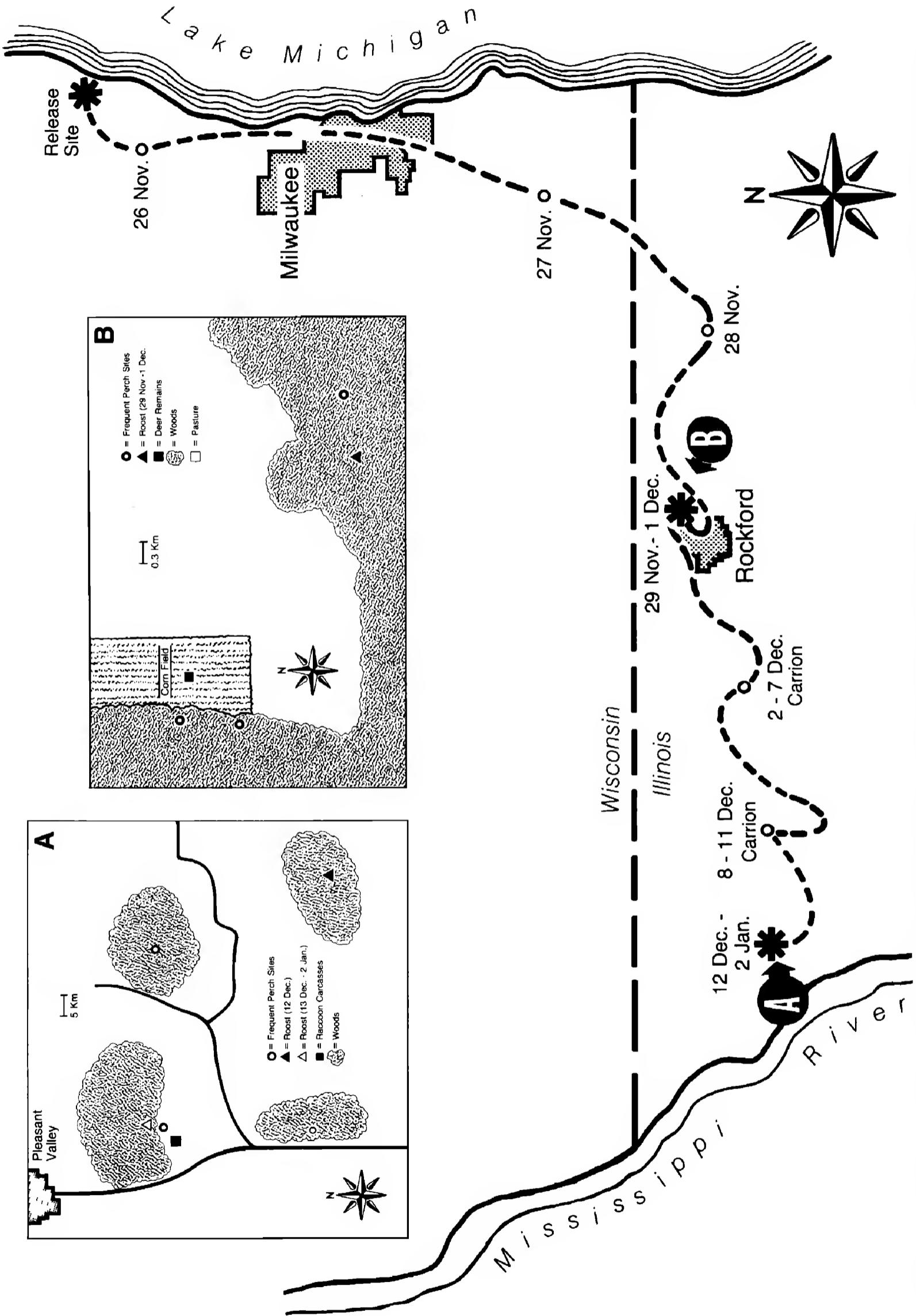


Figure 1. Migratory and winter movements of a Golden Eagle radio-tracked from Wisconsin to northwestern Illinois 26 November 1974-2 January 1975. Dashed line indicates general route taken by the eagle and closely approximates the actual route determined by visual observation and radio fixes. Dates indicate the roost locations used by the bird during the period of study. A) Detail of Golden Eagle activity associated with Raccoon (*Procyon lotor*) carrion. B) Detail of Golden Eagle activity associated with remains of a White-tailed Deer (*Odocoileus virginianus*). Alternate perch sites associated with A and B were used by the eagle during daytime flights to the carrion.

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Received 12 January 1987; Accepted 20 April 1987

*J. Raptor Res.* 21(2):70-72

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## FERTILITY AND HATCHABILITY OF FALCON EGGS AFTER INSEMINATION WITH FROZEN PEREGRINE FALCON SEMEN

JOHN E. PARKS AND VICTOR HARDASWICK

A procedure for freezing and post-thaw treatment of semen from the Peregrine Falcon (*Falco peregrinus*) was recently reported by Parks et al. (1986). During the spring of 1986, a project was undertaken to test fertility of Peregrine Falcon semen which had been frozen by this procedure and stored in liquid nitrogen for at least one year.

Four female Prairie Falcons (*F. mexicanus*) imprinted on humans and with histories of laying eggs in captivity were acquired from falconers and captive breeders in the United States. Prairie Falcons were used because of their availability and because of reasonable expectations for good fertility (Hardaswick and Smith 1981). Birds were housed in individual breeding chambers at the Ithaca, New York, facility of the Peregrine Fund, Inc. (see Weaver and Cade 1983 for description). Chambers were modified with low perches and nest ledges to enhance interaction between the birds and individuals working with them and to facilitate subsequent artificial insemination. At the onset of the breeding season, individuals working with imprinted falcons engaged in vocalizations, food transfers and other courtship rituals necessary to induce females to lay. Two female American Kestrels (*F. sparverius*) were housed in 1.82 × 1.22 × 2.44 m (L × W × H) chambers equipped

with a food port and nest box. Kestrels were not imprinted on humans so that interaction with a male was considered important to initiate courtship behavior and laying by females. Therefore, male kestrels were maintained in adjacent chambers. A window with vertical barring was placed in the common wall which permitted courtship between the male and female but prohibited copulation.

Straws of frozen semen were thawed in a water bath at 4°C and dialyzed to remove glycerol using a stepwise procedure (Parks et al. 1986). Preparation of semen for artificial insemination required approximately 1.5 hr post-thaw. Single inseminations (80 µl) of semen originally diluted 1:3 (v/v) were made within 4-10 hr after oviposition. Thawed, dialyzed semen was maintained at 0-4°C until the oviduct was everted for insemination. Semen was then transferred to an insemination syringe and deposited in the oviduct (Weaver 1983).

