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## DIAGNOSTIC FINDINGS IN 132 GREAT HORNED OWLS

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**ABSTRACT.**—We reviewed diagnostic findings for 132 great horned owl (*Bubo virginianus*) carcasses that were submitted to the National Wildlife Health Center from 1975–93. The carcasses were collected in 24 states but most came from Colorado ( $N = 21$ ), Missouri ( $N = 12$ ), Oregon ( $N = 12$ ), Wyoming ( $N = 11$ ), Illinois ( $N = 10$ ), and Wisconsin ( $N = 9$ ). Forty-two birds were emaciated but presumptive causes of emaciation, including old injuries, chronic lesions in various organs, and exposure to dieldrin, were found in only 16. A greater proportion of juveniles (56%) than adults (29%) were emaciated. Twelve owls were shot and 35 died from other traumatic injuries. Poisonings were diagnosed in 11 birds, including five associated with hydrogen sulfide exposure in oil fields and six cases of agricultural pesticide poisonings. Electrocution killed nine birds and infectious diseases were found in six. Miscellaneous conditions, including egg impaction, drowning, and visceral gout were diagnosed in three of the birds and the cause of death was undetermined in 14 owls. While this review identifies major diagnostic findings in great horned owls, sample bias prevents definitive conclusions regarding actual proportional causes of mortality.

**KEY WORDS:** *Bubo virginianus*; disease; emaciation; great horned owl; mortality; toxicosis; trauma.

Encuentros diagnósticos en 132 individuos de la especie *Bubo virginianus*

**RESUMEN.**—Revisamos el diagnóstico para 132 carcasas de *Bubo virginianus* que fueron sometidos al National Wildlife Health Center desde 1975 a 1993. Las carcasas fueron colectadas en 24 estados, pero la mayoría venían de Colorado ( $N = 21$ ), Missouri ( $N = 12$ ), Oregon ( $N = 12$ ), Wyoming ( $N = 11$ ), Illinois ( $N = 10$ ) y Wisconsin ( $N = 9$ ). Cuarenta y dos aves estaban adelgazadas, pero las presuntas causas de adelgazamiento, incluyendo antiguas heridas, lesiones crónicas en varios órganos y exposición al dieldrin sólo fueron encontradas en 16. El adelgazamiento ocurrió en mayor proporción en juveniles (56%) que en adultos (29%). Doce búhos fueron cazados y 35 murieron de otras heridas traumáticas. Envenenamientos se diagnosticaron en 11 aves, incluyendo cinco asociadas con exposición a “hydrogen sulfide” en campos petroleros y seis casos de envenenamiento por pesticidas de uso agrícola. Nueve aves murieron electrocutadas y en seis se encontró enfermedades infecciosas. Condiciones miscelaneas, incluyendo impacto de huevos, ahogamiento, fueron diagnosticados en tres de las aves y causas de muerte no indentificadas ocurrieron en otros 14 individuos. Mientras esta revisión diagnostica los mayores encuentros en *B. virginianus*, sesgos de la muestra previenen conclusiones definitivas sobre la proporcionalidad de las causas de muerte.

[Traducción de Ivan Lazo]

The great horned owl (*Bubo virginianus*) is widely distributed throughout North America and occupies a greater variety of habitats than any other species of

owl (Johnsgard 1988). Great horned owls are adaptable feeders with a highly diverse diet that includes insects, small mammals, and birds (Johnsgard 1988). Although few data are available regarding the longevity of wild great horned owls, one band recovery documents survival for over 20 yr (Klimkiewicz and Futcher 1989). Comparatively little is known about causes of death in this cosmopolitan species. Scattered reports of

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great horned owl mortalities exist in reviews of morbidity and mortality of raptors as a group, but compilations of diagnostic findings specific to great horned owls are lacking. Of the conditions diagnosed in raptors, trauma is among the most frequent and is often associated with human-related causes (Keran 1981, Fix and Barrows 1990, Cooper 1993, Franson et al. 1995). Poisonings are also commonly reported causes of mortality in raptors (Henny et al. 1985, Lumeij et al. 1993, Franson et al. 1995), and compounds previously associated with great horned owl deaths include chlorinated hydrocarbons (Blus et al. 1983a, 1983b, Stone and Okoniewski 1988, Okoniewski and Novesky 1993) and organophosphorus pesticides (Henny et al. 1987). Little is known about the significance of diseases in great horned owl populations, although individual case reports have been published describing several infectious, parasitic, and neoplastic conditions (Halliwell 1971, Keymer 1972, Sileo et al. 1975, Kocan et al. 1977, Clark et al. 1986, Swayne and Weisbrode 1990). We report the results of postmortem examinations of 132 great horned owl carcasses submitted to the National Wildlife Health Center (NWHC), Madison, Wisconsin from 1975-93 to provide additional information on the variety of factors resulting in morbidity and mortality in this species.

#### METHODS

For this review we selected only intact carcasses, excluding those that were heavily scavenged, in advanced stages of decomposition, or cases in which birds had spent extended periods in rehabilitation. Specimens, submitted by field biologists and others from 1975-93, were stored refrigerated or frozen until examination. Necropsies were conducted by 14 different diagnosticians during the 19-yr period of the study. Each bird was examined by gross inspection to identify, for example, abnormalities in organ systems suggestive of diseases, traumatic injuries indicating gunshot or collisions with objects, burns suggestive of electrocution, gender, stage of maturity (juvenile or adult, based on gonadal development), and to assess the overall body condition. Subsequent laboratory analyses of appropriate tissues were carried out to identify conditions suggested by necropsy observations. Diagnoses of diseases were based on the presence of characteristic lesions at necropsy and histopathological examination of tissues or laboratory isolation of the causative agent. We report the specific causes of death or the most significant findings identified by the diagnosticians, thus omitting incidental conditions unlikely to have caused harm to the birds. Proportional categories of findings, according to gender and age, were compared using the chi-square test for homogeneity (Daniel 1978).

Brain cholinesterase activity, as an indicator of exposure to organophosphorus or carbamate pesticides, was determined for 22 birds using methods described by Ellman et al. (1961) as modified by Dieter and Ludke (1975) and Hill and Flem-

ing (1982). The magnitude of cholinesterase inhibition was calculated by comparison with the mean control value ( $16 \pm 2.5 \mu\text{moles}/\text{min}/\text{g}$ ) reported by Hill (1988). Pesticide analyses were done at the Patuxent Wildlife Research Center, Laurel, Maryland. Organophosphorus and carbamate compounds were recovered from stomach contents by column extraction and identified by gas chromatography as described by Belisle and Swineford (1988). Brains were tested for residues of chlorinated hydrocarbons by gas-liquid chromatography (Cromartie et al. 1975). Lead and sulfide residues in tissues were determined according to Boyer (1984) and Feldstein (1960), respectively.

Tissues for histopathology were fixed in buffered 10% formalin, embedded in paraffin, and sectioned for light microscopy; slides were stained with hematoxylin and eosin for routine examination, Ziehl-Neelsen acid-fast for mycobacteria, or Grocott silver for fungi. Bacterial isolation attempts were carried out by inoculating tissues onto 5% sheep red blood agar and eosin-methylene blue plates (DIFCO Laboratories, Detroit, MI U.S.A.), and isolates were characterized and identified with the API-20E system (Analytab Products, Plainview, NY U.S.A.). Cell cultures and embryonating eggs were used for isolation of viruses as described by Docherty and Slota (1988) and Senne (1989).

#### RESULTS AND DISCUSSION

The 132 specimens were submitted from 24 states, but most came from Colorado ( $N = 21$ ), Missouri ( $N = 12$ ), Oregon ( $N = 12$ ), Wyoming ( $N = 11$ ), Illinois ( $N = 10$ ), and Wisconsin ( $N = 9$ ). Gender was determined for 121 carcasses (61% were female) and stage of maturity was assessed for 116 (84% were adults). Emaciation and trauma were the most frequent diagnostic findings followed by gunshot, toxicoses, electrocution, infectious diseases, and miscellaneous (Table 1). No significant findings were reported for 14 (11%) carcasses. No difference was noted in the distribution of proportional diagnostic findings between males and females, but a slight difference ( $\chi^2 = 12.76$ ,  $df = 7$ ,  $P = 0.08$ ) was indicated when proportional categories of findings for adults were compared with those for juveniles. Emaciation was the primary source of this difference ( $\chi^2 = 4.73$ ,  $df = 1$ ,  $P = 0.03$ ), and a higher proportion of juveniles (56%) than adults (29%) were emaciated.

**Emaciation.** Although emaciation was diagnosed in 42 (32%) carcasses, factors contributing to this condition were identified in only 16. Two had ocular lesions (corneal lacerations and plaques), and one had masses on the eyelids that covered the eyes and may have impaired sight and hence hunting ability. Lesions of the eyes are relatively common in raptors, including great horned owls, and are frequently the result of some type of physical injury (Murphy et al. 1982). Joint dislocations and old fractures in various stages

of healing, including one instance of apparent injury from a leg-hold trap, were found in three carcasses and probably led to decreased mobility and subsequent debilitation through malnutrition. Two emaciated owls had oral lesions, a beak deformity and a proliferative membranous lesion on the tongue that may have hindered consumption of prey.

Six carcasses had lesions of other organ systems thought responsible for emaciation, including one carcass each with intestinal nematode impaction (*Porrocaecum* sp.), abdominal adhesions secondary to a healing puncture wound, granulomatous hepatitis of undetermined etiology, and necrotizing verminous pneumonia. One carcass had a swollen foot and bacterial cultures of the foot and liver yielded heavy growth of *Serratia* sp., indicating a possible septicemia. Another bird had a laceration of the skin over the back of the neck, surrounded by an accumulation of tissue debris, fly ova, and maggots. This condition was thought to be antemortem and contributory to emaciation.

Elevated dieldrin residues were found in the brains of two emaciated owls. An adult female found dead in Minnesota in 1981 had 2.8 ppm wet weight dieldrin in its brain. Another adult female, found moribund in late 1981 in Illinois, had a brain dieldrin concentration of 4.4 ppm wet weight. Brain residues of 4–5 ppm wet weight dieldrin are considered to be the lower threshold of toxicity (Stickel et al. 1969). Although the use of most organochlorine pesticides is now banned in the United States, avian mortality continues from exposure to historically treated areas (Okoniewski and Novesky 1993), and these compounds should be considered in cases where emaciated birds are found dead.

For the remaining 26 emaciated owl carcasses, no etiology was revealed by necropsy or laboratory evaluations of tissues. Although heavy parasitism by lice (*Strigiphilus* sp.), gastrointestinal parasites (*Porrocaecum* sp. and unidentified capillarids), and renal coccidia occurred in four of these carcasses, it was concluded that these infections were secondary to debilitation, not the cause of it. Liver lead concentrations were determined for 16 of these birds and in all cases were less than 2 ppm wet weight, which is considered to be within normal limits of exposure for many species of birds (Franson 1996). Brains of two carcasses were analyzed for organochlorine pesticides, with negative results. In eight emaciated owls, no testing beyond gross inspection at necropsy was conducted, precluding any further diagnosis. These 26 emaciated birds were found during all months of the year, although slightly more were found from April to September ( $N = 15$ ) than

Table 1. Categories of diagnostic findings in 132 great horned owls.

DIAGNOSTIC FINDING	<i>N</i>	%
Emaciation	42	32
Trauma	35	26
Undetermined	14	11
Gunshot	12	9
Toxicoses	11	8
Electrocution	9	7
Diseases	6	4
Miscellaneous <sup>a</sup>	3	2

<sup>a</sup> Visceral gout, egg bound, drowning.

October to March ( $N = 11$ ). This may simply reflect an increased number of observers in the field during the summer months. Of the 24 birds in this group for which stage of maturity was determined, eight were juveniles and 16 were adults. Overall, a greater proportion of juveniles (56%) than adults (29%) were emaciated. Indeed, most (eight of 10) of the emaciated juveniles were in this category of unidentified etiology, suggesting that these birds may have been too naive to obtain adequate food. These results agree with other reports, including Cooper (1993) who found a similar frequency of starvation in barn owls (*Tyto alba*), and Kenward et al. (1993) who reported that juvenile northern goshawks (*Accipiter gentilis*) were more frequently diagnosed with starvation than adults.

**Trauma.** Trauma, excluding gunshot, was the second most frequent (26%) finding. Types of trauma suggested by information provided by the submitter or lesions observed at necropsy included collision with a moving vehicle or stationary object, being struck by a blunt object, and non-gunshot puncture wounds. Extensive skin and feather damage were noted in eight owls and skeletal fractures in 17. Hemorrhage, most frequently of the head, body cavity, and air sacs, was present in 21 of the 35 trauma cases. Internal organs including liver, spleen, duodenum, and stomach were ruptured in six carcasses. Concurrent abnormalities, including lesions of owl herpesvirus, renal gout, septicemia, and pododermatitis, were noted in four of the birds that died from trauma. These findings did not alter the cause of death as trauma, but may have rendered the owls more susceptible to traumatic injuries.

**Gunshot.** In 12 (9%) of the carcasses examined, gunshot wounds were diagnosed based on the presence of shot in association with fractures, recent hemorrhage, and other trauma or when tracts indicating the

path of a bullet or pellet could be identified. Seven were shot with a rifle, three with a shotgun, and two with an undetermined type of weapon. The frequency of cases with physical injury as the primary diagnosis (trauma plus gunshot) was 36%, somewhat less than the 43% reported in barn owls from England (Cooper 1993).

**Toxicoses.** Toxicoses were identified in 11 (8%) great horned owls. Hydrogen sulfide poisoning was diagnosed in five owls collected in North Dakota oil fields in 1982. The owls were found near flare or vent pipes, perhaps used as perches, designed to burn off or vent natural gases released during crude oil production, storage, and pipeline operations (Bicknell 1984). Hydrogen sulfide (1.5–4.0 ppm wet weight) was found in pulmonary fluid of each carcass. Hydrogen sulfide acts as a direct irritant, producing a chemical pneumonitis, and combines with and inhibits metabolic enzymes (Robinson et al. 1990, Short and Edwards 1989). Inhibition of the central nervous system respiratory drive produces apnea, the major cause of death (Warenycia et al. 1989).

Poisonings by phorate, fenthion, and an unidentified organophosphorus compound were diagnosed in three owls. One owl was found dead in South Dakota in 1982 in association with over 275 other dead birds, primarily ducks. Brain cholinesterase activity in this bird was inhibited by 83% and phorate (Thimet®) residues, 200 ppm wet weight, were recovered from stomach contents that consisted of feathers and grain. Phorate poisoning was also diagnosed in several of the ducks, and the owl apparently fed on those carcasses. Another great horned owl found dead in 1993 in Missouri had a 98% inhibition of brain cholinesterase activity and its stomach contents, consisting primarily of avian remains, contained 14.7 ppm wet weight fenthion. Brain cholinesterase activity in a third great horned owl, found in Utah in 1991, was inhibited by 88% without reversal after incubation of the sample. These findings are consistent with exposure to an organophosphorus pesticide (Hill and Fleming 1982, Smith et al. 1995) but, because the avian remains found in the stomach were not analyzed, the specific compound was not identified. Secondary poisoning by organophosphorus compounds, including fenthion, has been previously reported in several species of raptors (Henny et al. 1985, 1987, Bruggers et al. 1989, Hunt et al. 1991).

The brain cholinesterase activity of an owl found dead in Delaware in 1989 was within the normal range, but carbofuran (4.6 ppm wet weight) was re-

covered from the feathers and flesh found in its stomach. The carcass was partially decomposed and the lack of cholinesterase inhibition was probably the result of postmortem reactivation of the enzyme (Hill and Fleming 1982), one of the factors that contribute to a lack of correlation between cholinesterase inhibition and carbamate exposure (Greig-Smith 1991). Two birds died of poisoning by chlorinated hydrocarbons (endrin and chlordane) and those cases are described elsewhere (Blus et al. 1983a, 1983b).

**Electrocution.** Nine (7%) great horned owls died of electrocution, including three from Colorado, two from Oregon, two from Illinois, and one each from Arkansas and Wisconsin. The frequency of electrocution in this group of owls is considerably lower than the rates of 12% and 25% reported for bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*), respectively (Franson et al. 1995).

**Infectious Diseases.** Infectious diseases were diagnosed in six (4%) of the great horned owls. Two owls found dead in Nebraska in 1992 had gross and microscopic lesions consistent with owl herpesvirus infection (Green and Shillinger 1936, Sileo et al. 1975). Nodular lesions characteristic of avian tuberculosis were found in the liver and spleen of an owl collected in Nevada in 1984 and one found in Nebraska in 1987. Acid-fast bacteria, consistent with tuberculosis, were seen microscopically in impression smears of tissues and *Mycobacterium avium* was isolated from the liver of both birds. Bacterial pneumonia was diagnosed histologically in an owl found in 1980 in Oregon, but bacterial cultures of lung were negative. In 1980 an owl from Wisconsin was found to have numerous small abscesses in its enlarged liver and spleen and bacterial culture of spleen yielded heavy growth of *Staphylococcus aureus*.

**Miscellaneous.** Unusual diagnoses were reached in three of the 132 cases reviewed. One adult female had extensive bruising and tissue damage surrounding a fully formed egg in the distal oviduct, and apparently was egg bound. Drowning was diagnosed upon discovering water in the anterior thoracic air sacs of another owl. Severe visceral gout characterized by urate deposits within the kidneys and throughout the intestinal tract was found in a third owl.

Cause of death was not determined in 14 (11%) of the great horned owl carcasses examined. All of the carcasses included in this category were found to have adequate stores of body fat and no evidence of trauma. In five of the birds, no testing beyond gross inspection at necropsy was conducted. Liver lead concentrations

were determined in five cases and brain cholinesterase activities were evaluated in two of the 14 birds, but those results were within normal limits. Isolation of infectious agents was attempted in six of the 14 cases, but proved unsuccessful.