After several eggs had been laid following inseminations with frozen-thawed semen two female Prairie Falcons were inseminated with fresh semen to 1) provide a measure of female fertility with fresh semen, and 2) ensure production of young for a separate project. Fresh semen was obtained from a Peregrine Falcon and a Peregrine Fal-

Table 1. Fertility of falcon eggs after artificial insemination with fresh or frozen-thawed semen.

FEMALE <sup>a</sup>	CLUTCH <sup>b</sup>	EGG-LAYING SEQUENCE IN DAYS <sup>c,d</sup>				
		1	5	10	15	20
P1	1	O <sub>o</sub> — O <sub>o</sub> — — O <sub>o</sub> — O <sub>o</sub> — —				
	2	O <sub>•</sub> — — — X <sub>•</sub> — — X <sub>•</sub> — X <sub>•</sub> — — X <sub>•</sub> —				
P2	1	O <sub>o</sub> — X <sub>•</sub> — — X <sub>•</sub> — — X <sub>•</sub> — —				
	1 (cont'd)	X <sub>•</sub> — X <sub>•</sub> — X <sub>•</sub> — — X <sub>•</sub> — X <sub>•</sub> — — X <sub>•</sub> — X <sub>•</sub> — X <sub>•</sub> —				
P3	1	O <sub>o</sub> — — O <sub>o</sub> — O <sub>o</sub> — — O <sub>o</sub> — O <sub>o</sub> — X <sub>o</sub> — — O <sub>o</sub> — —				
	2	O <sub>o</sub> — — — O <sub>o</sub> — O <sub>o</sub> — O <sub>o</sub> — —				
P4	1	O <sub>o</sub> — — X <sub>o</sub> — X <sub>o</sub> — X <sub>o</sub> — — X <sub>o</sub> — —				
	2	O <sub>o</sub> — — — O <sub>o</sub> — — O <sub>o</sub> — —				
K1	1	O <sub>o</sub> — X <sub>o</sub> — — O <sub>o</sub> — O <sub>o</sub> — O <sub>o</sub> — —				

<sup>a</sup> P1–P4, Prairie Falcons; K1, American Kestrel.<sup>b</sup> Second clutches began 12 to 14 days after removal of first clutches.<sup>c</sup> O = infertile egg, X = fertile egg, — = no egg laid.<sup>d</sup> Open circle = insemination with frozen-thawed semen, closed circle = insemination with fresh semen.

con × Gyrfalcon (*F. rusticolus*) hybrid as previously described. Inseminations with fresh semen were similar to those described for frozen-thawed semen except that volumes of 20–70 µl of untreated and undiluted semen were used.

Female Prairie Falcons were managed according to Burnham et al. (1983) in an effort to maximize egg production. Therefore, eggs were removed sequentially as subsequent eggs were laid. The duration of fertility and schedule of inseminations are presented in Table 1.

Eggs were artificially incubated from day one until female P1 began to demonstrate incubating behavior near the end of her first clutch. From that time, all Prairie Falcon eggs were naturally incubated by one of the female Prairie Falcons for 7–10 days prior to artificial incubation to enhance hatchability (Burnham 1983). Consequently, all fertile Prairie Falcon eggs were incubated under the same conditions. Incubation was carried out in Roll-X incubators (Marsh Farms) at 37.5°C with humidity regulated to achieve 15% weight loss to pip. Kestrel eggs were naturally incubated by the laying female from day one until pip.

After individual female Prairie Falcons had incubated eggs for up to 11 d, all eggs were removed in an effort to recycle females and obtain a second clutch. Second clutches were obtained from all three females from which first clutches were removed (Table 1).

After pipping, eggs were transferred to a hatcher and maintained at 36.5°C with relative humidity between 55 and 60% from pip to hatch. Chicks were left in the hatcher until dry and then transferred to a still air brooder at 36°C. Chicks were fed a diet of whole Coturnix Quail (*Coturnix coturnix*) freshly killed and ground daily. Young birds were fed with the aid of small forceps until capable of eating from a shallow dish.

Of a maximum of 28 eggs potentially fertilized with frozen semen seven were fertile (Table 1). Twenty-four eggs were from four Prairie Falcons and four were from a single American Kestrel. Five of the fertile eggs were from female P4, one from female P3, and one from female K1. The reason for the large difference in fertility between females with frozen semen is not known. Five of the fertile Prairie Falcon eggs developed to pip, hatched unassisted and developed normally to fledging. One of the fertile eggs from the kestrel developed normally to pip and hatched with assistance, but the chick died shortly after hatching.

Sixteen of 17 Prairie Falcon eggs potentially fertilized with fresh Peregrine Falcon semen were fertile, eight developed to pip, seven hatched normally and one hatched with assistance. Based on the 11 d duration of sperm fertility reported in female American Kestrels (Bird and Buckland 1977) it is possible that the first eggs laid by female P2 after insemination with fresh semen could have been fertilized by frozen-thawed sperm. However, this possibility is considered unlikely since the first egg laid following insemination with fresh semen was infertile. Female P1 was not inseminated with fresh semen until the beginning of her second clutch, which was 23 d after the final insemination with frozen-thawed semen.

Fertility of eggs following inseminations with frozen semen was 25% compared to 94% fertility with fresh semen. There was no apparent difference between eggs from fresh vs. frozen semen in time of incubation or survival and development of young. Poor hatchability of fertile eggs obtained using fresh semen appeared to be directly related to use of hybrid falcon semen, although this cannot be stated conclusively for every egg. Death of the Peregrine × kestrel hybrid after hatching probably reflects the viability of that hybrid rather than any effect of frozen semen.

All young produced in this project were placed with

licensed Master falconers at approximately 10 d of age in return for information on their growth and development. Young produced using frozen semen have developed normally.

The level of fertility obtained in this study was low but encouraging. Others have obtained fertility levels of up to 30% with frozen kestrel semen using dimethylacetamide as the cryoprotectant rather than glycerol (Brock et al. 1983; Brock 1986). George Gee (pers. comm.) suggested that 50% fertility can be obtained with frozen kestrel semen when dimethyl sulfoxide was used as the cryoprotectant. We have been unable to maintain post-thaw viability of Peregrine sperm with either of these cryoprotectants. The procedures used in this study demonstrate that use of frozen semen is a realistic option in the captive breeding of large falcons. However, more practical methods for processing peregrine semen and higher fertility are needed before frozen semen will be useful in most captive breeding situations.

#### ACKNOWLEDGMENTS

This project was supported in part by The American Wildlife Research Foundation, Inc., The Sulman Falcon Centre and The Peregrine Fund, Inc. The authors are especially grateful to those falconers and raptor breeders who placed healthy, productive imprinted Prairie Falcons in the project and to Allison LaVigne for her excellent technical assistance.

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Received 6 October 1986; Accepted 12 March 1987

*J. Raptor Res.* 21(2):72-73

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#### NORTHERN HARRIER (*Circus cyaneus*) PREDATION ON WINTERING WATERFOWL

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Foods of the Northern Harrier (*Circus cyaneus*) include mammals (small and/or immature individuals), birds (mostly passerines), amphibians, reptiles, insects and carrion (Errington and Breckenridge 1936; Randall 1940; Hecht 1951; Weller et al. 1955). Blohm et al. (1980) reported flushing harriers from waterfowl carcasses; however, it is uncertain if these harriers had actually killed or were scavenging.

Schipper et al. (1975) observed Northern Harriers opportunistically preying on sick or wounded waterfowl, and Fitzpatrick (1979) observed a harrier drowning a Common

Moorhen (*Gallinula chloropus*). However, few observations of harrier attacks on healthy adult or subadult waterfowl have been documented. Hammond (1948) and Griffiths et al. (1954) described harrier attacks on waterfowl; accounts were based upon single observations. Additionally, in neither account was the physical condition of the prey reported.

Our objective is to report four chronological observations of Northern Harriers attacking wintering waterfowl in Castro, Hale, and Parmer counties, Texas. In three of the four observations the ducks were known to be capable of

flight, and all of the carcasses recovered had deposits of visceral, omental, and subcutaneous fat. The harrier in each observation was dark brown with chest and wing streaking, presumed to be a female.

On 22 January 1985, about 1630 H, a male Northern Pintail (*Anas acuta*) was apparently wounded by hunters. The pintail flew a short distance, landed on ice near an area where a harrier had previously been observed quartering for prey, and walked toward shoreline vegetation. The harrier reappeared and quickly approached the pintail. The pintail crouched evading the harrier's initial attack. The harrier then circled and grasped the pintail. No movement was seen from the pintail afterwards, and it was apparently dead before the harrier started feeding. Attacks by the harrier came both with and against the wind, a behavior not previously described for attacks on waterfowl. The carcass of the pintail could not be recovered for examination.

On 14 December 1985, about 1100 H, several Green-winged Teal (*A. crecca*) were flushed from an opening in lake ice. The majority of the teal remained together; however, a male separated and landed on the ice. A harrier previously seen quartering for prey grasped the lone teal, but was unable to retain its grip on the back of the duck. Following the initial attack, the teal made four attempts to escape by flight, only to be driven back onto the ice by the harrier. The harrier successfully captured the teal on the fifth attempt pinning it onto the ice. Several seconds passed without any movement from the teal before the harrier began feeding. Examination of the carcass revealed fat reserves, indicating the teal was not emaciated from stress or disease.

On 19 December 1985, about 1130 H, a harrier attacked a flock of American Wigeon (*A. americana*) on open water surrounded by ice. Following the attack, most wigeon flew several meters and landed on the ice, but one male submerged. When the male wigeon resurfaced, the harrier dropped from a hovering position and the duck submerged again. The harrier hovered with legs descended, apparently aided by a strong wind. The harrier attacked seven times before the wigeon attempted to escape by flight. The harrier quickly grasped the wigeon in the scapular region, and both birds fell to the ice. The wigeon struggled and nearly escaped, but the harrier successfully held the duck onto the ice. The wigeon continued to struggle but died following repeated strikes to the head and neck by the harrier. The harrier fed only upon the breast region of the wigeon. Examination of the carcass revealed fat reserves, indicating the wigeon was not emaciated from stress or disease. No previous record of aerial attacks on subadult or adult waterfowl by harriers was located.

On 18 February 1986, about 1630 H, a harrier was seen with both feet clasped around the neck of a male Green-winged Teal and was attempting to drag the duck from the water. The harrier released its grip and the teal

submerged. The harrier hovered with legs descended until the teal resurfaced and then attacked again, a sequence which occurred several times. The harrier once again caught the teal by the neck, but the teal struggled and escaped. At this point, the harrier flew off but returned, passing over several ducks including the previously attacked teal. The teal initiated a series of dives which the other ducks did not. The harrier hovered, made several unsuccessful attacks each time the teal resurfaced, and then flew away. The teal rejoined a group of ducks nearby.

Our observations contribute information on the hunting behavior of Northern Harriers. Additionally, we also observed Northern Harriers perched on waterfowl traps containing ducks. From our observations it is apparent that wintering harriers will opportunistically prey on live waterfowl.

#### ACKNOWLEDGMENTS

We thank Jerry Broda for supplemental details on the 14 December 1985 attack. We also thank Eric Bolen for comments on this manuscript. Funding for this manuscript was provided by the Caesar Kleberg Foundation for Wildlife Conservation. This is contribution No. T-9-445, College of Agricultural Science, Texas Tech University.

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Received 20 December 1986; Accepted 6 April 1987

*J. Raptor Res.* 21(2):74

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## COMMON BARN-OWLS FROM CAPTIVE PROPAGATION FOUND NESTING IN THE WILD

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The Common Barn-Owl (*Tyto alba*) is an endangered species in Missouri and much of the Midwest. Dwindling Midwestern barn-owl populations have been linked to loss of foraging habitat, lack of available nest sites, winter mortality, and predation by Great Horned Owls (*Bubo virginianus*) (Colvin, *J. Field Ornith.* 56(3):224–235, 1985; Marti, *Condor* 87(1):111–115, 1985). In an effort to restore barn-owl populations, Missouri has been involved in a barn-owl captive breeding and reintroduction project.

From 1983–85 the Raptor Rehabilitation and Propagation Project, Inc. (RRPP) and the Missouri Department of Conservation reintroduced 157 captive-reared barn-owls into St. Charles County, Missouri. The release area centered around a 400 ha riverine marsh (Marais Temps Clair Wildlife Area) which is surrounded by Missouri and Mississippi River agricultural bottomland. All reintroduced barn-owls were banded with USFWS aluminum lock-on leg bands. Beginning in 1985, seamless USFWS leg bands were also placed on all captive reared barn-owls at the RRPP. A search of the study area was conducted from 1 March to 1 August 1985 and 1986 to determine the nesting success of reintroduced barn-owls.

Three barn-owl nests were discovered in St. Charles County during 1985. Photographs of nesting pairs confirmed that both parents of one nest site wore USFWS lock-on leg bands. A two m long wooden trough served as a nesting structure for the banded pair. Three chicks hatched and fledged from this nest. Band numbers on the trough site pair could not be read from the photographs and the pair was not captured. Mobility of barn-owls and the occasional banding of wild birds preclude a firm conclusion that this banded nesting pair was captive-propagated (C. Marti, pers. comm.). However, an adult female barn-owl was found dead below the trough nest site during the last week of the nestling period. The band number revealed that she had been born in captivity at the RRPP and released in May 1984 in a barn 200 m south of the recovery site.