The significance of these results and their impact on great horned owl populations are difficult to evaluate because of the retrospective nature of the study and the nonrandom carcass collection techniques. However, this report does serve to identify major diagnostic findings in great horned owls. Increasing educational efforts may help mitigate causes of mortality related to human activities. More judicious use and monitoring of pesticides should help prevent poisonings and modifications to structures such as power lines and utility poles may reduce electrocution and trauma mortalities. Emaciation of undetermined etiology is a significant finding and should be further evaluated. A study designed to examine emaciation in great horned owls with regard to age, food availability, and the temporal and geographic distribution of emaciated birds may help to identify potential causes of emaciation.

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## A RETROSPECTIVE STUDY OF POSTMORTEM FINDINGS IN RED-TAILED HAWKS

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**ABSTRACT.**—We studied necropsy results from carcasses of 163 red-tailed hawks (*Buteo jamaicensis*) submitted to the National Wildlife Health Center from 1975 through 1992. The most frequent post-mortem finding was emaciation of unknown etiology, diagnosed in 33 (20%) carcasses. Proportionally more juveniles than adults were emaciated. Evidence of non-gunshot trauma, often suggestive of collision with vehicles or structures near roadways, was found in 29 (18%) birds. Of 25 (15%) toxicoses, 20 were attributed to agricultural pesticides, including famphur (4), fenthion (3), carbofuran (2), phosphamidon (2), endrin (1), and unidentified organophosphorus compounds (8). Lead and strychnine poisoning were diagnosed in two birds each, and selenium poisoning in one. Diseases, including aspergillosis, tuberculosis, pasteurellosis, and pox, were found in 21 (13%) hawks. Gunshot and electrocution were each diagnosed in six (4%) birds, one (0.6%) was trapped, miscellaneous conditions were found in 10 (6%), and no diagnosis could be determined for 32 (19%) of the carcasses.

**KEY WORDS:** *Buteo jamaicensis*; diseases; mortality; pesticides; poisoning; red-tailed hawk; trauma.

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Un estudio retrospectivo de encuentros postmortem en *Buteo jamaicensis*

**RESUMEN.**—Estudiamos los resultados de la necropsia de restos de 163 individuos de la especie *Buteo jamaicensis* sometidos al National Wildlife Health Center desde 1975 hasta 1992. El encuentro post-mortem más frecuente fue adelgazamiento de etiología desconocida, diagnosticado en 33 (20%) restos. Proporcionalmente, más juveniles que adultos estaban adelgazados. Traumas no causados por armas de fuego, sino que por posibles colisiones con vehículos o estructuras cerca de las carreteras, fueron encontrados en 29 (18%) aves. De 25 (15%) individuos intoxicados, 20 fueron atribuidos a pesticidas de uso agrícola, incluyendo “famphur” (4), “fenthion” (3), “carbofuran” (2), “phosphamidon” (2), “endrin” (1) y compuestos organofosforados no identificados (8). Envenenamiento por plomo y estricnina fueron diagnosticados en dos aves, respectivamente, envenenamiento por selenio, sólo en una. Enfermedades, incluyendo aspergilosis, tuberculosis, pasteurellosis y viruela, fueron encontradas en 21 individuos (13%). Disparos y electrocución como causa de muerte fue diagnosticada en seis aves (4%), una fue atrapada, condiciones miscelaneas fueron encontradas en 10 (6%). No se pudo emitir un diagnóstico para 32 (19%) restos.

[Traducción de Ivan Lazo]

The red-tailed hawk (*Buteo jamaicensis*) is a frequent breeder in North America and the most abundant hawk in the United States and southern Canada during cold-weather months (Johnsgard 1990). Despite its wide range and abundance, little is known about factors that influence the health of the red-tailed hawk. Occasional case reports of diagnostic

findings, primarily infectious diseases and toxicoses, have been published but most of these accounts involve only one or several birds. Some of the diseases previously reported from individual sick and dead red-tailed hawks include avian pox (Halliwell 1972, Fitzner et al. 1985, Chubb 1987, Rosskopf et al. 1987), tuberculosis (Sykes 1982, Mollhoff 1983, Clark 1986), erysipelas (Pace et al. 1987), and oral capillariasis (Santiago et al. 1985). Poisonings documented in red-tailed hawks have often been the result of their exposure to pest-control chemicals. Henny et al. (1985, 1987) reported mortality in red-tailed hawks from exposure to famphur, an insecticide topically applied to livestock for parasite control, and Hooper et al. (1989) described intoxication

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Table 1. Postmortem findings in 163 red-tailed hawks.

CATEGORY	N	%
Emaciation	33	20
Undetermined <sup>a</sup>	32	19
Trauma	29	18
Toxicoses	25	15
Diseases	21	13
Miscellaneous <sup>b</sup>	10	6
Gunshot	6	4
Electrocution	6	4
Trapped	1	<1

<sup>a</sup> Postmortem examination revealed no cause of death or significant findings.

<sup>b</sup> Peritonitis, visceral gout, parasitism, hepatitis, endocarditis, and other nonspecific infections based on gross observations only, etiologies unknown.

of red-tailed hawks by organophosphorus pesticides applied to orchards. Cyclodiene organochlorine insecticides persistent in soil in urban and suburban areas have been implicated in recent poisonings of red-tailed hawks (Okoniewski and Novesky 1993).

In an effort to evaluate the scope of the causes of illness and death in red-tailed hawks, we studied diagnostic findings from 163 carcasses examined at the National Wildlife Health Center (NWHC) over nearly 20 yr. Because of the nonrandom nature of carcass collection and submission, this summary does not necessarily reflect the actual proportional distribution of causes of illness and mortality in the red-tailed hawk population as a whole. However, our findings identify some of the major factors that cause or contribute to the death of these hawks.

#### METHODS

We reviewed and summarized records of 163 red-tailed hawk carcasses that were submitted for cause of death determination to the NWHC, a U.S. Department of Interior facility that provides diagnostic services to natural resource managers throughout the United States and its territories. Most of these birds had been found dead in the field and were collected in 26 states from 1975 through 1992. Some birds were captured alive and later died or were euthanized because of the extent of their injuries or illness at the time of capture, but no birds undergoing extended rehabilitation were included in the review. A gross examination, including a description of wounds and abnormalities and an evaluation of overall body condition with respect to fat reserves and pectoral muscular development, was conducted on each carcass. Samples of organs were tested for a variety of microorganisms, parasites, and toxins as indicated by gross findings and field information provided by the collector. Tissues for histopathology were fixed in 10% buffered formalin, embedded in paraffin,

sectioned for light microscopy and stained with hematoxylin and eosin for routine examination, Ziehl-Neelsen acid-fast for mycobacteria, and/or Grocott silver for fungi. Bacteria were isolated by inoculation of tissues onto 5% sheep red-blood agar and eosin-methylene blue plates (DIFCO Laboratories, Detroit, MI U.S.A.), incubated at 37° C for 72 hr, and then characterized with the API-20E system (Analytab Products, Plainview, NY U.S.A.). Tissues for virus isolation attempts were processed according to Docherty and Slota (1988) and Senne (1989).

When agricultural pesticide poisoning was suspected by those who submitted the carcasses, or when the pathologist found stomach contents of animal remains consistent with possible secondary poisoning, brains were screened for cholinesterase activity. Cholinesterase assays were according to Ellman et al. (1961) and as later modified by Dieter and Ludke (1975) and Hill and Fleming (1982), including incubation (18 hr at 37°C) and retesting of samples with initially low enzyme activities. Cholinesterase inhibition was calculated by comparison with normal published values (Hill 1988) or control values determined by the NWHC (Smith et al. 1995). In most cases where inhibition of brain cholinesterase activity was noted, stomach contents were analyzed at the Patuxent Wildlife Research Center, Laurel, Maryland for 24 organophosphorus and six carbamate compounds according to Belisle and Swineford (1988) (Patuxent Analytical Control Facility standard operating procedure 0-25.00). Brains were analyzed for residues of chlorinated hydrocarbons by gas-liquid chromatography (Cromartie et al. 1975, Blus et al. 1989), liver lead residues were determined according to Boyer (1984), and methods for selenium analysis of liver followed Krynsky (1987). Analysis of stomach contents for strychnine was according to Feldstein (1960). Animal material found in esophagi and stomachs of the hawks were described, but not identified to species. Chi-square and analysis of variance (Zar 1984) were used for age and gender comparisons of diagnostic findings.

#### RESULTS AND DISCUSSION

**General Findings.** Ninety-seven (60%) of the 163 red-tailed hawks were females, 59 (36%) were males, and seven (4%) were of undetermined gender. The age distribution was 83 (51%) juveniles, 74 (45%) adults, and 6 (4%) undetermined. The gender distribution by age, of the 155 birds for which both were determined, was 51 juvenile females, 31 juvenile males, 46 adult females, and 27 adult males. The most frequent state of origin was California ( $N = 54$ , 33%), followed by Wisconsin ( $N = 27$ , 16%) and Illinois ( $N = 17$ , 10%). Factors contributing to or directly causing the death of the bird were determined for 131 carcasses. The most frequent findings were emaciation, trauma, toxicoses, and diseases (Table 1). Less common causes of death included gunshot, electrocution, trapping, and a variety of miscellaneous conditions. We found no differences in the proportional distribution of gender or age

among the various categories of diagnostic findings. However, there was a significant ( $\chi^2 = 5.26$ ,  $df = 1$ ,  $P = 0.02$ ) difference in the distribution of juveniles and adults when emaciated birds were compared with all other groups combined. Proportionally more juveniles than adults were emaciated.

Because a diagnosis of emaciation was applied subjectively, based on visual observation of fat reserves and muscle mass, we sought to verify this determination by comparing the mass of emaciated red-tailed hawks with the mass of birds diagnosed with gunshot, other trauma, and electrocution. The latter three groups were selected for comparison because we expected hawks that died such acute deaths would have body mass representative of the normal population. In fact, the mass of birds in this acute death group (Table 2) agreed closely with those reported by Dunning (1984). Regardless of gender or age, the average mass of emaciated birds was significantly ( $F = 78.21$ ,  $df = 1,46$ ,  $P = 0.0001$ ) less than birds in other mortality categories (Table 2).

**Emaciation.** Diagnosed in 33 birds, emaciation was the most frequent finding, but examination of the carcasses failed to reveal its causes in individual birds or an explanation for the high rate of occurrence. These hawks may have died of starvation because of scarcity of prey or perhaps had unapparent injuries or diseases that led to their emaciated condition. However, chronic poisonings cannot be ruled out because tissues were not analyzed for the presence of toxins. As for the finding that more juveniles than adults suffered from emaciation, we speculate that juveniles, because of their more restricted diet (Craighead and Craighead 1956), may be less successful in obtaining food during periods of adverse environmental conditions, reduced prey populations, or dispersal into new territories.

**Trauma.** Trauma, exclusive of gunshot, was the second most commonly identified finding and was noted in 29 red-tailed hawk carcasses. Frequent traumatic injuries included fractures of long bones, vertebrae, and of the skull. These injuries and the evaluation of information, when provided, regarding the locations where the carcasses were found suggested that at least 10 of these birds probably collided with vehicles or structures near roadways. The fact that human observers spend a great deal of time on or near roadways may have contributed to the high frequency of traumatic injuries found among the hawks that were submitted.

Gunshot trauma was diagnosed in six birds. The

Table 2. Mass (g) of emaciated red-tailed hawks and of those that died acute deaths.

SEX	MEAN MASS (SD, N)	
	EMACIATION	ACUTE DEATH <sup>a</sup>
Male		
Adult	680 (94, 6) <sup>b</sup>	1031 (72, 4)
Juvenile	747 (118, 7)	1025 (167, 3)
Female		
Adult	1040 (85, 2)	1236 (173, 11)
Juvenile	777 (105, 12)	1192 (131, 9)

<sup>a</sup> Trauma, gunshot, and electrocution.

<sup>b</sup> Regardless of sex or age, weights of emaciated hawks were significantly ( $F = 78.21$ ,  $df = 1,46$ ,  $P = 0.0001$ ) less than weights of birds in the acute death category.

appearance of the wounds and characteristics of projectiles, or portions thereof, that were recovered led pathologists to conclude that four of the hawks were shot with rifles and two with shotguns.

**Toxicoses.** Of the 25 poisoning cases in red-tailed hawks, 20 were attributed to agricultural pesticides. A single case of poisoning by endrin, a chlorinated hydrocarbon pesticide, was diagnosed in a bird of very poor body condition collected in 1982. This hawk was among 11 species of Falconiformes that died of endrin poisoning in or near orchards in central Washington (Blus et al. 1989). Organophosphorus or carbamate compounds were responsible for the remaining 19 agricultural chemical poisonings, collected from 1987 through 1992, based on brain cholinesterase activity or analytical identification of a pesticide in stomach contents. Carbofuran, phosphamidon, fenthion, and famphur were responsible for 11 of the mortalities (Table 3). Stomach contents in 10 of these hawks were of avian origin and the other contained the remains of a small mammal, consistent with secondary pesticide poisoning from consuming intoxicated prey (Stone et al. 1984, Henny et al. 1985, 1987, Hunt et al. 1992). Brain cholinesterase activity was inhibited by 77–97%, except for one case of carbofuran poisoning in which the initial activity was inhibited by only 39%, probably because of partial postmortem reactivation (Hill and Fleming 1982). After incubation and retesting, the cholinesterase activity of this sample increased to 113% of normal, a characteristic response to carbamate exposure (Smith et al. 1995) and the carbofuran concentration in stomach contents was

Table 3. Organophosphorus and carbamate pesticide poisonings in 11 red-tailed hawks.

PESTICIDE	STATE YEAR (N)	CONCEN- TRATION IN STOMACH CONTENTS <sup>a</sup>	BRAIN ChE <sup>b</sup> INHIBI- TION (%)
Carbofuran	MD, 1988 (1)	150	39
	MD, 1988 (1)	38	87
Phosphamidon	KS, 1990 (2)	3.5, 9.7	94, 97
Fenthion	IL, 1992 (2)	0.5, 2.8	83, 87
	MO, 1992 (1)	13	96
Famphur	UT, 1987 (1)	0.2	84
	UT, 1991 (2)	0.9, 0.5	78, 77
	WA, 1989 (1)	1.5	89

<sup>a</sup> ppm, wet weight; stomach contents consisted of avian remains in all instances, except that parts of a small mammal were found in the first carbofuran (150 ppm) case listed.

<sup>b</sup> Cholinesterase.

150 ppm wet weight. The relatively low level of brain cholinesterase inhibition, but high carbofuran residues, are in agreement with Greig-Smith (1991) who reported that a correlation between brain cholinesterase activity and carbamate pesticide residues is lacking.

In eight birds, brain cholinesterase activity was inhibited by 48–99%, without reversal after incubation of the sample, but chemical analysis of stomach contents was not done ( $N = 5$ ) or failed to reveal the presence of any of the compounds included in the assay ( $N = 3$ ). The magnitude of cholinesterase inhibition and the lack of reversal is consistent with exposure to an organophosphorus compound (Ludke et al. 1975, Hill and Fleming 1982, Smith et al. 1995), and we describe these as cases of suspected poisoning by an organophosphorus compound. In fact, three of these birds were found during mortality events where stomach contents from other red-tailed hawks were positive for famphur or phosphamidon. At least three possible explanations exist for the situation in which brain cholinesterase results and field circumstances point to organophosphate poisoning, but analytical results from stomach contents are negative: (1) Brain cholinesterase activity can remain inhibited several days after exposure to organophosphorus pesticides (Fleming and Bradbury 1981), and it is possible that by the time these birds died the concentration of the responsible chemical in stomach contents was below detectable limits as a result of degradation, absorption, or regurgitation;

(2) A loss of brain cholinesterase activity might result from advanced decomposition, although Prijono and Leighton (1991) found this enzyme to be quite stable for up to 8 d at 25°C; or, (3) The birds may have been poisoned by a compound not included in the testing procedure.

The earliest of the organophosphorus and carbamate poisonings in this group of birds occurred in 1987, well after secondary famphur poisoning was documented in a red-tailed hawk in 1982 (Henny et al. 1985). This may reflect nonrandom sample bias, expressed by an increased interest in these types of poisonings during the mid-1980s, and the fact that screening for brain cholinesterase activity was not common practice at the National Wildlife Health Center until about 1985. Our finding of a 12% (19 of 163) frequency of organophosphorus and carbamate poisonings in red-tailed hawks is similar to that (17%) reported in a 1975–88 survey in The Netherlands of eight raptor species (Lumeij et al. 1993), but higher than that found in some other studies. A 30-yr summary of over 4300 bald eagle (*Haliaeetus leucocephalus*) and golden eagle (*Aquila chrysaetos*) mortalities that began in the early 1960s indicated an overall frequency of anticholinesterase poisonings of about 3% (Franson et al. 1995). Most of those cases occurred after the early 1980s. Gremillion-Smith and Woolf (1993) tested brain cholinesterase activity of 105 raptor carcasses of five species collected in Illinois in 1985–87, and reported that 6% were anticholinesterase poisoning suspects.

Lead toxicosis was diagnosed in one red-tailed hawk collected in Illinois in 1981 and one found in California in 1985. Both birds were emaciated and the liver-lead concentrations were 4.3 and 10 ppm wet weight, respectively, but no ingested lead was found. In raptors, liver-lead residues of 2–4 ppm wet weight indicate unusual exposure to lead, while residues greater than 5 ppm wet weight are compatible with death when pathology consistent with lead poisoning is present (Franson 1996). The liver-lead concentration of 4.3 ppm wet weight in the first hawk reflects lead exposure in the toxic range but, because emaciation was the only lesion noted, this concentration is not itself conclusive for a definitive diagnosis of fatal lead poisoning. We can merely infer that this bird was affected by lead toxicosis. The liver-lead concentration of 10 ppm wet weight and the emaciated condition of the second hawk are compatible with a lead-poisoning diagnosis. This second case is complicated by the presence of pas-

teurellosis (*Pasteurella multocida*) and aspergillosis (*Aspergillus fumigatus*) in the bird's respiratory tract. Debilitation and immunosuppression, subsequent to lead exposure, may have facilitated the invasion of these organisms. Immunosuppressive effects of lead are well-known from studies of laboratory animals but less understood in wildlife (Franson 1986), although reduced numbers of immunologic cells in mallards (*Anas platyrhynchos*) exposed to lead has been reported (Rocke and Samuel 1991).

One hawk found in Minnesota in 1983 and another in California in 1990 died of strychnine poisoning, with concentrations of strychnine in stomach contents of 16 and 330 ppm wet weight, respectively. The death of a hawk collected in 1987, from an area in California with a previous history of selenium contamination (Ohlendorf et al. 1990, Schuler et al. 1990), was attributed to selenium toxicosis. The carcass was emaciated and had selenium residues of 19 ppm wet weight in its liver. Background residues of selenium in avian liver are generally less than about 5 ppm wet weight (White et al. 1980, Hutton 1981). Mallard ducklings that died after experimental selenium exposure had liver selenium residues of 7 and 18 ppm wet weight (Heinz et al. 1988). Eastern screech-owls (*Otus asio*) euthanized after receiving selenomethionine in their diet for more than 3 mo were thin and had a mean liver selenium concentration of 17 ppm wet weight (S.N. Wiemeyer pers. comm.).

**Diseases.** Evidence of infectious disease was the primary finding in 21 of the red-tailed hawk carcasses. Aspergillosis was the most frequent of these, occurring in nine birds. Gross observations were consistent with chronic disease, characterized by the presence of fungal mats, caseous nodules, or plaques within the respiratory system, and *Aspergillus fumigatus* was isolated from tissues. Aspergillosis is frequently associated with other conditions that weaken birds and predispose them to infection (O'Meara and Witter 1971). Concurrent diseases, two cases of pasteurellosis and one of mycobacteriosis (*Mycobacterium* sp.) were found in three of these hawks, but no other infectious agents or contributory causes were identified in the other six birds with aspergillosis. Aspergillosis is also common in birds undergoing rehabilitation, but four of the hawks were found dead in the field and the others were in captivity for less than 7 d.

Pasteurellosis was found in five of these red-tailed hawks, including two cases where it was the primary

finding, one case associated with lead poisoning and aspergillosis, and two concurrent with aspergillosis only. Of the two birds with primary pasteurellosis, one had a swollen foot and yellow fibrinous material in the pericardial sac, both of which yielded cultures of *P. multocida*. The only lesion seen in the second hawk was congestion of the lungs, but *P. multocida* was isolated from liver, lung, and heart. No lesions suggestive of pasteurellosis were seen in the lead-poisoned hawk, but *P. multocida* was isolated from air sacs. Gross lesions in the birds with concurrent aspergillosis/pasteurellosis included thickened air sacs and fibrinous adhesions within the body cavity, and *P. multocida* was isolated from the lungs and air sacs. All five carcasses were collected in California, one each in January and November of 1978, two in January of 1985, and one in January of 1988. Pasteurellosis, or avian cholera, is an endemic disease of wintering waterfowl in California, where yearly losses of ducks and geese numbering in the tens of thousands are commonplace (Botzler 1991). Pasteurellosis was reported from a red-tailed hawk collected in California in 1982 (Brogden and Rhoades 1983). Reports in raptors are infrequent, although they are often exposed to the organism when scavenging on carcasses of waterfowl that have died of avian cholera.

Mycobacteriosis (tuberculosis) was diagnosed in four hawks, including three in which tuberculosis was the primary finding. Tuberculosis is caused by bacteria of the genus *Mycobacterium*, including several species with a predilection for birds. The disease can be acquired by carnivorous birds that ingest the bacteria in tissues of infected prey, or may be spread among ground-feeding birds through fecal contamination of soil or food. The characteristic lesions of avian tuberculosis are nodules located along the gastrointestinal tract or in various organs. The affected red-tailed hawks were found in Wisconsin in 1976 and 1978, Illinois in 1977, and California in 1985. Typical nodular lesions were found in liver and lung, liver, spleen, and sternum; liver and spleen; and proventriculus, respectively. In all cases, characteristic acid-fast bacteria were seen on histopathology and in two cases tissues were sent to the National Veterinary Services Laboratories, Ames, Iowa, where *Mycobacterium avium* was isolated.

Avian pox, characterized by proliferative lesions on unfeathered skin of the feet and face, was noted in three birds. These hawks were found in Wisconsin in 1985, in Utah in 1987, and in Nebraska in 1988.

Intracytoplasmic inclusions consistent with pox were seen in tissues of all three hawks, and pox virus was isolated from lesions of one bird. Viral enteritis was diagnosed in one bird and protozoal enteritis in another by histologic examination of tissues, but attempts to further characterize these agents were unsuccessful. One hawk had splenitis and severe pneumonia, with consolidation of part of one lung and thickening of the air sacs. *Klebsiella pneumoniae* was isolated from the spleen and *Pseudomonas* sp. was isolated from the spleen, liver, and air sac.

**Other Diagnoses.** Electrocution was diagnosed in six carcasses with burn marks on feathers or skin, four of which were found in close proximity to utility lines. One red-tailed hawk had injuries to a foot and wing as the result of having been caught in a leg-hold trap. Miscellaneous conditions ( $N = 10$ ) of uncertain etiology included visceral gout (2), peritonitis (2), verminous enteritis (2), pneumonia (1), sinus abscess (1), and air sacculitis (1). These diagnoses were based on gross observations only. Histopathology revealed hepatitis of unknown origin in one bird.

**Summary.** Because of biases inherent in the non-random collection and submission of carcasses, the true relative significance of these causes of mortality on red-tailed hawk populations cannot be determined. However, these cumulative findings provide baseline data on a variety of factors that cause mortality in red-tailed hawks, against which future diagnostic surveillance can be compared. Of the 131 carcasses for which diagnoses were determined, 39 (30%) died as a result of anthropogenic causes (toxicoeses, gunshot, electrocution, and trapping). In addition, a portion of the 29 trauma cases were apparently the result of collisions with man-made structures. Steps can be taken to reduce these mortalities by providing education to increase public awareness of the impact of human activities on red-tailed hawks. Future research might be designed to identify significant temporal and geographic patterns of anthropogenic causes of mortality in red-tailed hawks, monitor pesticide poisonings, identify causes of undetermined mortality and emaciation, and to evaluate population effects of all mortality factors.

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## NESTING AND FOOD HABITS OF THE FLAMMULATED OWL (*OTUS FLAMMEOLUS*) IN SOUTHCENTRAL IDAHO

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**ABSTRACT.**—Flammulated owls (*Otus flammeolus*) arrived at our 25-km<sup>2</sup> study area in Idaho from mid-to late May 1991–94. Twenty-four nesting pairs utilized 22 nesting cavities. Twenty (83%) of the nests were in dead trees and four (17%) in live trees. Thirteen (54%) nests were in broken-top Douglas-fir (*Pseudotsuga menziesii*) snags, and 11 (46%) were in trembling aspen (*Populus tremuloides*). Mean diameter at breast height of 13 nest trees was 49.9 cm (SD = 18.9), while mean cavity height was 5.1 m (SD = 0.6). Mean entrance diameter for 11 nests was 6.8 cm (SD = 1.3). Mean hatching date at 11 of the 24 nests was 26 June (range, 12 June through 11 July) and mean fledging date was 18 July (range, 7 July through 2 August). Mean brood size for nine nests was 2.3 (range, 2–3) young per nest. Nightly food deliveries at nest sites peaked within the 2-hr period after dark and before daylight. Mean number of nest visits by adults during the nesting stage was 93. Although lepidopterans comprised 79% and orthopterans 0.3% of the available prey within the study area in 1992, 65 food deliveries at one nest revealed 43.1% orthopteran and 9.2% lepidopteran prey. At other nest sites, lepidopterans were the prominent prey. Four banded owls returned to the same territory for two, three, and four consecutive nesting seasons.

**KEY WORDS:** *flamulated owl; food habits; Idaho; nesting; Otus flammeolus.*

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### Nidificación y hábitos alimentarios de *Otus flammeolus* en el centro-sur de Idaho

**RESUMEN.**—*Otus flammeolus* arribó a nuestra área de estudio de 25 km<sup>2</sup> en la segunda quincena de mayo de 1991 a 1994. Veinticuatro parejas nidificantes utilizaron 22 cavidades. Veinte (83%) de los nidos se ubicaron en árboles muertos y cuatro (17%) en árboles vivos. Trece nidos (54%) se encontraron en ramas alta quebradas de *Pseudotsuga menziesii* y 11 (46%) nidos estaban en *Populus tremuloides*. El diámetro medio a la altura del pecho de 13 árboles con nidos fue 49.9 cm (DS = 18.9). Mientras la cavidad se ubicó a una altura media de 5.1 m (DS = 0.6). El diámetro medio para la entrada en 11 nidos fue de 6.8 cm (DS = 1.3). La fecha media de eclosión en 11 de los 24 nidos, ocurrió el 26 de junio (rango 12 de junio hasta el 11 de julio). La fecha media del estado volantón fue el 18 de julio (rango 7 de julio al 2 de agosto). El tamaño medio de nidada para nueve nidos fue de 2.3 (rango 2–3) juveniles por nido. La alimentación nocturna en el nido ocurrió en el período de dos horas después de hacerse oscuro y dos horas antes de la luz diurna. El número promedio de visitas al nido por adultos, durante el estado de pollo, fue de 93. Aunque los lepidópteros constituían el 79% y los ortópteros el 0.3% de las presas disponibles en el sitio de estudio en 1992, 65 entregas de alimento en un nido revelaron que las presas estaban constituidas por un 43.1% de ortópteros y un 9.2% de lepidópteros. En otros nidos, los lepidópteros fueron las presas dominantes. Cuatro búhos marcados retornaron al mismo territorio, por dos, tres y cuatro estaciones de nidificación consecutivas.

[Traducción de Ivan Lazo]

Until recently the flammulated owl (*Otus flammeolus*) was one of the least-known species of owl occurring in the mountain forests of western North America (Reynolds et al. 1989). Ranging from British Columbia to Central America, this small, cavity-nesting, predominantly insectivorous owl was formerly considered rare throughout much of its range (Bent 1938). Recent studies, however, have found it to be present in Montana (Holt et al. 1987) and fairly common in portions of California (Winter 1974, Marcot and Hill 1980), Colorado (Linkhart and

Reynolds 1987), New Mexico (McCallum and Gehlbach 1988), Oregon (Bull and Anderson 1978, Goggans 1986, Bull et al. 1990) and British Columbia (Cannings et al. 1978, Howie and Ritcey 1987). The flammulated owl is presumed to be migratory at least within the Canadian and United States portions of its range (Reynolds et al. 1989) with supporting evidence for such being documented in New Mexico and Arizona (Balda et al. 1975).

Flammulated owls occur in Idaho (Larrison et al. 1967, Burleigh 1971) and although their distribution

and nesting status have been documented (Hayward 1986, Atkinson and Atkinson 1990, Moore and Frederick 1991), their breeding biology has received little study within the state. Currently the owl is listed as a species of special concern by the Idaho Department of Fish and Game and as a sensitive species (Moseley and Groves 1994). The status of this owl is in further jeopardy because it is a Neotropical migrant (Saab and Groves 1992). Objectives of our study were to document the occurrence, nesting activities and food habits of flammulated owls in the west portion of the Sublett Mountains during four nesting seasons, 1991–94.

#### STUDY AREA AND METHODS

The Sublett Mountains are approximately 68 km southeast of Burley, Cassia County, Idaho on the east edge of the Raft River Valley. Scattered Utah juniper (*Juniperus osteosperma*) communities skirt the lower regions and isolated pockets of trembling aspen (*Populus tremuloides*) and Douglas-fir (*Pseudotsuga menziesii*) are found at upper elevations, especially along north-facing slopes and draws. Our study area encompassed six dry canyons running north into the South Fork of Sublett Creek drainage. Topography is characterized by narrow canyon bottoms and moderate side slopes with elevation ranging from 1540–2200 m. Annual precipitation, primarily snow, varies from 25–75 cm and temperatures range from  $-37$ – $38^{\circ}\text{C}$  (J. Chard pers. comm.). Forest vegetation is predominantly aspen and Douglas-fir. Vegetation types in the study area are primarily sagebrush–grass, mountain shrub, riparian with scattered forbs, and grassland types. With the exception of scattered springs or seeps, there is no running water in any of the canyons studied.

Approximately 8 km<sup>2</sup> in Beaverdam and Twin Canyons were surveyed for owls in 1991. We expanded our surveys to approximately 25 km<sup>2</sup> in 1992 including an unnamed canyon (“Fenceline”), Kossman, and Eyrie Springs Canyons.

In 1991 our study efforts centered in Beaverdam Canyon where field studies were conducted between 5 April and 22 September. During 1992 we continued our studies in Beaverdam Canyon between 15 May and 26 June, and on 26 June we expanded our study into “Fenceline,” Kossman and Eyrie Canyons, visiting all three canyons between 27 June and 15 November. In 1993 field work was conducted within the entire study area between 10 May and 28 July. The 1994 study season began on 25 May and continued through 12 August. We visited each suspected and known nest site at least once each trip to the study area. Previous incidental observations on nest sites, nesting phenology and banding efforts in the study area by one of us (LP) dating back to 1983 are also included with these data.

During April (1991 only), May, and June we conducted nocturnal surveys of the study area using playbacks of tape-recorded calls between sunset and midnight. Areas where responses were obtained were flagged for diurnal revisitation and investigation. All living trees and snags

bearing cavities were scratched (Bull et al. 1990) for determination of occupancy two or three times during June and July. In addition, we sometimes skylighted cavities (Reynolds and Linkhart 1984) and made nocturnal observations with night-vision optics to determine occupancy and stage of nesting phenology at their cavities. Activity at nest cavities was monitored by periodic diurnal visits, to confirm nocturnal visitation by adults, and nestling or fledgling food-begging vocalizations. All-night observations recording the time and number of adult nest visits were on two nights each at two nests.

At least once each trip to the study area, nocturnal prey was sampled with a standard black-light (ultraviolet) and 1.5 × 1.5 m framed sheet sampling station. Insect sampling was always done within one of the occupied owl territories. Insects captured were measured and categorized into size classifications of small (8–11 mm), medium (12–13 mm) or large (14–32 mm) body length (Balda et al. 1975). To determine prey selection, we photographed prey deliveries and visually documented prey by close observations of artificially lighted nest cavities.

To determine nest site and mate fidelity and document individual activities at nest sites, owls were trapped and banded whenever possible. Adult owls were captured either in hand nets or mist nets placed in front of occupied nest cavities. All owls were banded with U.S. Fish and Wildlife Service aluminum bands.

#### RESULTS

Owls were first detected in the study area from mid- to late-May each year with the earliest date being 16 May 1993. April and early May playback tape surveys in the study area produced no vocalizing or other evidence of their presence. In the latter part of May and early June territorial calling by males and pair-bonding behavior, such as food solicitation callings (mewing) by females and allofeeding by males (McCallum 1994a), became more evident about prospective cavities. Such behavior was observed at three territories during the night of 9 June 1993.

Twenty-four nesting attempts by flammulated owls utilized 22 different nest cavities during our study (two of the cavities were occupied twice in consecutive years). Including previous observations of an active nest in 1983 and two others in 1988, 14 nests were found in Beaverdam Canyon, one in west Twin Canyon, four in Kossman Canyon, two in Eyrie Canyon and three occurred in “Fenceline” canyon between Twin and Kossman Canyons. The number of known nesting pairs was three in 1991, four in 1992, eight in 1993 and six in 1994.

We were able to determine brood size at only nine of our 24 nests. Single fledglings were observed at two additional nests. Three of the nine nests produced three nestlings each and the rest contained two young each ( $\bar{x} = 2.3$ ).