During the summer of 1986, three barn-owl nests were discovered in St. Charles County. A pair of barn-owls utilizing a nest box was captured. The male was banded

and had been born in captivity at the RRPP and released in May 1985 seven km south of where it was found. The male was 13 mo old at the time of the nesting. Of the five eggs laid four chicks hatched and fledged. Two 1985 captive-propagated and reintroduced barn-owls were captured from an airplane tail section during January and February of 1986. No eggs were present at the time of the captures. In July 1986 seamless and lock-on leg bands were visually confirmed for both parents of a nest in the plane tail section by the use of 7 × 35 binoculars. Three barn-owl chicks were present in the airplane nest site at the time of the banding confirmation. The parents could not be captured and it could not be determined whether these were the same owls captured in January and February.

We could find no published accounts which document successful breeding in the wild by captive-propagated barn-owls. Marti and Wagner (*Raptor Res.* 14(1):61–62, 1980) fostered a young male barn-owl to a wild nest and discovered it nesting in the wild one yr later. They also reported a “tame” female barn-owl, not born in captivity but raised in captivity, later forming a pair bond in the wild (C. Marti, pers. comm.). Although limited, these results suggest that barn-owls born in captivity and released in suitable habitat can survive and breed in the wild.

### ACKNOWLEDGMENTS

Support facilities for this study were provided by the RRPP, Inc. This work was supported in part by funds from the Missouri Department of Conservation. The authors would like to thank J. E. Wylie, P. Gillett, C. Hager, J. Meshach, D. Matlock and J. Brown for their assistance. Richard W. Coles, R. Knight, J. S. Krikley, C. D. Marti, J. D. Wilson and J. H. Wilson reviewed earlier versions of this manuscript.

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Received 28 November 1986; Accepted 12 March 1987

*J. Raptor Res.* 21(2):75–77

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## APPARENT INCREASE IN A GRIFFON VULTURE (*Gyps fulvus*) POPULATION IN SPAIN

JOSÉ ANTONIO DONÁZAR

Little is currently known about the population dynamics of large carrion-eating raptors. These species maintain fairly constant numbers which are limited by the capacity of their environment (Wilson 1975; Mundy 1982), since populations have a low capacity to expand (Mertz 1971).

The Griffon Vulture (*Gyps fulvus*) is a large carrion-eating raptor weighing 6–11 kg. This article presents data on possible causes of a substantial increase in a Griffon Vulture population in the northern part of the Iberian Peninsula.

The study area extends 11 000 km<sup>2</sup> and includes the province of Navarre and the northern part of the province of Zaragoza in the western zone of the Spanish Pyrenees. The first census of Griffon Vultures in the area was conducted by the Spanish Ornithological Society in 1979, and a second was carried out privately in 1984. Elósegui (1974) provided detailed information on the distribution of the vultures. Every rock site capable of harbouring vultures (94 cliffs) was visited in both censuses. Ten personnel participated in the 1979 census working 38 d. In 1984 nine personnel participated working 54 d. The number of days worked/vulture colony was 1.3 in 1979 and 1.4 in 1984. Each observer was responsible for a series of colonies. A drawing of each colony indicating front elevation and position of each nest was accomplished in 1979. In the 1984 census each experienced observer counted the same colonies he had counted five yr earlier. Five of nine observers were experienced and evaluated 73.6% of the nests in 1984. Unexperienced observers used the drawings showing the position of nests found in 1979. Both censuses occurred basically between February and April, the 1979 census being conducted later (March–April) than in 1984 (February–March) due to climatological difficulties encountered during February 1979. All colonies were counted during acceptable light conditions on days with no rain. Counting method consisted of observations with telescopes at a distance that would not cause disturbance. Most nests were placed in canyons, and observations were made from sites located on opposite canyon walls. Inactive pairs (identified by the continuous presence of two adults in possible nesting localities and/or by the presence of an empty nest) as well as incubating pairs were counted. Each colony was visited until virtually all nests were counted, including those partially concealed by vegetation which were detected by the behaviour of the incubating adults (incubation relief and position changes; see also Leconte 1985). Nevertheless, a fraction of the population may have gone unnoticed. Census coverage was calculated to be 85–90% in 1979 and 95–100% in 1984. The differences are due mainly to the fact that the dates of the 1979 census may

have resulted in pairs without eggs and with abandoned nests not being detected.

Census results are listed in Table 1. Twenty-nine colonies were detected in 1979 and 39 in 1984. A marked population increase (51.8%) appears to have occurred between 1979 and 1984. Based on the number of nests each colony contained in 1979, there was an increase of 22.3% in colonies that had one to ten nests, 30.8% in those that had 11–20 nests and 64.7% in those of >20 nests. Twelve new colonies with one to five nests were counted in 1984, and two previous colonies with one and two nests, respectively, were no longer in existence. It must be pointed out that in only two colonies (No. 5 and No. 12) an increase of 90.1% (91 nests) was produced (Table 1). The annual population increase (8.7%) exceeds any predicted increase under even optimum conditions for similar carrion-eating raptors (Piper et al. 1984). These results are not due to the census methods. In both years the dates of the field work, the number of observers, climatology and the effort spent in each colony were very similar. The increase in the total number of work days in 1984 is a logical result of the greater volume of colonies and nests. The fact that the same personnel that worked in 1979 also counted the greater part of the nests in 1984 helped to insure valid results. Such was the case with the largest colonies (No. 5 and No. 12) that were counted in both years by J. Elósegui and the author. In both colonies new nests were occupied in parts of cliffs that were formerly unoccupied by vultures and were thus easily detected. On the other hand, in the years between the censuses we realized through occasional visits that these and other colonies were progressively increasing, a trend which seems to have continued since 1984.

The increase of Griffon Vulture populations is a recent event in the Iberian Peninsula and is not restricted to the study area; recent increases have been well documented in the French and Catalonian Pyrenees (C.R.P.R. 1984; Leconte 1985). Further, there is evidence of increases in the Aragonian Pyrenees and Cantabrian Mountains (R. Heredia, pers. comm.), in Rioja (Lopo and Ceballos 1985) and in Vascongadas (Alvarez et al. 1985). Determining the causes of the increase is very complicated. There is no data to indicate a recent increase in reproduction in my study area. The only data available is the reproductive success in 1984 which ranged between 0.52 and 0.88 fledgling/egg for some colonies. Also, it could be that in 1984 previously non-reproductive adults and/or subadults were nesting, but such was rare in the study area (J. Elósegui, unpubl. data). Immigration from other Iberian colonies would be possible, but such is very rare in the rest of

Table 1. Census data for 1979 and 1984 of a Griffon Vulture population in the northern Iberian Peninsula.

COLONY NUMBER	CENSUSED PAIRS	
	1979	1984
1	10	10
2	0	3
3	10	20
4	2	1
5	46	89
6	3	3
7	7	8
8	12	19
9	6	2
10	13	11
11	0	1
12	52	103
13	0	1
14	0	1
15	1	1
16	0	2
17	2	2
18	7	8
19	0	1
20	0	1
21	20	31
22	3	3
23	5	6
24	34	47
25	6	9
26	17	24
27	5	9
28	32	38
29	0	1
30	16	17
31	23	31
32	7	9
33	3	2
34	5	7
35	0	1
36	2	0
37	9	15
38	0	2
39	1	0
40	0	1
41	0	5
<b>Totals</b>	<b>359</b>	<b>545</b>

Europe and north of Africa where *Gyps fulvus* populations are very scarce (Cramp and Simmons 1980). Currently, there is no information (ringing recoveries) to support this possibility.