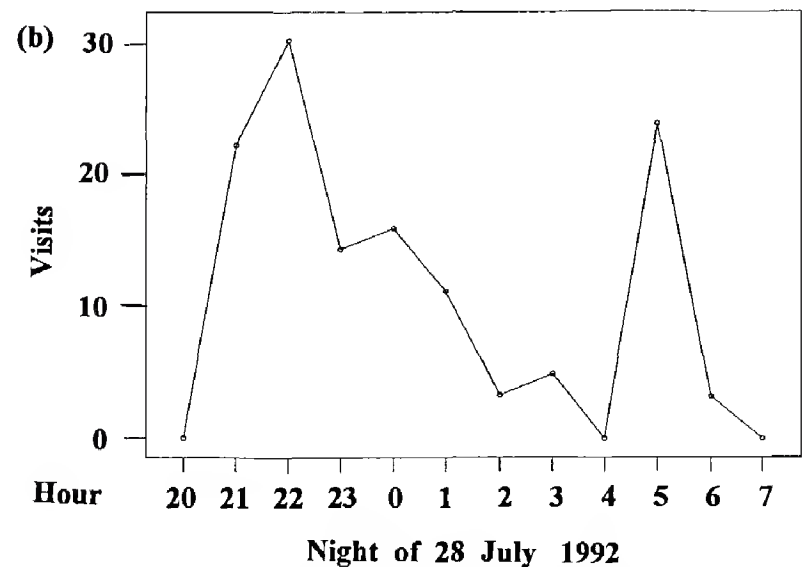
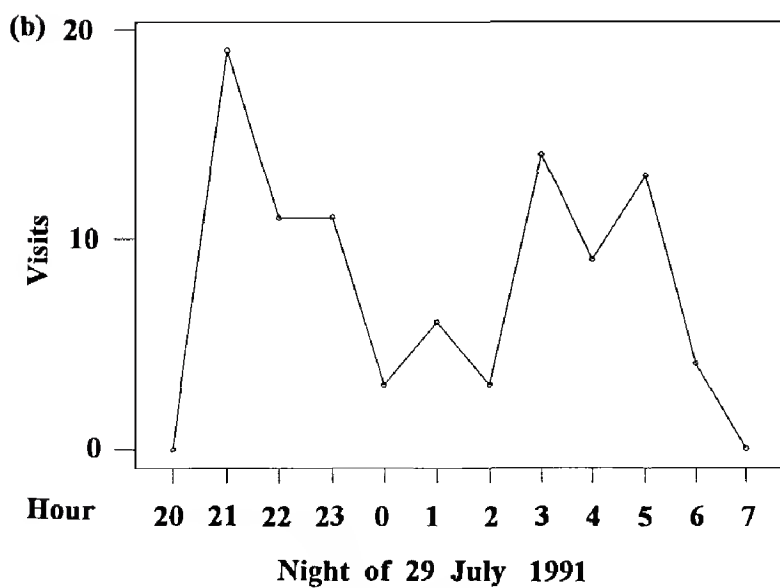
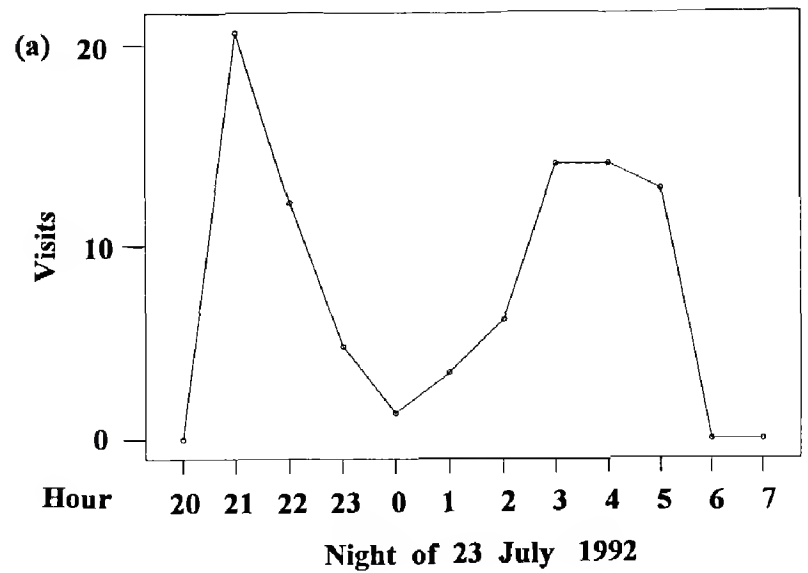
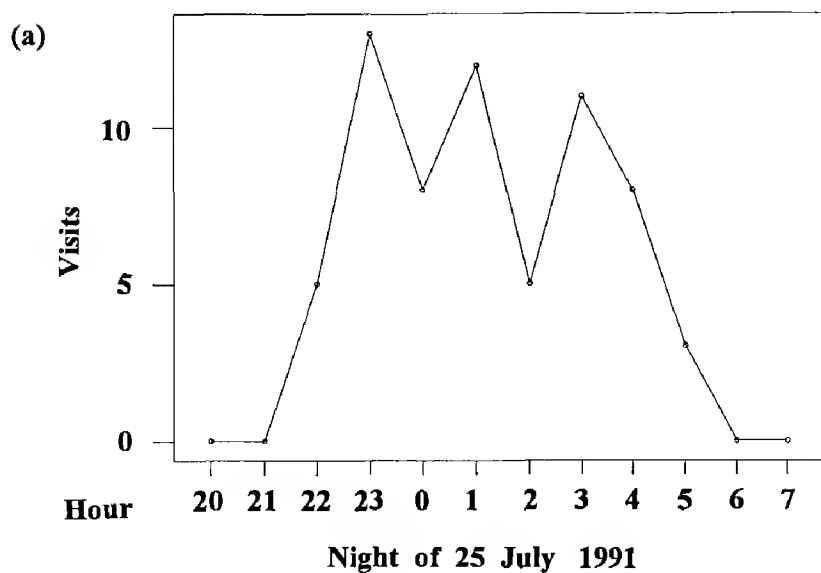


Figure 1. Nest visits by flammulated owls at Side Canyon during the nights of 25 July (a) and 29 July (b), 1991.

Figure 2. Nest visits by flammulated owls at Eyrice Canyon during the nights of 23 July (a) and 28 July (b), 1992.

Twenty (83%) of the owl nests were in dead trees and four (17%) in live trees. Of these, 13 (54%) were in dead broken-top Douglas-fir snags and 11 (46%) in trembling aspens—seven (29%) in dead trees and four (17%) in live aspens. Mean dimensions for 13 nest sites were 49.9 cm (SD = 18.9) for diameter at breast height, 5.1 m (SD = 0.6) for cavity height; entrance diameter for 11 of the nests was 6.8 cm (SD = 1.3). Primary excavators of cavities within our study area were the northern flicker (*Colaptes auratus*), hairy woodpecker (*Picoides villosus*) and the yellow-bellied sapsucker (*Sphyrapicus varius*).

We were able to determine hatching or fledging dates at 11 of the 24 nests. Using 22 d for both the incubation and nestling periods (Reynolds and Linkhart 1987, Johnsgard 1988, McCallum 1994a) we

calculated the mean hatching date for the 11 nests as 26 June (range, 12 June through 11 July) and mean fledging date as 18 July (range, 7 July through 2 August).

During the nestling stage at two nests, four all-night surveillances (Figs. 1 and 2) recorded 65, 93, 133, and 81 ( $\bar{x} = 93$ ) nocturnal nest visits by adult owls, primarily the male. These nightly food deliveries at nest sites peaked within the 2-hr periods after dark and before daylight.

Insect sampling in 1992 (Tables 1 and 2) recorded more smaller-sized invertebrates (37.6%) compared to larger potential prey (27.4%) and found lepidopterans to comprise 78.8% and orthopterans 0.3% of the prey sampled within the study area. Photographic analysis (Table 3) of 65 food deliveries at one nest

Table 1. Invertebrate sizes recorded at black-light sampling stations within the study area, summer 1992.

LOCALITY	DATE	NUMBER BY SIZE CLASS		
		SMALL (8–11 mm)	MEDIUM (12–13 mm)	LARGE (14+ mm)
Beaverdam Canyon	25 June	24	8	12
	2 July	0	2	9
Kossman Canyon	3 July	19	14	13
Eyrie Canyon	8 July	40	52	27
	13 July	38	35	22
	14 July	69	57	35
	23 July	18	11	22
	24 July	37	49	39
Totals		245 (37.6%)	228 (35.0%)	179 (27.4%)

identified 43.1% as orthopterans and 9.2% as lepidopterans. Observations at other nests (Table 3) revealed a predominance of lepidopteran prey.

A female owl was captured in the same territory in 1992, 1993 and 1994; nesting in the same cavity the first 2 yr but in a different snag the third year. Her mate was not banded in 1992 but was known to occupy that territory in 1993 and 1994. Another male nested in different snags 60 m apart in 1991 and 1993, but could not be identified during 1992 and 1994 when no occupied nests could be found within that territory. A third male, nesting in 1988 was recaptured again in 1991 in a mist net 50 m from the 1988 nest tree. We did not sample the area between 1988 and 1991.

#### DISCUSSION

Although spring arrival dates for flammulated owls in Idaho are not well-documented, the mid- to late-May arrivals in our study area seem comparable to

the few records elsewhere in the state. For example, singing owls were heard on 10 May in the Salmon National Forest (Atkinson and Atkinson 1990), on 24 May 1991 in westcentral Idaho (Moore and Frederick 1991), and a migrating flammulated owl was photographed roosting in a black-billed magpie (*Pica pica*) nest near Boise, Ada County, Idaho on 16 May 1970 (E. Thompson pers. comm.). Owls may have arrived earlier in May some years since the number of consecutive days we spent in the study area was limited and inclement weather occasionally prevented our early access to the study area.

Reynolds and Linkhart (1992) reported that with the exception of a single nest in a piñon pine (*Pinus edulis*) in California, all reported nests of the flammulated owl occur in forests containing at least some ponderosa pine (*Pinus ponderosa*). Recent studies have found this owl mostly avoiding the ponderosa pine belt in southern British Columbia (Howie and Ritcey 1987) and nesting in forests devoid of this pine in Nevada (S. Garland pers. comm.). Our study provides another exception in that ponderosa pine does not occur within our study area. Douglas-fir and aspen were the only tree species utilized by nesting owls in our study. Although this owl is known to occur in trembling aspen (Webb 1982), the high incidence of its utilization of this tree species for nest sites in our study area (46%) is apparently much greater than reported elsewhere. Our findings contribute to the mounting evidence that flammulated owls may not be so exclusively tied to ponderosa pine as much of the earlier literature indicates.

Nesting phenology is not well-documented for the flammulated owl throughout its range. In Colorado

Table 2. Invertebrates recorded at black-light sampling stations in the study area, summer 1992.

INVERTEBRATE	NUMBER SAMPLED	PERCENT
Lepidoptera	514	78.8
Diptera	112	17.2
Coleoptera	15	2.3
Dermaptera	7	1.1
Orthoptera	2	0.3
Arachnida	2	0.3
Totals	652	100

Table 3. Prey delivered to four flammulated owl nests, 1991–93.

PREY CATEGORY	1991 <sup>a</sup>	1992 <sup>b</sup>	1993 <sup>c</sup>	TOTALS
Orthoptera	1 (4.3%)	28 (43.1%)	5 (13.9%)	34 (27.4%)
Coleoptera	0 (0)	5 (7.7%)	0 (0)	5 (4.0%)
Diptera	3 (13.0%)	0 (0)	0 (0)	3 (2.4%)
Lepidoptera	9 (39.1%)	6 (9.2%)	29 (80.5%)	44 (35.5%)
Larva	10 (43.5%)	2 (3.1%)	2 (5.6%)	14 (11.3%)
Unidentified	0 (0)	24 (36.9%)	0 (0)	24 (19.4%)
Totals	23	65	36	124

<sup>a</sup> Beaverdam/Side Canyon nest (29 July, dusk-to-dawn observations).

<sup>b</sup> Photographic analysis of prey delivered to Eyrice Canyon nest (23 and 28 July, dusk-to-dawn observations).

<sup>c</sup> Beaverdam/Side Canyon nest and Beaverdam Base Camp nest (7, 8, 18 and 27 July, partial-night observations).

the mean date at which the last egg hatched was 29 June (Reynolds and Linkhart 1987) and 30 June was given as the hatching date at a single flammulated owl nest in southwestern Idaho (Hayward 1986). Our mean hatching date (26 June) may seem early considering the northern extent of our study area and the migratory demands on our owls compared to the more southern Colorado birds. However, even though more southern in latitude, the 350–1300 m higher elevation of the Colorado habitat where snow lingered until early May (Reynolds and Linkhart 1987), likely places their owls into a similar nesting phenology.

Productivity data from our study are limited but the observed brood size ( $\bar{x} = 2.3$ ) of nine nests appears lower than reported for most other populations (McCallum 1994a) except in New Mexico (McCallum et al. 1995), and may support the view that ponderosa pine is the most productive habitat for this owl, even if not the only one used (D.A. McCallum pers. comm.).

In southwest Idaho, Hayward (1986) recorded 54–97 nest visits per night by adults during 9 d of the nestling period. Numerous nocturnal observations by Reynolds and Linkhart (1987) at nests in Colorado all terminated at 0300 H and thus cannot be directly compared to either Hayward's (1986) or our data. However, the food delivery rate at Colorado nests peaked at over 16 trips per hour during the 8–12 d after hatching (Reynolds and Linkhart 1987). Our maximum nest visits per night (133) and peak visits per hour (>30; Figs. 1 and 2) exceed those reported elsewhere. Like Hayward (1986), we observed a greater number of food deliveries early in the night, following the lengthy diurnal fasting period.

Although small vertebrate prey has been documented at flammulated owl nests (Linkhart and Reynolds 1994), as elsewhere (Hayward 1986, Reynolds and Linkhart 1987) we observed only invertebrate prey, predominantly small lepidopterans, being delivered to nests. Orthopterans, which comprised only a minor part of this owl's food in other studies (Hayward 1986, Reynolds and Linkhart 1987, McCallum 1994a), were the predominant prey (43.1%) during the late nestling stage at one of our 1992 nests (Table 3), despite their concurrent low incidence at the black-light sampling stations within the study area (Table 2). During that same time, we observed a general surge of crepuscular and nocturnal activity of the shield-backed katydid (*Neduba carinata*) along roadside areas in proximity to the nest, suggesting that the owls were opportunistically utilizing this abundant food source. Otherwise, prey selection at our nests followed the usual predominance of lepidopterans (Table 3). Goggans (1986) found that food habits of Oregon owls shifted from noctuid moths early in the summer to orthopterans later. Our sampling of potential prey with the black-light station seemed effective for most nocturnal insects but did not attract many orthopterans (pers. obs.), hence their scarcity in our samples may merely reflect a sampling bias.

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## BREEDING, GROWTH, DEVELOPMENT, AND MANAGEMENT OF THE MADAGASCAR FISH-EAGLE (*HALIAEETUS VOCIFEROIDES*)

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**ABSTRACT.**—Increasing population size and distribution in suitable unoccupied habitat is one of several management options that would help prevent the extinction of the Madagascar fish-eagle (*Haliaeetus vociferoides*), one of the rarest raptors in the world. Breeding studies from 1991 through 1994 show this species exhibits siblicide or Cainism. In 1993 we tested sibling rescue as a low-cost *in situ* method for increasing annual production of Madagascar fish-eagles. Of three nests tested, two fledged two young using an abbreviated captive rearing period in which removed siblings were reintroduced to artificially enlarged nests as soon as they could defend themselves from siblings and compete for food. Sibling rescue increased production from four to six young from a sample of 10 nests. Measurements of weight gain, feather development and description of the behavioral development of chicks in captivity and in the nest, provide new information and a better understanding of siblicide in this little studied species.

**KEY WORDS:** *Cainism; conservation; development; growth; Madagascar; management; siblicide.*

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Reproducción, crecimiento, desarrollo y manejo de *Haliaeetus vociferoides*

**RESUMEN.**—Incremento del tamaño poblacional y distribución en hábitat adecuados pero no ocupados, es una de las varias opciones que podrían prevenir la extinción de *Haliaeetus vociferoides*, uno de los rapaces más raros del mundo. Desde 1991 a 1994, estudios de reproducción mostraron que esta especie exhibe fratricidio o Cainismo. En 1993, probamos el rescate de hermanos como método *in situ*, de bajo costo, para incrementar la producción anual de esta águila. De los tres nidos probados, dos volantones y dos juveniles fueron sometidos a un corto período de crianza y reintroducidos artificialmente en grandes nidos. Esto ocurrió tan pronto como fueron capaces de defenderse de sus hermanos y competir por el alimento. El rescate de hermanos aumentó la producción de cuatro a seis juveniles en una muestra de 10 nidos. Medidas de ganancia de peso, desarrollo de plumaje y descripción conductual de polluelos en cautividad y nido, permiten proveer nueva información y una mejor comprensión del fenómeno de fratricidio.

[Traducción de Ivan Lazo]

The Madagascar fish-eagle (*Haliaeetus vociferoides*) is one of the rarest birds of prey in the world with a population size estimated at 50–70 breeding pairs (Langrand and Meyburg 1989, Watson and Rabarisoa 1995). Habitat degradation is one cause of the species' rarity but persecution, and other factors have reduced its density even where suitable habitat remains (Watson et al. 1993). Increasing population size and distribution in suitable unoccupied habitat is one of several management options that would help prevent extinction of the species.

Meyburg (1983) suggested sibling rescue as a technique for increasing annual production in birds of prey that exhibit sibling aggression in the absence

of food shortage, known as siblicide or Cainism. He used the Madagascar fish-eagle as an example of an endangered species that may benefit from this form of management. Langrand and Meyburg (1989) surmised that siblicide was the basis for their observation that only one young was produced in each of three nests despite two eggs being laid in each. Between 1991 and 1994 we observed breeding success in Madagascar fish-eagles to determine the frequency of siblicide in this species.

In 1993 we tested sibling rescue, a technique pioneered by Meyburg (1978, 1983) in lesser spotted eagles (*Aquila pomarina*) and Spanish imperial eagles (*A. heliaca*) and demonstrated in black eagles (*A. verreauxii*; Gargett 1990, S. Thomsett pers. obs.;  $N = 3$ ), augur buzzards *Buteo rufofuscus augur* (S. Thomsett pers. obs.;  $N = 1$ ) and African hawk-eagles

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Table 1. Breeding of Madagascar fish-eagles on Lakes Befotaka, Soamalipo and Ankerika in 1993.

PAIR NAME	CLUTCH SIZE	NUMBER HATCHED	SIBLING		CAUSE OF FAILURE
			RESCUE ATTEMPTED	NUMBER FLEDGED	
Ankerika-1	1	0	No	0	Possibly infertile egg
Ankerika-2	2	2	Yes	2	
Ankerika-3	2	1	No	1	Infertile egg
Ankerika-4	0	0	No	0	Did not nest
Ankerika-5	2	0	No	0	Infertile eggs
Befotaka-1	0	0	No	0	Adults disappeared soon after breeding began
Befotaka-2	2	0	No	0	Fertile eggs deserted
Befotaka-3	2	2	Yes	2	
Soamalipo-1	2	0	No	0	Eggs covered by nest material
Soamalipo-2	2	2	Yes	1 <sup>a</sup>	Chick fell and died
Total 15	7	6			

<sup>a</sup> Chick A fell from nest and died, chick B injured when nest fell from tree but later rehabilitated. Without human intervention, this figure may have been zero.

*Hieraaetus spilogaster* (S. Thomsett pers. obs.;  $N = 2$ ), as a low-cost *in situ* method for increasing annual production in the Madagascar fish-eagle (O'Daniel 1995). In other species with siblicide, sibling aggression may diminish after 4–6 wk of age (e.g., African fish-eagles [*Haliaeetus vociferoides*]; Brown 1980) or it may continue throughout the nestling period, as demonstrated in experiments with black eagles (Gargett 1990). The procedure for sibling rescue has typically been to separate siblings for six or more weeks, leaving one in the nest and rearing the other by hand, followed by exchanging siblings weekly and ending with reintroduction of removed siblings to the nest for rearing to independence by their parents (Gargett 1990). By 6 wk, either levels of aggression have declined to allow coexistence, or chicks are capable of avoiding siblings in nests that are large enough to accommodate them (Gargett 1990).

In this experiment, we tested whether removal of one chick from its sibling for 3–4 wk until both appeared large enough to avoid siblings and compete for food in the nest would result in both young surviving to fledging after reintroduction of the removed siblings. This technique of abbreviated captive rearing (i.e., not for the full nestling period) minimized the time of human involvement, while also reducing the costs and equipment needed.