A decline in mortality could have occurred in recent decades. Between 1956 and 1961, 968 vulture deaths were

recorded in only six Spanish provinces (Anon. 1962), which could explain the parallel decrease in vulture numbers (Elósegui 1974; S.E.O. 1981). In the last few decades hunting pressure has virtually disappeared since raptors are now protected by law. With an adult mortality of near 0%, a subadult mortality of around 30% would be necessary to obtain an 8% population increase (see Mertz 1971), assuming, optimistically, that all females reproduce at age five and produce one hatchling. However, these percentages do not fit with those for other large carrion-eating species (Hiraldo et al. 1979; Piper et al. 1981).

In conclusion it is difficult to explain the rapid increase in the effective number of *Gyps fulvus* in the northern part of Spain given the current level of knowledge on the biology of carrion-eating raptors. There may not, in fact, be a single reason for the increase. In any case the need for new data on the status of the Griffon Vulture in the Iberian Peninsula and for in-depth research into population dynamics of the species is one way to begin to answer such questions.

#### ACKNOWLEDGMENTS

The field work was done in collaboration with J. Elósegui, R. Elósegui, A. Senosiain, A. Munilla, C. Fernández, J. Leoz, A. Bergerandi, G. Bergerandi and group SAIAK. F. Hiraldo, D. C. Houston, P. Rabenold and J. Jackson read earlier drafts of the manuscript and made valuable suggestions for its improvement.

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Received 1 December 1986; Accepted 11 March 1987

*J Raptor Res.* 21(2):77-78

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### NORTHERN PYGMY-OWL NESTS IN NORTHEASTERN OREGON

EVELYN L. BULL, JANET E. HOHMANN AND MARK G. HENJUM

Little is known about the Northern Pygmy-Owl (*Glaucomys gnomus*) and nests have been reported infrequently (Bendire 1883; Calderwood 1889; Holman 1926; Braly 1930; Norton and Holt 1982; Holt and Norton 1986). Because so little is known of the pygmy-owl in North America, we are reporting our findings for two nest sites in Union County in northeastern Oregon.

On 17 April 1981 a pygmy-owl nest was found in an old Northern Flicker (*Colaptes auratus*) cavity 10 m off the ground in a dead Douglas fir (*Pseudotsuga menziesii*). The nest tree was 39 cm dbh (diameter at breast height) and had a broken top. The tree was on the edge of a meadow at the base of a 63% slope in a mature, unlogged stand of Douglas fir with a canopy closure of 81%. The stand was 100-200 m wide, 2 km long, and surrounded by meadows; adjacent forest stands were within 150 m. The nest tree was 110 m from a stream. The outcome of this nesting attempt was unknown.

On 21 April 1986 a second pygmy-owl nest was found 12 m above the ground in a 52 cm dbh live grand fir (*Abies grandis*). The nest cavity was probably excavated by a Williamson's Sapsucker (*Sphyrapicus thyroideus*) originally, based on general appearances (Bull 1980). The tree was broken off at 15 m height.

The second nest failed sometime before 15 May, although fresh pellets were found regularly through 7 May. We climbed the tree on 15 May and found three or four eggs in the cavity; at least one was cracked. The cavity opening was 4.8 cm high × 4 cm wide. The cavity was 18 cm deep × 32 cm wide with five cm of wood between the outside of the tree and the inside of the cavity. The tree was 41 cm dia at the cavity entrance, and the tree was hollow with a shell of sapwood surrounding the cavity.

The nest tree was located 15 m from a stream on an

east-facing 58% slope. The surrounding stand within 100 m was unlogged, old-growth grand fir with 87% canopy closure and three canopy layers, the highest at 40 m. Outside the immediate stand but within a 500 m rad of the nest, 86% of the forested land had been recently logged (partial removal).

Pellets and prey remains were found under eight trees, which we called roosts. We assumed that these pellets were deposited by the female because the female keeps the nest hole clean of old prey remains (Mikkola 1970; Schonn 1980). The roosts were 10-17 m uphill from the nest tree. Five of the roosts were grand fir (four live trees and one dead tree), and three were live Douglas fir. The dbh of these roosts were 22-50 cm ( $\bar{x} = 35$  cm).

We found 44 pellets and prey remains under the roosts between 21 April-7 May. The length and width of pellets averaged 27 × 11 mm, respectively. Skulls, jaws, or other remains of four voles (*Microtus* spp.), four shrews (*Sorex* spp.), one Heather Vole (*Phenacomys intermedius*), two Deer Mice (*Peromyscus maniculatus*), 10 insects, and 12 sparrows were found. Many pellets contained no identifiable skulls. Males frequently eat the forepart of the body of a small animal and take the posterior part to the nest (Mikkola 1970), thus few remains of skulls were found in the female's pellets.

Our observations are similar to those reported for *G. passerinum* (Scherzinger 1974; Schonn 1980). More information is needed on nest site characteristics of the Northern Pygmy-Owl to understand habitat requirements and potential impacts of land management activities on the species.

#### ACKNOWLEDGMENTS

The Pacific Northwest Research Station of the USDA

Forest Service and the Oregon Department of Fish and Wildlife funded this study. We thank H. D. Cooper, W. I. Haight, C. E. Hallett, M. St. Louis, P. Sullivan, and W. G. Williams for their assistance.

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Received 15 December 1986; Accepted 12 March 1987

**Request for Assistance**—Snowy Owls (*Nyctea scandiaca*) are being banded and color-coded RED in central Wisconsin. The RED color-coding schemes being used are as follows: 1) RED X on the nape, dorsal surface of the right wing near the tip, dorsal surface of the rectrices near the tip; 2) RED O on the nape, dorsal surface of the left wing near the tip, dorsal surface of the rectrices near the tip; and 3) RED X on the nape, SOLID RED tips of right primaries, SOLID RED on left half of tail. A total of 15 Snowy Owls have been banded and color-coded since 10 December 1986. Report any sightings, including marking schemes observed, to Wisconsin Foundation for Wildlife Research, Inc., 9201 Rock Inn Road, Arpin, WI 54410, telephone (715) 652-2510.

**Request for Assistance**—The George Miksch Sutton Avian Research Center (GMSARC) is releasing Bald Eagles in east-central Oklahoma. The eagles are independent and begin to disperse from the release site in late June. The eagles are banded with a standard FWS aluminum band on the left leg and a white color band with black alphanumeric codes A-01 through A-99 on the right leg. In addition each eagle carries a radio-transmitter in the 216 MHz range.

Three previous sightings of hacked eagles suggest that these eagles can be expected to disperse and summer in the area of the upper Great Plains to the Great Lakes and perhaps into Canada. A researcher will be afield searching for radio-tagged eagles summering in the area. Anyone sighting immature eagles in this area, especially before locally produced eagles fledge, should 1) look for the right tarsal color band and report all information including band number, date and location to the Bird Banding Lab and 2) ASAP contact **GMSARC, P.O. Box 2007, Bartlesville, OK (918) 336-7778 collect** (leave a message on the recorder after hours). Cooperators with 216 MHz are needed.

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*J. Raptor Res.* 21(2):79

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## THESIS ABSTRACTS

### ENERGY REQUIREMENTS AND FOOD RESOURCE OF THE CAPE VULTURE *Gyps coprotheres* IN THE MAGALIESBERG, TRANSVAAL

This study describes the energy requirements and food resource of the Cape Vulture (*Gyps coprotheres*) around the Magaliesberg escarpment range in the Transvaal Province, South Africa.

The investigations of this study were concerned with growth, energy requirements and nutritional status of hand-reared and wild nestlings, and the energy requirements of captive adult and immature Cape Vultures. From these data annual food requirements of the Magaliesberg Cape Vultures were estimated. Growth and food requirements were interpreted in terms of an adaptive breeding strategy consistent with existing hypotheses in the fields of avian breeding biology and ecology. The potential food resource of the Magaliesberg Cape Vultures was inferred from agricultural, pastoral and veterinary census data for an arbitrary potential foraging area (PFA) around the Magaliesberg escarpment range. Food requirements and food resource of the Magaliesberg Cape Vultures were evaluated, and compared with other factors in terms of the possible limiting effect of these factors on the continued existence of Cape Vultures in rural areas.

Body mass and wing length are similar for hand-reared and wild nestlings of known age, and wing length is a reliable measure of age and growth. The rate of growth in nestlings is intrinsic and shows very little geographic or seasonal variation except in severely emaciated nestlings. The nutritional status of nestlings, as determined by lipid reserves, "sets" the maximum body mass at any stage of growth. From hatching to about 60 d of age lipids and other body constituents are rapidly deposited. Thereafter, lipids are primarily deposited as a nutritional reserve, and other constituents are directed to the development of functionally important tissues such as the pectoral muscles.

Hand-reared nestlings consume about 80 kg meat from shortly after hatching to fledging age (about 136 d). Between 60 and 100 d of age (September–October) nestling food consumption is roughly double the quantity of food estimated for active adults to satisfy daily energy expenditure (DEE). In 1982 the Magaliesberg colonies required 1156 cattle carcasses annually, or roughly four carcasses/d.

The potential food resource (livestock carcasses) of the PFA around Magaliesberg, and similarly, that of the apparently favourable southwestern and western sectors within the PFA, exceeds the food requirements of Magaliesberg Cape Vultures by a wide margin.

This study has a valuable bearing on management programmes for the Cape Vulture in rural areas of southern Africa and presents testable results for future conservation-oriented research. **Komen, Joris.** 1986. M.Sc. Thesis. Department of Zoology, University of the Witwatersrand, 1 Jan Smuts Avenue, Johannesburg, SOUTH AFRICA. Present address: c/o Bird Department, State Museum, P.O. Box 1203, Windhoek, NAMBIA.

*J. Raptor Res.* 21(2):79–80

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### ECOLOGICAL RESEARCH ON THE JAPANESE GOLDEN EAGLE *Aquila chrysaetos japonica* DURING THE POST-FLEDGING PERIOD IN THE HAKUSAN RANGE

Five pairs of Golden Eagles in the Hakusan Range of central Japan were studied for seven yr (1978–84). The Hakusan Range is located in the west part of the Japan Alps and consists mostly of deciduous forest. The mean fledging date and age at fledging were 10 June and 76 d, respectively (N = 5). From a few days before fledging eaglets began to walk out of and return to the aerie. Eaglets fledged without any coaxing from their parents. During one to two wk after fledging, juveniles seldom flew and had poor flight ability until ca three to four wk after their first flight. Development of flight ability varied according to topography near the aerie. Juveniles roosted in the vicinity of the aerie until three to four wk after fledging. Thereafter juveniles perched most frequently in trees on ridge tops. Expansion of home range of juveniles was related to development of flight ability. Juveniles were fed by their parents until at least three to four wk after fledging. Prior to being fed by the parent, "dueting" (mutual calling) and "postponement of prey delivery" (the parent with prey flew in front of its offspring time after time) were performed. Dueting facilitated

locating juveniles in forest habitat, and delayed prey delivery encouraged juvenile flight. Shortly after fledging, juvenile eagles began to attempt hunting. However, juveniles remained dependent on their parents until early winter when, as they became increasingly independent, each left the area of its own accord. **Ikeda, Yoshihide.** 1985. M.S. Thesis, Kanazawa Univ., Japan. 302 pp. (In Japanese). Present address: Division of Life Sciences, Graduate School of Natural Science & Technology, Kanazawa University, Marunouchi 1-1, Kanazawa 920, Japan.

*J. Raptor Res.* 21(2):80

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**ASPECTS OF THE ECOLOGY, FOOD HABITS AND FORAGING CHARACTERISTICS  
OF GYRFALCONS IN THE CENTRAL CANADIAN ARCTIC**

A population of breeding Gyrfalcons (*Falco rusticolus*), studied from 1982–1986 on a 2000 km<sup>2</sup> study area in the central arctic of the Northwest Territories, occupied 14 to 18 territories each year. The mean internest distance was 10.6 km, giving a density that approaches the highest recorded. There was a tendency for regularity in spacing of territories. Most (85%) nests were in abandoned stick nests of Ravens (*Corvus corax*) or Golden Eagles (*Aquila chrysaetos*) ( $\bar{X} \pm SD$ ) of clutch was  $3.80 \pm 0.52$ , of brood was  $2.53 \pm 0.89$ , and mean productivity was  $1.50 \pm 1.43$  fledged young. Reproductive success declined with increased severity of spring weather.

Three prey species, Rock Ptarmigan (*Lagopus mutus*), Arctic Ground Squirrel (*Spermophilus parryii*) and Arctic Hare (*Lepus arcticus*), accounted for 96.5% of the total prey biomass identified. Gyrfalcons responded functionally to the varying availability of prey. Ptarmigan and hares were taken in May and June of all years (98.2% biomass). About 1 July, when nestling Gyrfalcons were growing rapidly, juvenile ground squirrels emerged and vulnerability of ptarmigan appeared to decline. Squirrels were used extensively in July and August of 1984 and 1985, but in 1986 there was a nearly complete failure of squirrel production, and ptarmigan continued to be the dominant prey species throughout the summer. Spring counts suggested densities of breeding ptarmigan were relatively constant during the study. Mean weight of prey taken by male Gyrfalcons (250 g) was significantly less than prey captured by females (330 g) (*t*-Test;  $t = -1.81$ ;  $P = 0.036$ ). As predicated by optimal foraging theory, larger prey items, on average, were brought to the nest as foraging time away from the nest increased.