#### METHODS

Breeding was observed in 65 Madagascar fish-eagle nests between 1991 and 1994 (Watson et al. 1993). Nest

contents were observed two to three times during each breeding season using the least intrusive method possible (in order of preference: binoculars from a distance, mirror pole from below nest, and climbing to nest) to determine clutch size, hatching rate and fledging rate. Logistics prevented obtaining complete data sets for all known pairs.

Sibling rescue was tested at three nest sites on Lakes Befotaka, Soamalipo, and Ankerika, respectively, in western Madagascar during the 1993 breeding season (May through November). Breeding pairs were observed at 2–7 d intervals to determine the number of eggs laid and hatching dates using least intrusive methods (as above) required to obtain the information. Of 10 pairs observed, three hatched two eggs each (Table 1).

The first-hatched nestling from each nest was removed within 2–8 d after hatching (after the second egg had hatched) and raised in a brooder for 10–22 d before being exchanged with its sibling for a similar period. A total of six chicks were thus held in captivity, and all were color-banded before being returned to the nest. Swapping brood mates allowed both to experience being fed by parents without interference from the sibling, which we assumed might help with habituation to parents and imprinting on conspecifics.

Brooders consisted of plastic bowls about 40 cm in diameter, lined with plastic doormat material that was cleaned daily. Brooders were heated by kerosene lamps at night and cotton towels were added for chicks less than about 3 wk old to help them keep warm. Bowls were surrounded by a vertically placed rigid clear plastic sheet which allowed adjacent chicks to see but not contact each other. It also caught feces. A large aluminum bowl was inverted and suspended above the brooder to help reduce drafts and maintain warmth while allowing free circulation of air.

Chicks were fed locally captured fresh fish (*Tilapia* spp.) with a calcium-rich vitamin supplement. While in captivity, chick weight was measured before and after every



feeding using 1-kg or 3-kg Pesola scales. Behavior was described *ad libitum*, usually whenever new behaviors were noticed. Development of feathers (proportion of down remaining on each of the wing, back, breast and head) was visually estimated, and growth of tarsus, longest primary, and center tail feather was measured to the nearest millimeter.

The first reintroduction of a chick with its sibling was attempted when captive chicks showed the ability to defend themselves against conspecific attack. Aggression and defense was tested by placing two non-sibling chicks together in the same brooder or by using styrofoam models of chicks to elicit a response. All chicks were observed for at least 45 min after reintroduction to siblings to ensure that no fatal aggression occurred.

The chicks and adults at Befotaka-3 nest were observed for 59 h on 12 d between 17 September (chicks aged 55 and 59 d, respectively) and 1 October 1993, using a 15–25× zoom telescope. The first 2 d of observation were from a blind built in a tree 100 m north of the nest. The remaining observations were done from 400 m east across the lake on the opposite shore. The second chick had been reintroduced to the nest on 24 August and both were within about 1 mo of fledging when observations began.

## RESULTS

**Breeding.** Of 65 observed breeding attempts between 1991 and 1994, 17 pairs laid two-egg clutches, two pairs laid one-egg clutches, and clutch size of the remainder was undetermined. No nests successfully fledged two young, 33 fledged one young, and the remainder fledged no young. Of six nests known to hatch two chicks, all raised only one young, the second to hatch dying within 10 d after hatching. In these cases one egg hatched 2–4 d before the second, and the first-hatched chick almost doubled in weight before the second egg hatched. Sibling mortality was apparently related to observed aggression (O'Daniel 1995, Thomsett pers. obs.) by the older sibling causing death by battering, starvation or displacement of the younger chick from the nest.

**Growth and Feather Development.** Chicks were completely covered by white down until 16 d old, when brown contour and flight feathers first appeared on the head and wings. Down was lost from the head first; heads were fully feathered by about 45 d of age. The fleshy part of the wings lost all their down by about 55 d, the breast by 74 d and the back by about 76 d. Flight and tail feathers first emerged at 17 and 21 d, respectively, the longest primary (third from outermost) growing to a maximum length of 400 mm by 90 d (linear regression,  $a = -91.26$ ,  $b = 5.47$ ,  $r^2 = 0.99$ ,  $P < 0.001$ ) and center tail feather to 260 mm by 98 d (linear regression,  $a = -71.71$ ,  $b = 3.39$ ,  $r^2 = 0.96$ ,  $P <$

0.001) respectively. Tarsus length increased from 20 mm at 3 d to about 60 mm at 20 d and 100 mm at 45 d (linear regression,  $a = 19.25$ ,  $b = 2.13$ ,  $r^2 = 0.96$ ,  $P < 0.001$ ). Claws turned from pale olive at hatching to predominantly black by 16–18 d of age and the intact egg tooth dropped off the bill by 23 d.

Weights taken before first feeding of the day followed a typical sigmoid growth curve, from 80 g at 3 d after hatching up to about 2500 g at 54 d. Data were pooled for all chicks because no single chick was measured from hatching through fledging. Gompertz, logistic, and von Bertalanffy growth models were tested using nonlinear least squares method (Wilkinson 1990). The Gompertz model provided the best fit ( $r^2 = 0.98$ , asymptotic mass,  $A = 2584$  g, mass at zero days,  $B = 42.2$  g, growth constant,  $k = 0.057$ ). Females are probably slightly larger than males, with about 3000 g being the weight of a fully developed female, as identified from observed copulation of banded adults ( $N = 2$ ).

Captive fish-eagle chicks, when offered food *ad libitum*, fed from three to six times per day until about 20 d old, when the number of feedings dropped to twice a day. The amount of food eaten per meal increased from an average of 20 g at 3 d after hatching to an average of 300 g at about 54 d.

**Behavioral Development.** An aggressive reaction was observed from chicks aged anywhere from 2–56 d of age. Levels of aggressive behavior varied considerably among the six chicks held in captivity. Some were indifferent while others were aggressive toward other chicks or models of chicks.

A chick <25 d old, when pecked by a larger chick, would instantly bow its head and remain that way for 2–3 min whether attacked again or not. The same response could be elicited by any pinching of the chick's neck, even by humans. However, after about 25 d of age the victim would resist the attack by either moving away or fighting back.

On hatching, chicks were weak and unable to move. By 8 d chicks could move around the brooder with wings and legs working together. They could also stand on the tarsi, preen, and shake the tail. First pellets were cast between 11 and 15 d, by which time chicks were vocal and active, walking to receive food. By 12 d chicks were capable of picking up small pieces of food from a flat surface. Assuming that, as in other raptor chicks, a neck out and panting posture indicated that a chick was too warm, while a head over back posture indicated that a chick was comfortable or cool, by 13 d chicks tolerated tem-

peratures from 21–30°C, appearing most comfortable at 25°C in dappled sunlight during the day. By 23 d old they could feed themselves while holding intact fresh fish in their feet. First wing flapping was seen at this time, with chicks jumping, falling over and facing into the wind. Chicks were returned to their nest and older sibling at 26, 31, and 39 d of age, respectively, after which behavioral development was observed in less detail. Chicks at Befotaka-3 fledged at 81–84 d after hatching.

By age 5 d the chicks produced at least three distinguishable vocalizations: first, a low volume “peep, peep, peep” call, second, the same call uttered louder and more frequently and associated with signs of discomfort (cold or hunger), and third, a monosyllabic three-hoot call of similar pitch to the adult’s descending tone call (similar also to the African fish-eagle, Brown 1980). By age 10–13 d they began a new call “gwa, gwa, gwa” usually in “protest” at not getting food or when cold. This call persisted and increased in volume and harshness to become the begging call typical of most immature eagles.

**Sibling Rescue.** Reintroduction of siblings to Soamalipo-2, Befotaka-3 and Ankerika-2 nests was attempted after chicks could avoid, or defend themselves, from sibling attack and appeared capable of tolerating diurnal temperature variation without parental or human help. Sibling rescue failed in Soamalipo-2 but succeeded in the other nests. Of 10 known pairs on all three lakes, including the three manipulated nests, six young fledged, two of which would not have succeeded without applying sibling rescue (Table 1).

*Reintroduction at Soamalipo-2 nest.* Eggs in Soamalipo-2 hatched on 7 and 9 July, 11 and 41 d ahead of first-hatched eggs in Befotaka-3 (20 and 24 July) and Ankerika-2 (15 and 17 August). We removed the older of the two chicks (chick A) at age 8 d, reared it in captivity for 10 d, then exchanged it for its younger sibling (chick B). When removed, chick A had a mass of 245 g and chick B 155 g. Chick B was taken from the nest at age 16 d and mass of 640 g, and exchanged with chick A (580 g, 18 d). Chick B was returned to the nest with its sibling on August 4 (1200 g, 26 d). Chick A was not weighed on this date. No aggression was seen between chicks during 45 min of observation after reintroduction. The next day at 1630 H both chicks had full crops. Chick A had a few scratches on the face. On 7 August, chick A was found dead under the nest. Injuries indicated the chick had most prob-

ably died as a result of falling from the nest that day. The dead chick was more developed but weighed less (1100 g dead at 30 d) than chick B (1200 g alive at 26 d), although the mass difference may have been from water loss after death. In our opinion, the nest was too small and poorly built to support two chicks. The frailty of the nest was demonstrated on 14 August when a strong wind blew it out of the tree. Although we believe the chick did not die from sibling attack directly, the possibility exists that it was driven from the nest by its sibling.

*Nest Enlargement and Reintroduction at Befotaka-3 and Ankerika-2 Nests.* We enlarged the nests at Befotaka-3 and Ankerika-2 before the remaining reintroductions. Both nests appeared small for the size of a fish-eagle with diameters of nest material capable of supporting an eagle of less than 1 m (adult mass ranges from 2150–3000 g,  $N = 6$ , and wing length = 520 mm). On 23 August Befotaka-3 nest was enlarged by weaving a 1-m diameter nest from local materials, and positioning it next to the original nest. The chick in the nest at the time (chick A, 1800 g, 34 d) was transferred to the new nest by 1200 H. The adult female flew into the new nest at 1330 H. Chick B (1300 g, 32 d) was placed in the original nest on 25 August, and a 0.4 m high fence of sticks built to separate the chicks while allowing each to be visible to parents. Chick B had been in captivity for 22 d. It was offered fish on five occasions by the adult, but appeared frightened by its parents during the first day. Both chicks were hand fed the following day and daily until 27 August when they were both seen to be fed by the parents. On 29 August two adults were seen feeding one chick each in their adjacent nests. Both chicks fledged by 16 October.

A similar procedure was used at Ankerika-2 where an artificial nest (1 × 2 m) was placed on top of the original nest on 1 September when the chicks were exchanged. Chick A was returned to the nest at age 17 d and chick B, aged 16 d, was taken into captivity. Chick A was left in the nest at 1200 H and was being attended by the adult female by 1400 H. Chick B (1400 g, 39 d) was reintroduced to the nest on 24 September, and both fledged after 28 October (exact date unknown as they were next seen in January 1994).

**Behavior of Chicks and Adults in the Nest: Befotaka-3.** Chicks in Befotaka-3 nest were separated by a stick fence when observations began on 17 September, 24 d after reintroduction. In addition to color bands for identification, several physical and

Table 2. Comparison of number of call bouts between older (A) and younger (B) chicks, number of visits by adults to each chick and the separating fence, number of fish loads brought to each chick by adults, and time spent feeding by chicks, at Befotaka-3 nest. (nr = not recorded, ? = chick not visible in the nest.)

DATE	OBSER- VATION TIME, hr	CALL BOUTS BY EACH CHICK		N OF VISITS BY ADULTS TO EACH CHICK AND FENCE			FISH LOADS BROUGHT BY ADULTS TO EACH CHICK		TIME (min) SPENT FEEDING BY CHICKS	
		A	B	A	B	FENCE	A	B	A	B
Sep 17	7.5	nr	nr	1	4	0	0	1	0	72
Sep 18	1.0	nr	nr	1	1	0	1	1	?	0
Sep 24	4.0	101	0	0	6	0	1	2	21	30
Sep 25	3.5	67	1	3	2	1	2	0	89	0
Sep 26	4.5	303	0	0	3	0	0	2	0	44
Sep 27	4.5	368	0	0	8	0	0	1	0	86
Sep 28	12.0	91	0	0	9	0	0	0	39	11
Sep 29	12.0	31	0	1	12	1	0	0	62	24
Sep 30	5.0	92	43	0	2	0	0	0	62	15
Oct 1	5.0	0	0	0	7	0	0	0	0	0
Total	59.0	1053	44	6	54	2	4	7	273	282

behavioral differences were apparent between the chicks that remained obvious throughout the period of observation. The older, chick A, had a mass of 1800 g on 23 August at age 33 d and appeared slightly larger, when observed from a distance, than chick B which had a mass of 1300 g at age 32 d on 26 August. Chick A had more down remaining on the underside of its wings, a higher pitched and louder vocalization than chick B, and its behavior was always the more aggressive of the two. During the first 2 d of observation the chicks appeared to ignore each other. From 24–27 September, chick B was seen to sit on top of the fence, looking into the opposite side at its sibling for a total of 3%, 6%, 13% and 9% of each observation day (Table 2), respectively. On 28 September chick A jumped into chick B's side of the nest, while chick B was being fed by an adult. They remained together on the same side of the nest until fledging.

Chick A vocalized almost continuously (Table 2) except immediately after it was fed on 25 September and after it fed on chick B's side on 28 September. Before this occurred, the adults landed on chick B's side of the nest four times more often than chick A's side (Table 2), and chick B was seen feeding over twice as long (232 min) as chick A (110 min, Table 2). The number of fish loads brought to chick B's side was almost twice that brought to chick A's side (Table 2). In contrast, the first 3 d both chicks were

together, chick A fed for 163 min while chick B fed for only 50 min. Up to this point, chick B had hardly ever vocalized, but on 30 September it called 40 times before being fed at 0930 H when it stopped calling.

Chicks were observed from dawn to dusk on 28 and 29 September (Table 2) to document behavior once they were no longer separated by the fence. When chick A first jumped into chick B's side of the nest and began feeding, chick B and the adult simply looked on. After 2 min, the adult flew from the nest. The first day together the chicks sparred occasionally with their bills, but inflicted no wounds. Thereafter, they fed side by side and coexisted without fighting. However, chick A usually appeared dominant over chick B, seizing fish brought to the nest by adults and feeding first. Chick B never responded aggressively to this behavior; it would circle chick A and wait to feed on the food remains. Chick B sometimes fed first, usually during the second or later meal of the day. Apart from the first night in chick B's side together, chick A always settled in the center of the nest, displacing its sibling to the edge.

Chicks began exercising their wings before 17 September, first flapping in place on the nest, followed by sustained flapping above the nest beginning on 24 and 26 September at 62 and 68 d of age. Both chicks showed a pattern of exercising frequency in which exercising on the nest reached a peak 3 d ahead of aerial flapping while hovering above the

nest. Chick B reached peak frequency of exercising in place on 24 September, while chick A reached its peak on 27 September.

Three different adults regularly visited the nest and fed chicks. The largest of the adults (assumed to be female) was colorbanded and wore a tail-mounted radiotag. The other two adults could not be distinguished unless seen simultaneously. During observations, the female spent over twice as much time at the nest (316 min) as the other two adults combined (136 min). The female was twice seen to fly to one of the other adults, take a fish from it and deliver the fish to the nest. Adults were seen actively feeding the chicks as well as simply delivering fish to the nest for the chicks to feed themselves.

#### DISCUSSION

Siblicide in eagles is either obligate (a chick is always killed by its sibling) or facultative (mortality may or may not occur) for each species (Edwards and Collopy 1983, Mock 1984). Our observations of breeding attempts by territorial pairs of Madagascar fish-eagles between 1991 and 1994 suggest the species exhibits siblicide which may be obligate. In addition, the mass difference between first and second hatched chicks when the second hatched, and the growth constant ( $k = 0.057$ ) for Madagascar fish-eagle nestlings, are consistent with eagle species that typically raise only one young ( $k = 0.024$ – $0.064$ , Bortolotti 1986). These observations help justify the use of sibling rescue as a technique for increasing annual production in this species.

Once the second egg hatched, it was easier to take the older chick from the nest first because this minimized human involvement in the labor intensive period of the first 8 d while chicks were feeble and required most attention. After 8 d, chicks could move around the brooder on their own and by 12 d they could pick up food on their own. Given the reaction to parents of the chick kept for 22 d compared with that of chicks exchanged each 10 d, swapping appeared to help chicks habituate to parents and may be important for the success of this method. Exchanging siblings after one had been in captivity about 10 d may have improved the chances of imprinting on conspecifics.

Introduction of both siblings to the nest once they appeared capable of thermoregulation and could remain separated by a physical barrier worked only after the nest had been enlarged. The barrier pre-

vented sibling aggression until chicks reached an age when they were capable of crossing the barrier. By this time (66 d in Befotaka-3 nest) aggression had declined sufficiently to allow chicks to coexist in the same nest. Although dominance by one chick over the other continued, it was not life-threatening under the circumstances observed in which adults appeared capable of providing sufficient food to satisfy both chicks.

Frequent vocalizing appeared to indicate hunger, since it dropped to zero immediately after feeding. Based on observed feeding bouts and vocalization rate, the motivation for Befotaka-3's chick A to move to the chick B's side of the nest appeared to be hunger. Chick A was dominant over chick B subsequent to this move. Similar dominance by heavier siblings has been documented in black eagles (Gargett 1990) that were experimentally placed together at 10 wk of age and has been recorded in tawny eagles (*Aquila rapax*; Steyn 1973) and golden eagles (*A. chrysaetos*; Beecham and Kochert 1975) although aggression in the latter did not cease. Although chick A was dominant over chick B when together, when they were separated by the barrier, chick A vocalized more often but received less food than chick B. The adult's stimulus to feed chick B more often was unknown, but may have been simply the greater ease of landing on chick B's side of the nest. Parents appeared to have no difficulty in feeding both chicks although parental effort was not measured in this study. Three adults at one nest have been reported in bald eagles (*Haliaeetus leucocephalus*; Sherrod et al. 1976, Heglund and Reisinger 1980, Fraser et al. 1983), but the high frequency of occurrence seen among Madagascar fish-eagles seems unusual (Watson et al. 1993).