Brood size was manipulated at two Gyrfalcon nests in 1986. The parent birds responded to altered brood size by compensatory changes in total prey biomass fed to the nestlings, suggesting that food was not limiting brood size. Conditions of food abundance were also observed at nests of unmanipulated broods, indicating that food was not limiting during the nestling period. I suggest that spacing of pairs was set during courtship and prelaying when food was most likely to be limiting. Courtship and prelaying coincided with the yearly low in prey availability and a period when the male was doing most of the hunting for himself and the female. The observation that most pairs did not initiate laying until after the spring arrival of migrating ptarmigan is consistent with this conclusion. **Poole, K. G.** 1987. M.Sc. Thesis, Dept. of Zoology, Univ. of Alberta, Edmonton, Alberta T6G 2E9, CANADA. 120 pp. Present address: Wildlife Management Division, N.W.T. Renewable Resources, Yellowknife, N.W.T. X1A 2L9, CANADA.

*J. Raptor Res.* 21(2):80–81

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**POST-FLEDGING BEHAVIOR OF THE EASTERN SCREECH-OWL (*Otus asio*)**

Three families of Eastern Screech-Owls (*Otus asio*) (six adults and 10 juveniles) were radio-tagged and monitored during the post-fledging period in central Kentucky. Fledging dates ranged from 14–27 May 1985. Five hundred fifteen roost sites were located and quantified. Adult and juvenile Eastern Screech-Owls used open limbs (46.4%), tangles (31.9%), and conifers (21.7%) for roosting; tree cavities were not used during the study period. Twenty-eight species of trees and shrubs were used for roosting; Eastern redcedar (*Juniperus virginiana*) (26.8%) and shagbark hickory (*Carya ovata*) (18.3%) were selected most often. Families differed significantly in mean roost height, roost tree height, roost tree diameter, distance between daily roost sites, distance from nest, distance from male, and the distance from female roost site. There were no significant differences among adults and juveniles for the above roost site variables. Mean distance between roost sites of juveniles and those of both adult males and adult females increased significantly after the fifth week post-fledging, possibly suggesting a time when juveniles are becoming independent of parents.

Height and diameter of roost tree, distance between daily roost sites, and distance from nest for juveniles differed significantly with age. Entire families roosted together on 37 occasions (22%).

Six juvenile owls occupied minimum area home ranges that averaged 33.4 ha in size (range, 12.3–60.4 ha). Four adult home ranges averaged 45.3 ha in size. Biweekly and cumulative home ranges of both adults and juveniles increased as post-fledging period progressed. Adult and juvenile home ranges did not differ significantly in size among families. Juvenile owls began to range more widely outside home ranges of their parents after about five weeks post-fledging, as evidenced by a smaller percentage of overlap in home ranges after this time.

Nine juvenile Eastern Screech-Owls remained on their natal territories for an average of 56 d (range, 45–65 d) after fledging. Dispersal dates ranged from 8–21 July 1985 ( $\bar{x} = 14$  July). Median straight-line dispersal distance was 1.8 km (range, 1.2–16.9 km). Median dispersal direction was 161 degrees (range, 141–306 degrees). There were no significant differences in dispersal distance or direction among families.

Juvenile mortality prior to dispersal was 10%. Five of six juveniles (83%) known to be alive following dispersal either starved or were killed by predators by March 1986. One juvenile male was known to have survived into the 1986 breeding season at which time it acquired a mate and nested. Four young hatched, but the nest was abandoned for unknown reasons. The young failed to fledge. **Belthoff, James R. 1987. M.Sc. Thesis, Department of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475 U.S.A. Thesis Advisor: Gary Ritchison. Present address of author: Department of Biological Sciences, Clemson University, Clemson, SC 29634, U.S.A.**

*J Raptor Res.* 21(2):81–82

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**THE FEEDING, ROOSTING, AND PERCHING BEHAVIOR OF THE  
BALD EAGLES (*Haliaeetus leucocephalus*) OF MASON NECK, VIRGINIA  
WITH SPECIAL REFERENCE TO THE DEVELOPMENT OF MASON NECK STATE PARK**

The feeding, roosting and perching behavior of Bald Eagles on Mason Neck, Virginia, were studied with special reference to effects from development of Mason Neck State Park. Observations were begun in January 1981 and continued into 1985.

Most eagle feeding activity was observed when wind speeds were <16 km/hr and temp was 18–26°C, although hunting success was not found to be dependent on wind speed, temp, or cloud cover. Eagles were observed to use four main hunting methods: 1) swooping from flight, 2) swooping from a tree perch, 3) wading from shore and grabbing with the beak or talons, and 4) gliding out from ice or a low perch on piles of ice. The last two methods were only used by adult eagles, but the frequency of use and success rates of methods one and two were independent of age. Few inter- and intraspecific interactions were seen in feeding areas, likely due to the fact that neither eagles nor their prey species were found in highly concentrated numbers. Observations of feeding and analysis of prey remains and pellets ( $N = 82$ ) indicated that diet of the eagles was composed of 53.7% fish [mostly Brown Bullhead (*Ictalurus nebulosus*)], 9.8% mammals [mostly Eastern Cottontail (*Sylvilagus floridanus*)], 28% birds, 6.1% turtles and 2.5% crayfish.

Roost trees selected by eagles were typical in that they were fairly large with a strong, open branching structure, easily accessible, had good visibility and were close to water and feeding areas. Roost trees measured ( $N = 22$ ) had a mean ( $\pm SD$ ) diameter at breast height (DBH) of 54.4 cm ( $\pm 27.4$ ), height of 18.9 m ( $\pm 5.5$ ) and distance from water of 12.4 m ( $\pm 17.7$ ).

Weekly roost counts showed that the numbers of eagles using the roost peaked between September and April with only a few birds using the roost during summer. Annual peak counts of eagles using the roost ranged from nine to 20 with highest numbers occurring in November, December and January. Color band numbers identified some of the eagles as coming from specific localities; 24 from the Chesapeake Bay Region of Virginia and Maryland, two from Maine, two from New York, and one from South Carolina. Many interactions were seen between immature eagles, the majority age group in the roost. Incidents of potential human disturbance in the roost are discussed.

Perch trees were found to be similar to roost trees in dimensions, but their mean distance from water was less. Eagles perched in 36% of all sightings exclusive of the roost. Interactions of birds perched in feeding and breeding areas are described.