Using our method, Madagascar fish-eagle chicks can be reintroduced to their nest by about 4 wk of age instead of  $\geq 9$  wk of age when aggression has diminished. This technique abbreviates the captivity period and is therefore easier to apply under remote field conditions of Madagascar than techniques involving lengthy rearing of young chicks. The method may also be useful in other raptors in which siblicide is invariably fatal regardless of the chick's age.

The Madagascar fish-eagles in this study may be unusual for the amount of human activity and intrusion tolerated at and around the nest. Our subjective impression is that the study pairs may be more tolerant of human intrusion at the nest than pairs elsewhere in Madagascar that have been subject to

human persecution. This method may not be so readily applied elsewhere.

Although sibling rescue increased fledging rates, its use may negatively affect other critical population parameters, such as adult survival or fecundity, or chick A survival to recruitment (Magrath 1991, Mock and Forbes 1994). For example, parents raising two chicks beyond the normal point of brood reduction may suffer increased mortality or reduced fecundity in future seasons, or chicks fledging from a two-chick nest may be less robust and suffer higher mortality between fledging and recruitment to the breeding population. Future attempts at sibling rescue should measure parental effort and body condition to look for negative consequences of caring for two-chick broods. Studies of survival, adult fecundity and impact on population recovery should be implemented if sibling rescue is adopted as a conservation tool for this species. It would be beneficial to test alternative methods for conservation management, such as sibling rescue followed by hacking in unoccupied suitable habitat, that do not require intensive intervention at the nest and that minimize possible negative effects on siblings or parents.

#### ACKNOWLEDGMENTS

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## SHORT COMMUNICATIONS

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### THE USE OF A POWER SNARE TO CAPTURE BREEDING GOLDEN EAGLES

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**KEY WORDS:** *Aquila chrysaetos*; capture techniques; golden eagle; power snare.

Adult golden eagles (*Aquila chrysaetos*) are difficult to capture. However, golden eagles of all age classes have been caught using a variety of methods: Harmata (1985) used padded-jaw traps, Ellis (1975) used helicopters and O'Gara and Getz (1986) and S. Brodeur (pers. comm.) used net guns fired from helicopters, Bloom (1987) used pit traps, Jackman et al. (1994) used power snares, and W.S. Clark (pers. comm.) used bow nets.

In western Scotland, where our study took place, it is illegal to use live lures, winters are mild with little snow cover, and the eagle population is nonmigratory. This paper describes a safe, inexpensive, and reliable method of catching breeding golden eagles without the use of live lures. It also compares the efficiency of this trap to other methods and discusses its impact upon the eagles.

#### METHODS AND MATERIALS

The trap (Fig. 1) is a modification of a power snare (Hertog 1987), and the radio-controlled trigger (Fig. 2) is similar to that described by Jackman et al. (1994). Table 1 lists the parts and their approximate prices.

We used a shock cord 10 m in length and 5 mm in diameter in most situations, and stretched it to achieve noose closure with 1–2 kg of tension. The length of elastic needed was determined by the size of noose to be closed. The tension was set using a spring balance. The diameter of the noose could be adapted to the situation, but was typically 30–35 cm. To close a noose this size our 10 m elastic was stretched to about 30 m. At the end of the noose-line, a small (3 mm) eyelet was affixed by tying the noose around the outside of the eyelet and locking the knot with Superglue. This ensured that the noose closed quickly and smoothly.

The trigger mechanism was designed to avoid inadvertent firing: the pin which holds the rat-trap armature fits into a deep sleeve, and the connection between the rat-trap and the trigger pin is a flexible nylon cord, ensuring that any vibration at the trigger pin would not be transferred to the rat trap. The radio controls are sometimes affected by radio signals from other sources (especially

around harbors) which can fire the trap accidentally, so radio controls with changeable crystals were used.

To avoid injury, a nest anchor was used to keep the captured eagle on the nest, but away from the nestling. This was usually a large (85 cm long) corkscrew with a sailing cleat attached to the top. The cleat allows the noose-line to travel only in the direction of the trigger, holding the noose closed. We sometimes used a nearby tree (<1 m away) as an anchor, nailing the cleat to the tree above the level of the nest. Otherwise, the cleat can be incorporated into the trigger assembly.

Thin wire (4 mm) or bamboo guides are used to ensure that the closing noose is not fouled by the nesting material, and help lift the noose around the bird's tarsi. The tips of the wires were filed to eliminate sharp points.

Nestlings must be isolated on the nest so that they do not foul the trap before firing, and are well out of the way of the captured parent. This can be done either by placing the nestlings within a small chicken-wire cage or by securing with jesses to a small corkscrew-shaped anchor (made from 3–4 mm steel wire).

Trapping success and safety were highest when the operator had a direct view into the nest. At some nests a video camera facilitated a clear view of the trap.

#### RESULTS

Eight territorial golden eagles (three males, five females) were captured during the nestling period in 1992 (1), 1993 (4), and 1994 (3). Both members of one pair were captured. In all, attempts were made to capture 10 individuals resulting in an 80% capture success. Successful captures were made having triggered the trap 12 times (75% efficiency). Capture of individual eagles took between 5 hr and 4 d, including trap setup and dismantling time.

No decline in productivity or nesting success was detected following capture, and all nestlings fledged. In the year following capture, all territories at which eagles were captured were active (nests built up), and five of seven pairs laid eggs. In the year subsequent to capture success ( $\chi^2 = 0.16$ ,  $P > 0.05$ ) and productivity ( $\chi^2 = 0.27$ ,  $P > 0.05$ ) were similar to that within the rest of the study area.

Trapping activities probably caused eagles to shift nests more often than they would without disturbance. All trapped eagles used new nests in the year following capture. In comparison, eagles on these territories changed

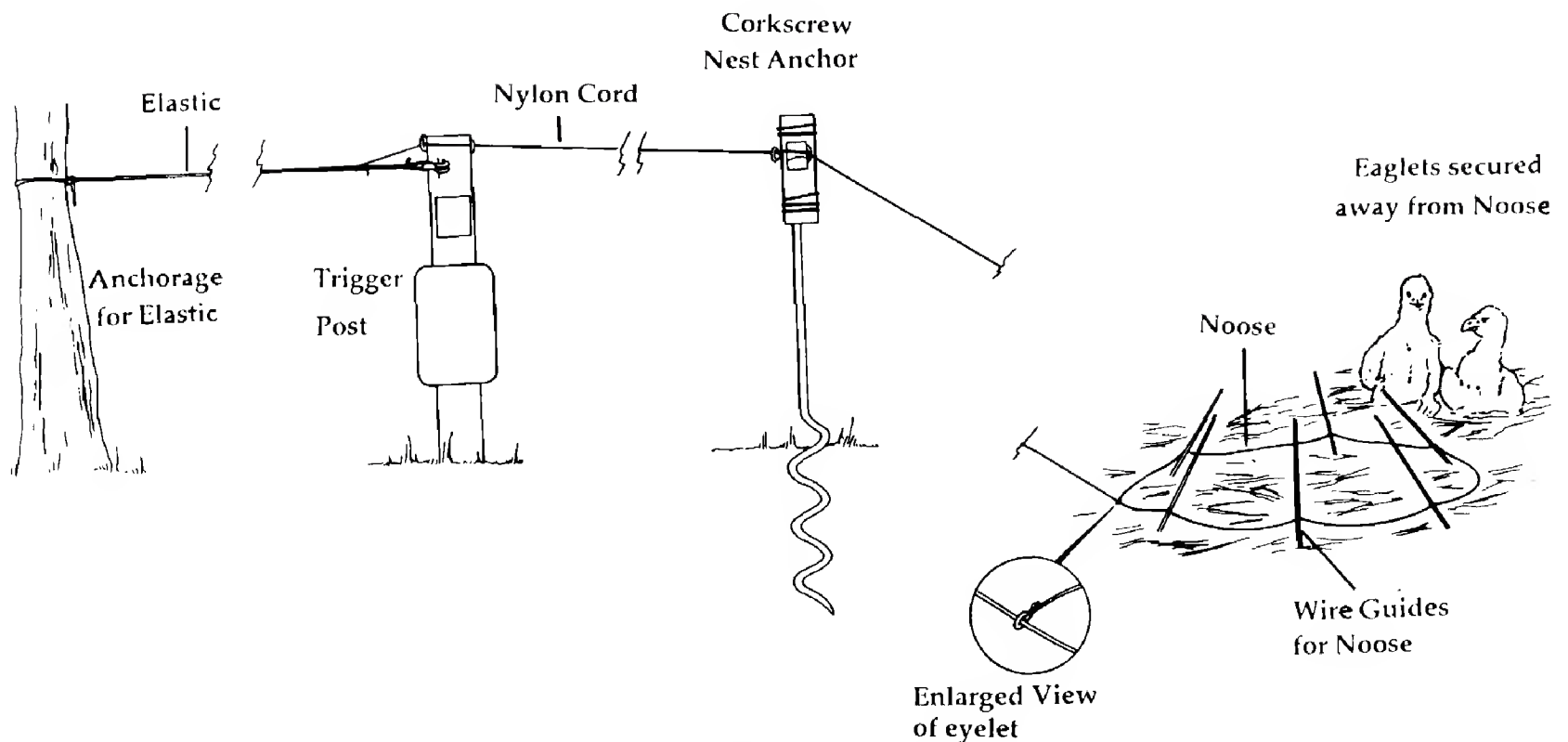


Figure 1. Diagram of the trap setup.

nests only 47 out of 84 nesting attempts (55.9%) in years prior to capture.

#### DISCUSSION

Territorial golden eagles can be caught on the nest efficiently and safely using the power snare design we describe. Failures to capture birds were due to the lack of a clear view into the nest or fouling of the noose on nest material or prey remains. The age of the nestling also affected the success of trapping because adults visited older nestlings less often, and the large nestlings left no room on the nest for the trap.

No major injury was sustained by any of the captured eagles. Although one was found to be cut on the abdomen, this injury may have been sustained at some other time because the blood surrounding the wound was dry when it was first noticed. Still, as with any trap, there are dangers, and all efforts must be made to ensure safety. Prevost and Baker (1984) reported some fatal injuries when trapping ospreys using a similar trap, although it was triggered automatically. As an additional safety precaution, we would recommend the use of flattened U-shaped wire guides, instead of straight ones.

We found no indication that trapping had any long- or short-term negative effects on the nestlings. No desertions occurred, and in all cases, the trapped bird revisited the nest within 24 hr. In two nests video cameras monitored the post-capture visitation rate by the adults. We were unable to assess whether captured birds took longer to return to their nest than those which had not been captured because of the variability in age of nestlings, weather, and time of day capture occurred.

The effect the trap had upon the adult's return to the nest was difficult to determine. The adults appeared wary, and sometimes flew past the nest before going onto it. Initially, the presence of the nest anchor may have caused

the eagles to be reluctant to return to the nest, but one adult returned in less than 2 hr (although it was not in a position to be caught). When eaglets were isolated on the nest using a cage, parents were seen to feed and brood them through the wire mesh. For large nestlings, restraining them with jesses allowed them to stand and move about more freely, and was believed to be less likely to damage growing feathers. However, A. Harmata (pers. comm) warns that jesses can cause leg tendon injuries, although no obvious injuries to eaglets occurred during our trapping efforts.

It is important that trapping should be conducted only after the nestlings are able to thermoregulate, and only in

Table 1. Trap and trigger components and approximate prices.

<b>Trap</b>	
Elastic cord	\$ 6.00
Noose with eyelet	0.50
Nest anchor	10.00
Cleat	5.00
Guides	nil
Anchor	nil
Trigger plate	nil
<b>Radio-controlled trigger</b>	
Radio control and servo	60.00
Battery	8.00
Water resistant box	2.00
Nuts, bolts, etc.	5.00

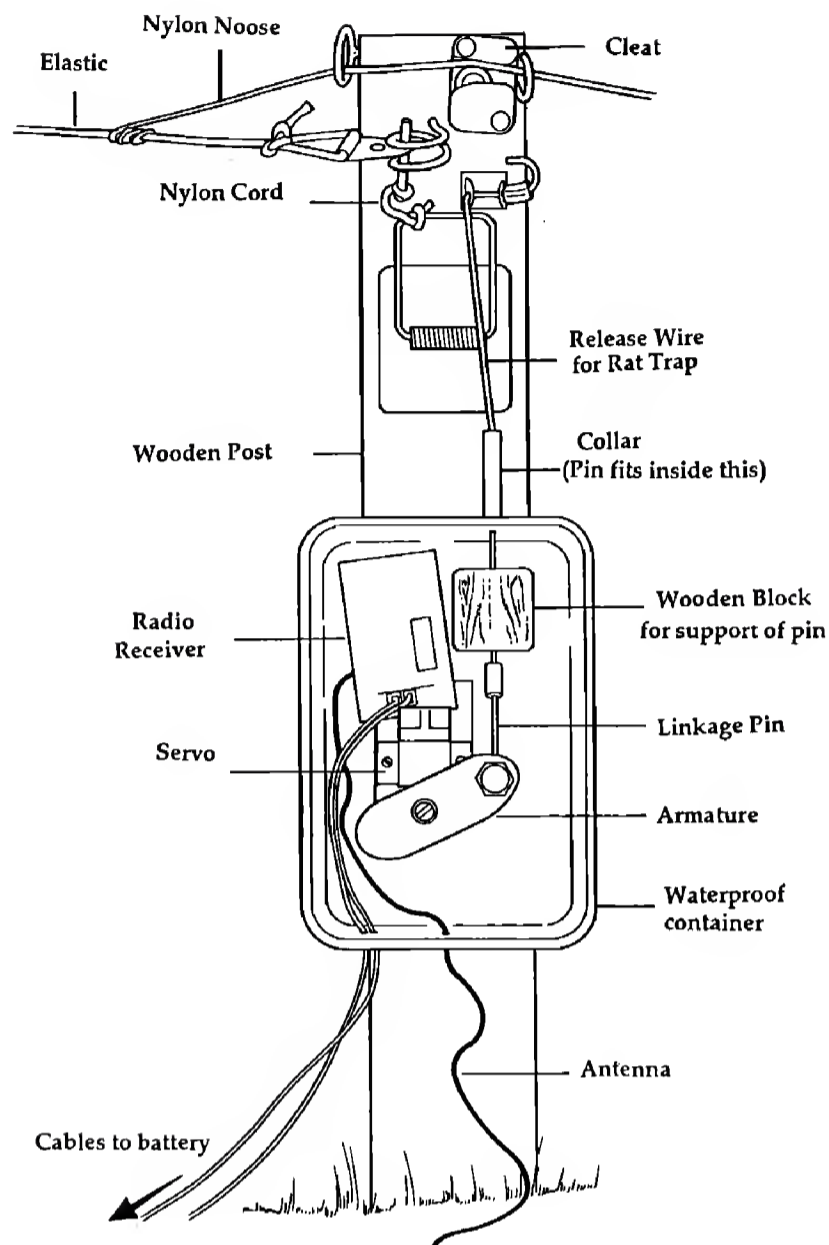


Figure 2. Detail of the radio-controlled trigger mechanism and sailing cleat. When a corkscrew nest anchor is used, the cleat on the trigger mechanism is not used (See Fig. 1).

good weather. Activities should be suspended in the hours prior to sunset to encourage the return of the adult to brood. Whether successful or not, eaglets should be handled by the trapper at the end of each trapping session. In our study area, eagles typically raise only one nestling, although they hatch two. At one site brood reduction occurred the week after cessation of (unsuccessful) trapping activities.

Because golden eagles are big, powerful birds, there is a temptation to set the elastic tension much too strongly. However, success rate was higher when the tension was less. When the tension of the elastic was too great, the whip-like closing of the noose startled the eagle and the noose fell from its feet as it flushed. A lightly set noose closed more gently around the legs of the eagle which was less likely to flush, instead walking around the nest with the noose around both legs. While walking it usually removed one leg from the noose which then closed around the other. Experience suggests that as little as 1.2 kg of tension is needed for golden eagles.

Although this is an efficient method for capturing eagles, we believe that capture outside the breeding season and away from the nest is preferable. Before using this method, one should weigh carefully its potential impact, particularly in areas where the number of nesting places is limited or where there is a difference in success between nesting places within a territory.

**RESUMEN.**—Como parte de un estudio de radiotelemetría de *Aquila chrysaetos*, una trampa radio-controlada fue diseñada para capturar individuos reproductivos. La unidad de gatillado incorpora una forma de protección que asegura que la trampa no pueda ser activada más que por el ave blanco. La efectividad de la trampa fue muy alta (80%), especialmente cuando el operador tenía una buena vista del nido (100%). Durante tres estaciones consecutivas, ocho individuos territoriales fueron capturados (tres machos y cinco hembras). No hubo abandonos de nidos y tampoco una reducción de productividad o éxito al año siguiente de las capturas. El trampeo causó más cambios en el sitio de nidificación al año siguiente de las capturas. Por lo tanto, este método puede ser usado solamente cuando muchos lugares de nidificación igualmente apetecibles están disponibles en el territorio. Aunque efectivo, nosotros sugerimos otros métodos, menos intrusivos, para la captura en nido.

[Traducción de Ivan Lazo]

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## A MECHANICAL OWL AS A TRAPPING LURE FOR RAPTORS

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**KEY WORDS:** *Bubo virginianus*; capture technique; great horned owl; lure; mechanical owl; mist net.

A live great horned owl (*Bubo virginianus*) used as a decoy is an effective method for capturing several species of breeding raptors (Hamerstrom 1963, Bloom et al. 1992, Steenhof et al. 1994). Similar techniques were practiced by Arab and Persian falconers (Meredith 1943). Taxidermy mounts of great horned owls have also been used successfully to capture breeding raptors, but are not as effective as a live owl (Bloom 1987). Gard et al. (1989) reported breeding American kestrels (*Falco sparverius*) responded less aggressively to a mounted great horned owl than to a live owl, suggesting that the lack of movement or some other subtle cue by the mounted owl may account for the lower response rate. However, logistics (e.g., weather conditions, remote nest sites, maintenance of owl, legal constraints) sometimes warrant the use of a mounted owl as a substitute for a live great horned owl. Here, I describe the materials used to construct a moving mechanical owl and compared the results of my trapping efforts with this lure to other studies using a live and mounted (taxidermic) great horned owl.

### METHODS

**Materials and Assembly.** A two-channel remote control unit (transmitter, receiver, battery pack, and two servo mechanisms) designed for a model car was slightly modified to provide movement to a mounted great horned owl. The owl’s head and body were separated and mounted independently using standard taxidermy procedures. The mechanical owl’s body was attached to a horizontal wooden perch (9 cm dia. × 20 cm). A piece of styrofoam was excised from the body of the mechanical owl at the top center and fitted with servo A (Fig. 1). Two vertical pins (3 mm dia. × 10 cm) were glued into the control arm of servo A and two corresponding sleeves were glued into the

styrofoam head of the mechanical owl. Servo A supported and provided movement to the mechanical owl’s head. Servo B was placed in a holding bracket constructed of sheet metal and attached to an aluminum rod (7 mm dia. × 1 m) used to support the mechanical owl’s perch. In the underside of the mechanical owl’s perch, I inserted a copper sleeve (9 mm dia. × 12 cm) into the center and a pin (4 mm dia. × 11 cm) at one end with approximately half of the pin exposed. To provide movement to the entire mount, servo B’s control arm was modified with a piece of tempered wire (3 mm dia. × 30 cm) bent in half and attached at both ends to the control arm. The mechanical owl and perch assembly were positioned on top of the aluminum rod, elevating the owl 1 m above the ground and allowing rotation of the mount. Servo B provided movement to the entire mount, allowing the observer to control movement of the entire mount and the mechanical owl’s head independently.

**Method of Use.** From 1989 through 1995, the mechanical owl was tested on breeding sharp-shinned hawks (*Accipiter striatus*), red-shouldered hawks (*Buteo lineatus*), and Cooper’s hawks (*Accipiter cooperii*). A response was considered to have occurred when the target species stooped at least once within 1.5 m of the mechanical owl’s head. During the nestling stage the mechanical owl was centered <1 m from the net, in view of and <50 m from the nest. An observer concealed <25 m from the net activated the owl (via transmitter) when at least one of the adults was detected near its nest.

### RESULTS AND DISCUSSION

Overall, the mechanical owl was successful in eliciting a stoop from 79% (75/95) of the nesting adults. This response was slightly lower than the 93% Gard et al. (1989) reported when using a live great horned owl on American kestrels, but considerably higher than the 33% they found with a mounted great horned owl. Fifteen of the 20 adults that did not attack the mechanical owl vocalized for >15 min before leaving the area. The remain-

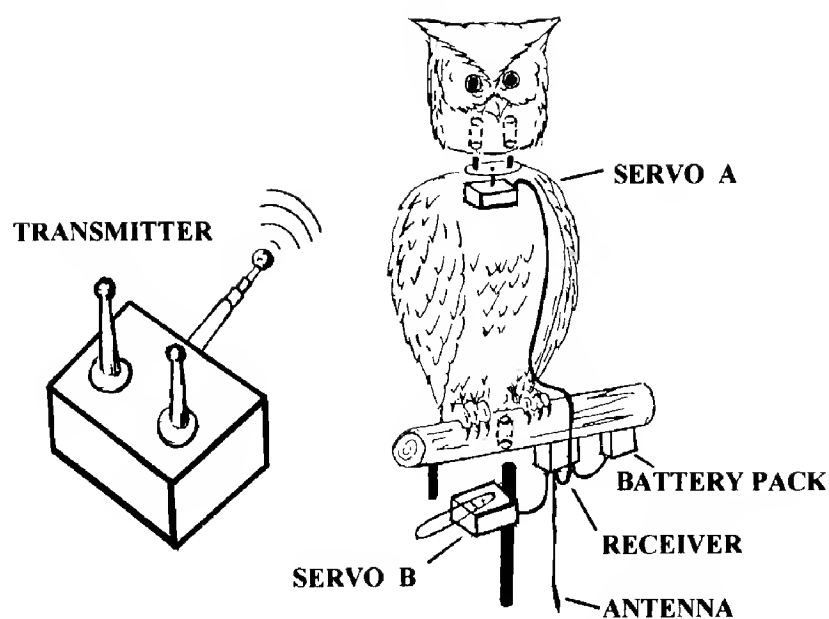


Figure 1. Mechanical owl, transmitter, battery pack, receiver and servo assembly.

ing five individuals did not show any aggressive behavior toward the mechanical owl and left the area after a few minutes.

While trapping red-shouldered hawks in California, Bloom et al. (1992) reported a higher capture rate using a live great horned owl than I experienced using a mechanical owl in Wisconsin (Table 1). Of the 13 red-shouldered hawks not captured with my technique, three stooped at the mechanical owl but escaped after hitting the net.

In general, Bloom et al. (1992) found larger raptors were more difficult to capture than smaller ones. I experienced similar results with the mechanical owl on the three species I tested. The sharp-shinned hawk was the most aggressive, occasionally hitting the net and escaping  $\leq 4$  times in  $< 10$  min. On six occasions the adult(s) apparently saw the net and avoided it on each stoop. The mechanical owl and net were then moved a short distance ( $< 15$  m), resulting in four captures.

The mechanical owl was an effective decoy for capturing these three raptors. Even though attack and capture rates were slightly lower using the mechanical owl than in studies using a live great horned owl, I recommend its use when logistics render the use of a live owl difficult.

Table 1. Comparison of capture rates of a mechanical owl to a live owl as a trapping lure.

	MECHANICAL OWL (THIS STUDY)	LIVE OWL (BLOOM ET AL. 1992)
Red-shouldered hawk	54% (15 of 28)	75% (199 of 264)
Cooper's hawk	60% (3 of 5)	52% (32 of 62)
Sharp-skinned hawk	77% (48 of 62)	<sup>a</sup>

<sup>a</sup> Not given.

**RESUMEN.**—Un búho preparado taxidermicamente fue equipada con mecanismos radio-controlados en la cabeza y percha que permitían movimientos al búho. Este ingenio mecánico y una red de niebla fue usada como técnica de captura durante siete estaciones reproductivas de tres especies de rapaces. Este método fue exitoso atrayendo a un 79% de adultos reproductivos. Setenta y siete por ciento de *Accipiter striatus*, 60% de *A. cooperii* y 54% de *Buteo lineatus*, fueron capturados por este método. El movimiento del búho mecánico pareció ayudar a las especies blanco a localizarlo y verlo como una amenaza hacia sus juveniles. [Traducción de Ivan Lazo]

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FEEDING OF THE BAT FALCON (*Falco ruficularis*)  
IN AN URBAN ENVIRONMENT

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**KEY WORDS:** bat falcon; *Falco ruficularis*; feeding; urban environment; Venezuela.

The bat falcon (*Falco ruficularis*) inhabits a variety of forested areas and forest clearings throughout the Neotropical region (Beebe 1950, Haverschmidt 1962, Iñigo-Elias 1993). Beebe (1950) made a detailed analysis of feeding behavior of a pair of these birds in a mountainous forest in Venezuela. He found that 16% of the vertebrates taken by the falcons were bats. Small birds, however, comprised the bulk (75%) of prey. Additional aspects of feeding are discussed by several authors (Wetmore 1965, Brown and Amadon 1968, Kirven 1976, and Chavez-Ramirez and Enkerlin 1991). The occurrence of bat falcons in urban areas has also been reported. Wetmore (1965) and Tostain (1986) mentioned them hunting bats and insects in small towns. However, details on feeding ecology of this species in urban environments are lacking. In this paper I analyze prey taken by three bat falcons, a pair and a juvenile, in an urban environment and compared it to the data available in the literature.

STUDY AREA AND METHODS

My observations were made in Guanare, a city of some 100 000 people located in the llanos of Venezuela (9°2'40" N, 69°44'30" W). The northern part of the city is bordered by hills and low plateaus covered by forest relicts and savanna-like vegetation. The rest is mostly surrounded by savannas and deforested areas dedicated to agriculture and cattle ranching. The climate of the region is biseasonal, with a rainy season that extends from May to October, and a dry season that goes from December to March. April and November are transitional. The annual precipitation is 1473 mm and the average annual temperature is 27.1°C.

My observations began on 4 December 1993 when I saw one bat falcon perching on the top of the tallest (seven stories) building in the city. From December 1993 to February 1994, only one bat falcon was seen at a time. A pair was rarely seen during March and early April. On April 23 the presence of a third falcon, likely a fledgling of the pair, was noted. The pair of falcons had nested in another

building 200 m from my observation point (M. Gonzalez pers. comm.). The prey remains left under perches were collected at irregular intervals between 5 February and 20 July 1994.

RESULTS AND DISCUSSION

Remains of 47 vertebrates were found (Table 1). Moths, grasshoppers, beetles, and butterflies were also occasionally found, but a more precise identification and quantification of these items was not attempted. The relatively high number of prey found during May probably reflects the presence of three falcons. After June the frequency in which the falcons were seen declined. That may explain the small number of remains found during that month.

These results confirm the importance of bats as prey of bat falcons; bats made up almost 64% of the identifiable vertebrate remains. All bat remains that could be identified to species were mastiff bats (*Molossus molossus*). Chase et al. (1991) calls this bat an almost strictly crepuscular species whose large colony size and predictable foraging times makes it particularly vulnerable to hawk predation.

Even though birds comprised a relatively small number of the prey taken, they represent a high proportion (at least 73.5%) of the biomass. Some of the birds, as for example the least bittern (*Ixobrychus exilis*) and the purple gallinule (*Porphyryula martinica*) may be as heavy or heavier than bat falcons (Karr et al. 1990, French 1991). Capture of relatively large prey by bat falcons has been mentioned by Sick (1993) and Chavez-Ramirez and Enkerlin (1991).

Some of the remains found belonged to common birds in Guanare, e.g., mockingbirds (*Mimus gilvus*) and ruddy-ground doves (*Columbina talpacoti*). Fringillidae remains were probably those of saffron finches (*Sicalis flaveola*), a species seen frequently in the area. The carib grackle (*Quiscalus lugubris*), another very common bird in the city, was not found in the prey remains even though I saw a bat falcon unsuccessfully chasing one of those birds. The most striking finding was the occurrence of aquatic birds among the prey captured by the falcons. Aquatic birds represented 35.2% of all bird remains and at least 51.9% of total vertebrate biomass. No wetlands or bodies of water occur within the city. Aquatic birds may have been captured along the Guanare River some 6 km to the southeast. Foraging by bat falcons in aquatic habitats has been reported (Stiles and Skutch 1990) or may be inferred from other published or unpublished evidence. Brown and Amadon (1968) pointed out that bat falcons were a "terror" to least grebes (*Tachybaptus dominicus*) in a locality in El Salvador. Iñigo-Elias (1993) found that these raptors

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Table 1. Prey of bat falcons in an urban area of Venezuela. Cumulative weight of prey was calculated taking the minimum mass value for each species.

PREY	COLLECTION DATES				CUMULATIVE PREY MASS, g
	FEB- RU- ARY	MAY	JUNE	JULY	
Bats	2	16	5	7	330 <sup>a</sup>
Birds					
Podicipedidae					
<i>Tachybaptus dominicus</i>	1	1	—	—	250 <sup>b</sup>
Ardeidae					
<i>Ixobrychus exilis</i>	1	—	—	—	80 <sup>b</sup>
Unidentified	—	1	—	—	80 <sup>b</sup>
Rallidae					
<i>Laterallus exilis</i>	1	—	—	—	32 <sup>b</sup>
<i>Porphyryla martinica</i>	—	—	1	—	205 <sup>b</sup>
Columbidae					
<i>Columbina talpacoti</i>	—	1	1	—	94 <sup>b</sup>
Dendrocolaptidae					
<i>Dendrocincla fuliginosa</i>	—	1	—	—	37.1 <sup>c</sup>
Tyrannidae					
Unidentified	1	—	—	—	30
Mimidae					
<i>Mimus gilvus</i>	1	—	—	—	49.5
Thraupidae					
<i>Thraupis episcopus</i>	—	1	—	—	30 <sup>b</sup>
Fringillidae					
<i>Oryzoborus angolensis</i>	—	—	1	—	10
Unidentified	—	—	1	—	10
Passeriformes					
Unidentified	—	—	3	—	10

<sup>a</sup> Minimum mass value (11 g) reported by Chase et al. (1991).

<sup>b</sup> Minimum mass values reported by Karr et al. (1990).

were more frequently seen in riparian forest (0–100 m from the edge of the river) than in any other natural or disturbed vegetation type in the Lacandon forest. Bat falcons have been seen along riparian forests and large rivers foraging on aquatic birds, swifts, and swallows (E. Iñigo-Elias (pers. comm.). Kirven (1976) pointed out that one characteristic of suitable habitat for bat falcons is the presence of mesic conditions (streams, rivers, ponds). A bat falcon collected in May 1981 in a wetland area in Venezuela (Ciénagas de Jaun Manuel, Zulia state) had a stomach full of dragonflies (A. Seijas unpubl. data). Dragonflies were often mentioned in the diet of the bat falcon

(Wetmore 1965, Brown and Amadon 1968, Kirven 1976, Cade 1987, Sick 1993) which may indicate the importance of aquatic habitat for this species.

The ability of bat falcons for taking and transporting prey from distant places was mentioned by Beebe (1950), but those prey were mostly small Passeriformes and Apodiformes. Chavez-Ramirez and Enkerlin (1991) also suggested that bat falcons hunted far from the perch where they were usually seen.

These results highlight the ecological plasticity of the bat falcon in the wide variety of habitats used and the wide spectrum of animals this falcon preys upon. The importance of aquatic prey, however, had not been emphasized in previous reports.

**RESUMEN.**—Se identificaron los restos de presas dejados por tres Halcones Golondrina (*Falco ruficularis*) bajo sus perchas en un edificio céntrico de la ciudad de Guanare, Venezuela. Se recolectaron restos de un total de 47 vertebrados. Los murciélagos representaron el 64% de las presas, el resto pertenecía a diversas aves. Al considerar el peso de las presas, las aves conformaron no menos del 73.5% del peso total de los vertebrados capturados. Se identificaron seis aves acuáticas, pertenecientes al menos a 4 diferentes especies. Las aves acuáticas representaron el 51.9% de la biomasa total. Estas aves deben haber sido capturadas fuera de la ciudad, ya que no existen humedales dentro de sus límites.

[Traducción Autore]

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### ESTIMATING AGE CLASSES IN KING VULTURES (*Sarcoramphus papa*) USING PLUMAGE COLORATION

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**KEY WORDS:** ageing; king vulture; plumage coloration; plumage maturation.

Researchers conducting field studies on sexually monomorphic vultures have utilized molt and plumage characteristics to identify individuals (Snyder et al. 1987, Wallace and Temple 1987). Such characteristics are valuable in determining age classes needed to detail survivorship patterns (Todd and Gale 1970). No reliable criteria are known for age class determination in king vultures (*Sarcoramphus papa*). Wallace and Temple (1987) distinguished six age classes in this species, but they failed to describe which plumage characters they considered. Additionally, Heck (1968) provided scant details of plumage color patterns with no discussion of 5 and 6 yr age classes. In order to determine reliable criteria for age determination in the wild, I examined known-age king vultures in captivity, and documented gross plumage coloration. For a detailed description of the definitive plumage coloration in king vultures, consult Friedmann (1950). A description of natal downs is detailed by Ramo and Busto (1988) and Schlee (1994).

#### METHODS

Twenty-seven photographs of 16 known-age birds (four males, four females) and eight of unknown sex were taken as follows: three photographs of 1-yr olds, nine of 2-yr olds, five of 3-yr olds, three of 4-yr olds, four of 5-yr olds, two of 6-yr olds, and one of a 7-yr old. Individual birds

were photographed from one to five times. Five birds were permanently housed outdoors in San Antonio, Texas. The remaining 11 were maintained at the Detroit Zoological Garden in Detroit, Michigan. The birds in Detroit were exhibited outdoors during the summer months and housed indoors under artificial lighting during the winter months (T. Schneider pers. comm.). Only feathers that change from black to white with maturity were considered: the interscapular and dorsal regions of the spinal tract, ventral tract, and under-tail coverts of the caudal tract. Also considered were the white alar-tract feathers including the seven upper middle coverts, carpal coverts, and all underwing coverts. The final region changing from black to white includes the feathers of the femoral and crural tracts (Fisher 1943).

#### RESULTS AND DISCUSSION

Five age categories were tentatively distinguished by plumage coloration in captive birds (Table 1) that were consistent with descriptions by Nuttall (1832), Dickey and van Rossem (1938), and Heck (1968). The categories conflict with statements by Brown and Amadon (1968) who indicate that second-year birds have all white underparts and third-year birds are in definitive plumage except for some black in the interscapular region. My findings also are inconsistent with Ruschi (1979) who stated that adult plumage is attained in the second year of life.

Throughout the first year, all contour feathers including retrices and remiges are sooty black (Fig. 1). White down feathers on the femoral and crural tracts can also be considered characteristic of this stage. During the bird's second year flecks of white begin to appear on the femoral,



Table 1. Plumage color criteria for estimating age classes in king vultures.

AGE, yr	COLORATION CHARACTERISTICS
1-2	Sooty black coloration with downy feathers observable on femoral and crural tracts
2-3	Ventral tract with varying amounts of white
3-5	Ventral tract feathers white; white feathers of alar tract less than 50% white
5-7	Specks of black remain in lesser wing coverts of alar tract
6->7	White feathering includes: interscapular and dorsal regions of spinal tract, ventral tract and underwing coverts of caudal tract. Seven middle upper coverts, carpal coverts, and all underwing coverts as well as all feathers of the femoral and crural tracts

ventral, and crural tracts. Although the number of third-year birds observed was limited to four, in all cases at least 50% of the ventral, femoral, and crural tracks became white. During the fourth year, coloration resembled the third year with ventral, femoral, and crural tract feathers white. At this age the alar tract region, e.g., upper wing coverts ( $N = 3$ ), also was <50% white. A mottled appearance, due to the intermixing of white feathers on the interscapular area of the spinal tract and alar tracts, occurred in 75% ( $N = 4$ ) of fifth-year birds. One individual obtained this mottled appearance in its fourth year. Of the three birds in their sixth or seventh year, only one had reached definitive plumage (a sixth-year individual). The other two retained specks of black in the upper wing coverts.