A certain amount of tolerance to human activity was shown by eagles on Mason Neck, but caution must be maintained to protect sensitive areas such as roost and nesting territory from adverse human disturbance. Recommendations are made to the state park to restrict human use near the roost site. **Haines, Susan L. 1986. M.Sc. Thesis, Biology Department, George Mason University, Fairfax, VA 22030, U.S.A. Present address: 107 Beaver Lodge Road, Stafford, VA 22554, U.S.A.**

*J. Raptor Res.* 21(2):82-83  
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## NEWS AND REVIEWS

**Hawk Mountain Research Award.** The Hawk Mountain Sanctuary Association is accepting applications for its eleventh annual award for raptor research. To apply for the \$750 award, a student applicant should submit a brief description of his or her research program (five pages maximum), a *curriculum vitae*, and two letters of recommendation to **Stanley E. Senner, Executive Director, Hawk Mountain Sanctuary Association, Rte. 2, Kempton, Pennsylvania 19529.** The deadline for applications is October 15, 1987. The Association's board of directors will make a final decision early in 1988. Only students in degree-granting institutions are eligible to apply; both undergraduate and graduate students may 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 the conservation of North American raptor populations.

**Western Raptor Management Symposium and Workshop**—The Western Raptor Management Symposium and Workshop, co-organized by the National Wildlife Federation and the Idaho Chapter of The Wildlife Society, will be held **26-28 October 1987 in Boise, Idaho.** The symposium will feature technical paper sessions on the status of western raptors and their habitats, land use activities impacting raptors, as well as workshops and a poster session. For more information, contact the **National Wildlife Federation, Institute for Wildlife Research, Department 162, 1412 Sixteenth Street NW, Washington, DC 20036-2266, or telephone (703) 790-4264.**

**Request for Assistance**—The Stazione Romana per l'Osservazione e la Protezione degli Uccelli (S.R.O.P.U.) is forming a library on diurnal and nocturnal birds of prey. Currently, the aim is to gather works on status, biology, methodologies, etc., on raptor research. Such a library will be of great value and interest to S.R.O.P.U. members conducting research on raptors. Anyone wishing to contribute materials to the library should contact **Vincenzo Penteriani, Via Festo Avieno No. 56, 00136 Roma, ITALY.** Your cooperation will be greatly appreciated.

**Raptor Research Foundation Resolutions Committee Chairman Needed**—Duties involve organizing, standardizing and posting proposed resolutions at the annual meeting of the Foundation, presenting them to the Board of Directors and/or membership, and processing final versions. Anyone interested in serving, please write to: **Jeffrey L. Lincer, President, The Raptor Research Foundation, Inc., % EcO-Analysts, Environmental Consultants, 4718 Dunn Drive, Sarasota, FL 33583.**

**Stephen R. Tully Memorial Grant.** The Raptor Research Foundation and the Tully family announce the availability of a \$500 grant to provide financial assistance to promote the research, management and conservation of birds of prey. Individuals demonstrating serious interest in raptors, particularly students and amateurs with limited access to major granting agencies, are eligible. Applicants must supply three copies of resume (*vitae*), specific study objectives, an account of how funds will be spent, and a statement indicating how the proposed work would relate to other work by the applicant and to other sources of funds. Applications must be postmarked by 15 September 1987 and sent to **Stephen R. Tully Memorial Grant, 5666 West Flying Hawk Lane, Boise, ID 83709, U.S.A.** Grant awards will be announced at the annual Raptor Research Foundation meeting 28-31 October 1987 at Boise, Idaho. Persons wishing to contribute to this and future Tully Grants may make their checks payable to The Raptor Research Foundation, Inc./Tully Grant and should be sent to the above address.

**Grants and Awards.** The National Wildlife Rehabilitators Association announces a small-grants program and the establishment of two awards. The grant program makes funding available to support two \$1000 research projects in the field of wildlife rehabilitation or several smaller research projects each totalling less than \$1000. Applicants must demonstrate financial need and submit a typewritten proposal that includes name(s) and resume of personnel involved, objectives of the project, a brief description of how the project will be carried out, a brief statement of the literature reviewed and an itemized budget. An annual report on progress is required.

The awards include the **Lifetime Achievement Award** given to an individual whose primary identification is with rehabilitation of wildlife and who has contributed to this field in a major way for many years. The **Significant Achievement Award** is for a person who has contributed something of merit to the field in the last two years. The contribution may be a research finding, publication, organization of a program, etc., with a major theme in wildlife rehabilitation. Both awards consist of a plaque, \$100, and free registration at the NWRA conference where the award will be presented. The deadline for submittal of proposals for the research grants or nominations for the awards is December 15 of each year. They should be sent to **Daniel R. Ludwig, Ph.D., Awards and Grants Committee, Willowbrook Wildlife Haven, Willowbrook Forest Preserve, P.O. Box 2339, Glen Ellyn, IL 60138, U.S.A. (312)790-4900, Ext. 283.**

**Leslie Brown Memorial Grant.** The Raptor Research Foundation, Inc., announces the availability of a \$500 grant to provide financial assistance to promote research or the dissemination of information on raptors. Applicants must supply a resume, specific study objectives, an account of how funds will be spent, and a statement indicating how the proposed work would relate to other work by the applicant and to other sources of funds. Proposals concerning African raptors will receive highest priority between proposals of otherwise equal merit. **Application material must be received by 1 October 1987.** Proposals, donations and inquiries about tax-exempt contributions to the fund should be sent to **Jeffrey L. Lincer, Chairman, RRF Leslie Brown Memorial Fund, 4718 Dunn Drive, Sarasota, FL 33583, U.S.A.**

**Recipient of 1986 William C. Andersen Award**—The William C. Andersen Award for the best student paper delivered at the 1986 Annual Meeting of The Raptor Research Foundation, Inc., in Gainesville, Florida, was presented to **John A. Smallwood**, Department of Zoology, The Ohio State University. The title of the paper was "Winter territoriality in American Kestrels: a mechanism of sexual segregation by habitat." **Congratulations to John for his accomplishment.**

THE RAPTOR RESEARCH FOUNDATION, INC.  
(FOUNDED 1966)

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The *Journal of Raptor Research* is distributed quarterly to all current members. Original manuscripts dealing with all aspects of general ecology, natural history, management and conservation of diurnal and nocturnal predatory birds are welcomed from throughout the world, but must be written in English. Contributors should submit a typewritten original and three copies of text, tables, figures and other pertinent material to the Editor. Two original copies of photographic illustrations are required. All submissions must be typewritten double-spaced on one side of 8½ × 11-inch (21½ × 28 cm) 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. 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.

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).

Metric units should be used in all measurements. Abbreviations should conform with the Council of Biology Editors (CBE) Style Manual, 5th ed. Use the 24-hour clock (e.g., 0830 and 2030) and "continental" dating (e.g., 1 January 1984).

A more detailed set of instructions for contributors appeared in *J. Raptor Res.*, Vol. 21, No. 1, Spring 1987, and is available from the Editor. Send all manuscripts for consideration and books for review to the Editor.