In addition to the small number of specimens examined, several additional considerations should be made in evaluating the aforementioned data and conclusions. First, given that only 50% of the individuals examined were of known sex, no conclusions could be drawn regarding the possible variation due to sex alone. Such an influence has not been determined in other monomorphic species that require long periods for plumage maturation (Jollie 1947, Palmer 1988, Snyder 1988). Hence, it is unlikely that it would prove so with this species. Additionally, while king vultures maintained in Texas were within the photoperiod and temperature likely experienced by wild birds, the 11 maintained in Detroit were not housed under such natural conditions. It should be noted, however, that previous studies on king vulture development were conducted with birds in captivity in north-temperate-zone environments (Heck 1968, Schlee 1994). Secondly, no published account exists on the annual molt cycle in king vultures. Dickey and van Rossem (1938) state that the species goes through an annual molt in August. Contrary to this, five captive birds that I maintained molted throughout the year (Eitniear unpubl. data). Without knowing the molt cycle, correlating feather replacement with age appears tenuous.

Using a captive bird, Todd and Gale (1970) determined that the California condor (*Gymnogyps californianus*) primary molt requires 2 yr, and Koford (1953) indicated that a complete body-feather molt requires more than 1 yr in the California condor. To prevent excessive loss of flight

efficiency (Tucker 1991), it is likely that the king vulture requires a similar period of time. In addition, significant variability in predefinitive feathering tends to hamper assigning chronological age or plumage reliably to individual king vultures. Such variability is common in birds requiring a lengthy period for maturation. Wilbur (1975) and Snyder (1968) noted that too much variation in plumage color exists within age cohorts of California condors to permit precise age determination of them. Wilbur did, however, suggest age categories of 1-3 yr (immatures), 3-4 yr (ringnecks), and 4-5 yr (subadults). He further suggested that first-year birds be aged based upon behavior and locality (Wilbur 1975). This situation is similar to that described by Palmer (1988) in bald eagles (*Haliaeetus leucocephalus*) as well as in golden eagles (*Aquila chrysaetos*; Jollie 1947), and northern goshawks (*Accipiter gentilis*; Sushkin 1928). Additional information on king vulture molt might provide some additional characters, e.g., stage of molting and feather shape that could augment coloration in age class determination. Until further information becomes available detailing the molt cycle in king vultures, the utility of using only plumage color characters as reliable aging criteria is limited.

RESUMEN.—Se investigo el posible uso de criterios de cambios en el color del plumaje para estimar la edad de Carroñero Rey (*Sarcoramphus papa*). El análisis de 27 fotografías representando a 16 individuos a diversas edades, indica que se distinguen cinco categorías de edad. El primer año se puede diagnosticar por la presencia de plumón. Las aves de dos años empiezan a mostrar coloración blanca en las áreas ventrales. Este reemplazo de plumas negras por blancas continua hasta que las aves alcanzan cuatro años de edad cuando tienen un aspecto moteado resultado de una matrix de plumas blancas y negras en el dorso. La etapa final de maduración del plumaje ocurre a los seis o siete años de edad cuando las "manchas" de negro en las coberteras superiores del ala son finalmente reemplazadas por plumas blancas. Se expresa cierta reserva en la confiabilidad de los criterios de color ya que existe una gran variabilidad en esta como en otras especies con periodos de madurez prolongados.

[Traducción de Ernesto Enkerlin]

←  
Figure 1. Age estimations based on plumage color development in king vultures. A. 1-2 yr, B. 2-3 yr, C. 3-4 yr, D. 4-5 yr, E. 6-7 yr, F. 7-8 yr.

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### BIGAMY IN RED-TAILED HAWKS IN SOUTHWESTERN YUKON

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**KEY WORDS:** *bigamy; Buteo jamaicensis; hare cycle; plumage pattern; red-tailed hawk; Yukon.*

Polygyny is well documented in some raptor species (Newton 1979), and is usually associated with an abundant food supply as seen in hen harrier (*Circus cyaneus*) populations in Orkney (Balfour 1962), and common buzzard (*Buteo buteo*) populations in Scotland (Picozzi and

Weir 1974). In red-tailed hawks (*Buteo jamaicensis*), only two cases of polygyny have been reported (Wiley 1975, Santana et al. 1986). In both cases two females shared the same mate and nest, but no information on food availability was available.

Here I describe three incidents of bigamy in a red-tailed hawk population. In these incidents a male was mated with two females at different nests, during years of declining prey abundance.



## OBSERVATIONS

The raptor community at Kluane Lake in the southwestern Yukon has been studied since 1986, as part of a larger project examining the boreal forest ecosystem (Krebs et al. 1986, 1992, Boutin et al. 1995). A total of 380 raptor territories of nine species, including 75 red-tailed hawk territories, have been closely monitored.

The ability to identify individuals by their plumage patterns helped me to realize that bigamy was occurring in this red-tailed hawk population. Light- and dark-phase birds in this population allowed identification of individuals by plumage characteristics. Of 127 birds for which plumage charts were made from 1990–94, 58–85% were individually distinguishable from any other bird within a year.

Another characteristic helpful in identifying possible cases of bigamy was the nearest-neighbor nest distance. Bigamous nests were much closer together (750–800 m) than were monogamous nests (1400–3500 m; Welch's approximate  $t$ -test,  $P = 0.0000$ ) within years and over the entire study period.

In 1992, two territories contained males paired with two females at different nests. At these sites, individually distinguishable plumage patterns were particularly useful. In the first territory, the nests were 750 m apart, and in sight of each other. The first nest discovered (nest #1) had been used previously and was checked on 9 May. At this time, the male was seen bringing food to a female on the nest. Nest #2 was found on 9 June, when the female was flushed from the nest. She was then joined by a male from the direction of the nest #1, who had the same plumage pattern as the male at nest #1. On 19 June, nest #2 contained two young. The view from the nest allowed me to see nest #1, and the male again flew from that direction and joined the female circling nest #2. He then returned to nest #1 where the other female could be heard begging. On 23 June, nest #2 was empty and great horned owl (*Bubo virginianus*) predation was suspected. A large clump of adult red-tailed hawk and great horned owl feathers was found at the base of the nest. The first nest fledged two young, and when checked on 22 June, the female from the failed nest joined the pair circling above the nest. Over 600 nest visits have been made to red-tailed hawk nests in the last 7 yr, and only on this occasion did more than two adults defend a nest.

The other two cases of bigamy were more circumstantial. In the second territory in 1992, the two nests were also 750 m apart. One nest (nest #1) has been used four times in the previous 5 yr. On 28 April a female (light-phase bird) was seen sitting in the nest, while the male perched 50 m away. Weekly checks showed both male and female to be present consistently. On 25 May, the female was off the nest and begging, and regular checks showed that she had lost interest in the nest. When the nest was checked on 27 May it was not defended by the adults, and it contained two cold eggs. The second nest (nest #2) was discovered on 20 May when incessant begging from a female (dark-phase bird) drew me to it. A minute after I was discovered, the adult female was joined in nest defense by a male. He flew in from the direction of nest #1, and had the distinctive plumage pattern of the male at nest

#1. The female at nest #2 was regularly heard begging from the nest for the next week. A check on 11 June found no adults present. I was unable to see inside the nest, and no birds were seen here for the remainder of that season. It is unlikely that young had already fledged, as red-tailed hawks in our area typically fledge in mid-July.

In 1991, two nests were discovered 800 m apart in a natural area of patchwork forest and meadow. On 19 June, one nest (nest #1), contained two healthy chicks and on 23 June the other nest (nest #2) contained one underweight chick. Nest checks were made every 2–3 d from hatching until the young fledged. A nest check was always made at nest #1 first and the male always appeared quickly and defended the nest. Nest #2 was visited next, and the male was consistently slow to defend or did not appear at the nest. When he did appear, the male always arrived from the direction of nest #1. On two occasions we then revisited nest #1 after nest #2 had been checked, and both times the male appeared from the direction of nest #2. On 8 July, the single chick in nest #2 was found freshly dead in the nest. There was no sign of predation and the chick weighed 17% less than the least mass of chicks ( $N = 19$ ) of the same age, suggesting it had starved. (Chicks were aged using the growth pattern of the 4th primary [Peterson and Thompson 1977]). Both young fledged at nest #1.

## DISCUSSION

In the two cases where bigamy has been previously documented in red-tailed hawks (Wiley 1975, Santana et al. 1986), two females shared the same nest, brooded and fed the young, and both females and the male defended the nest. Bigamy has been seen in the closely related common buzzard in Scotland (Picozzi and Weir 1974), where males were paired with two females at different nests in five out of 135 territories monitored from 1969–72. In the Scotland study, and in another report of bigamy in buzzards (Newton 1979), bigamy was associated with abundant food supply. This association with an abundant food supply was not obvious in our study area. An apparent peak in food availability occurred at the height of the snowshoe hare (*Lepus americanus*) cycle in 1989–90 (Boutin et al. 1995). However, bigamy in red-tailed hawks was only observed in 1991 and 1992.

Variations in fledging success may have been the trigger for bigamy in our population. During the period of greatest food supply at the peak of the hare cycle in 1989 and 1990, a peak in fledging success occurred with a mean of 1.75 (SD = 1.12) chicks fledged from 20 pairs. At the hare low in 1991 and 1992, only 0.76 (SD = 0.88) chicks were fledged per pair. This 1989–90 high in fledging success may have caused an increase in the number of birds in breeding condition over the next few years. Therefore, the incidence of bigamy in 1991 and 1992 may have been due to unpaired females joining an established pair rather than not breeding at all.

Bigamy described here may also be a feature of the northern location. The birds have a short breeding season after migration. Nest building and egg laying begin almost immediately after arrival in mid-April, with a median egg laying date of 28 April. The birds, therefore, have little time to assess the quality of the territory or their mate. A

female could mate with a male who already has a mate, either by accident or before the quality of the territory is known.

Whatever the reason for bigamy, 67% of the bigamous red-tailed hawk nests failed to fledge young. All three territories failed to fledge young from both nests, and in one case, both nests failed. These rates are similar to the monogamous pairs' breeding success where 55% of 22 nests failed to fledge any young in the low of the hare population cycle in 1991 and 1992. Bigamy in this red-tailed hawk population may be successful only with an abundant food supply.

RESUMEN.—Sólo en dos ocasiones se han registrado casos de bigamia para *Buteo jamaicensis*, en ambos, un macho estaba emparejado con dos hembras en el mismo nido. Aquí reporto tres casos de bigamia, donde un macho se emparejó con dos hembras en nidos diferentes. Estos fueron observados mientras se monitoreaban 78 intentos de nidificación en seis años. Las parejas bígamas se encontraban más cercanas entre sí (750–800) que parejas monógamas (1400–3500). La incidencia de bigamia ocurrió en años de baja abundancia de presa.

[Traducción de Ivan Lazo]

#### ACKNOWLEDGMENTS

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## LETTERS

### BARRED OWL NEST IN A NATURAL HOLE IN AN EARTHEN BANK IN EASTERN TEXAS

The barred owl (*Strix varia*) typically nests in old stick nests constructed by hawks, crows, or squirrels, but also in tree cavities (A.C. Bent 1938, Life histories of North American birds of prey, Part II, U.S. Natl. Mus., Washington, DC U.S.A.; P.A. Johnsgard 1988, North American owls, Smithsonian Inst. Press, Washington DC U.S.A.). A few records of nesting sites used by this owl depart from the usual. For example, there is an account of a nest on the ground in a small hollow dug by a barred owl (H. Mikkola 1973, page 125 in J.A. Burton [ED.], Owls of the world, Peter Lowe Publ. Co., London, U.K.). Gibbs (1988, *Oriole* 53:11) described a nest under a bridge in South Carolina, and Peterson (1988, pages 206–207 in R.F. Andrie and J.R. Carroll [EDS.], Barred owl, *Strix varia*, The atlas of breeding birds in New York state, Cornell Univ. Press, Ithaca NY U.S.A.) noted that this owl will nest in barns. Johnson and Follen (1984, *Raptor Res.* 18:34–35) reported barred owls nesting in boxes constructed for them in Minnesota. However, we found no records of this species nesting in a hole in an earthen bank or cliff.

While walking down Crawford Creek near Appleby, Texas, during the last week of March 1990, FE saw an unidentified owl fly from a hole in the side of a steep bank on two occasions. The forested area below the bank was a typical hardwood creek bottom with many mature trees, mostly oaks (*Quercus* spp.) and sweetgum (*Liquidambar styraciflua*), while the area above the bank was mostly loblolly pine (*Pinus taeda*) forest. Suspecting the possibility of a nest, FE rappelled down the sheer vertical face of this 20 m bank and discovered nestling owls in the back of the hole. The circular entrance to the hole was about 10 m above the creek bed, measured about 1 m in diameter, and extended horizontally into the bank for about 1 m. Later that week, CS and C.D. Fisher visited the site to identify the species of owl nesting in the bank. Two 10-d-old nestlings were identified by CS as barred owls.

The hole was an arroyo pipe (Bloom, 1991, Geomorphology, Prentice Hall, Englewood Cliffs, NJ U.S.A.). These natural pipes are fairly common in the Carrizo sandstones of eastern Texas (R.L. Nielson pers. comm.), and are formed by the action of water seeping vertically down the sand layers within the hill until it hits an impermeable layer of clay. The water then flows horizontally along this layer of clay until it eventually exits the hill producing an arroyo pipe. Through time, the hole becomes larger with the action of flowing water.

We visited the nest hole about 1 wk later after heavy rains in the area to find that the nestlings were not present in the hole. We suspected that the rainwater washed away the entire contents of the nest since the pipe appeared smoother, cleaner, and a little larger. If these arroyo pipes are used by nesting barred owls, a relatively flood-free period of about 6 wk must occur for the nesting attempt to be a success.

We appreciate the information provided on arroyo pipes by R.L. Nielson and we thank D.C. Rudolph and D. Saenz for constructive comments on an earlier draft of this letter.—Clifford E. Shackelford, Wildlife Habitat and Silviculture Laboratory, Southern Research Station, USDA Forest Service, Nacogdoches, TX 75962 U.S.A.; Frederick C. Earley, Law Environmental, Inc., Houston, TX 77040 U.S.A.

### UNUSUAL INTERACTION BETWEEN WOLF AND SHORT-TOED EAGLE

A pair of wolves (*Canis lupus*) with six pups was observed in the Great Indian Bustard Sanctuary, Nannaj (71°41'N, 75°56'E; altitude 486 m) in Solapur District of Maharashtra State, India. On 16 February 1994 at 0730 H the pair brought a road-killed female blackbuck (*Antelope cervicapra*) near their den where they were joined by three of the pups. The blackbuck was fully grown with a mass of about 30 kg. At 0800 H an adult short-toed eagle (*Circaetus gallicus*) soared above them and then perched on top of a tree close to the carcass. The eagle swooped at the wolves five times either attempting to reach the kill or to attack the pups which were about 5 kg in mass.

During each swoop the adult male wolf jumped up at the eagle. On the fifth sortie the eagle swooped much lower and was caught and killed by the wolf, but was not eaten. The male wolf resumed feeding on the blackbuck carcass and the pack abandoned the carcass around 1000 H, ignoring the dead eagle.

Interactions between raptors and wolves have been rarely reported (L.D. Mech 1970, *The wolf. The ecology and behavior of an endangered species*. Doubleday, New York, NY U.S.A.). Several reports involve interactions between wolves and common ravens (*Corvus corax*) since they often feed on the same carcasses (R.O. Peterson 1977, *Wolf ecology and prey relationships on Isle Royale*. U.S. Natl. Park Serv. Sci. Monogr. Ser. No. 11.). Ravens irritate wolves by swooping low over their heads and landing nearby (L. Crisler 1958, *Arctic wildlife*. Harper and Row, New York, NY U.S.A.; L.D. Mech 1966, *The wolves of Isle Royale*. U.S. Natl. Park Serv. Ser. No. 7). Wolves, in turn, leap at ravens in the air, stalk them on the ground, and scatter them from kills. I have also seen wolves chase crows (*Corvus* spp.) from their kills in a similar way. During Isle Royale wolf studies, a wolf was observed catching and killing a raven (Peterson 1977). The wolves played with the carcass of the raven for 15 min and did not eat it.

This is the first record that I am aware of of a short-toed eagle trying to scavenge a predator's kill or attack its young. This eagle is not reported to be a scavenger in the existing literature. The short-toed eagle is reported to feed mainly on snakes, and secondarily on lizards, amphibia, mice, and other mammals (to hare size), and birds as large as guineafowl (S. Ali and S.D. Ripley 1987, *Handbook of the birds of India and Pakistan*, Oxford Univ. Press, Bombay, India; T.J. Roberts 1991, *The birds of Pakistan*. Vol. 1, Oxford Univ. Press, Karachi, Pakistan).

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#### THE USE OF A ROCK BY AN OSPREY IN AN AGONISTIC ENCOUNTER

Whereas many birds manipulate material to build nests, and some use tools to procure food (H.B. Lovell 1958, *Wilson Bull.* 70:280–281; G.C. Millikan and R.I. Bowman 1967, *Living Bird* 6:23–41; J. Boswell 1977, *Avic. Mag.* 83:88–97), it is unusual to observe a bird using an object in an aggressive encounter. I report the use of a rock in an agonistic encounter by a male osprey (*Pandion haliaetus*).

I observed the rock-dropping incident close to an active osprey nest in Stonington, Connecticut on 8 July 1989. The nest was located in a salt-water marsh to the west of Wilcox Point and adjacent to Long Island Sound and Quiambaug Cove. A railroad track passed within approximately 100 m of the nest and a series of utility poles ran along the side of the railroad bed. I observed the nest from 1310–1710 H on 8 July 1989 with a 15–45× telescope and 9 × 35 binoculars (see J.P. Roche 1995, *Conn. Warbler* 15:74–77). I was approximately 200 m from the nest and 100 m from the site where the tool was used.

At 1438 H the female osprey began giving alarm calls (A.F. Poole 1989, *Ospreys*, Cambridge Univ. Press, Cambridge, U.K.) from the nest as one male osprey flew into the nest area, followed shortly by three more males. The second male to enter the area (osprey A) was carrying a partly-eaten alewife (*Alosa pseudoharengus*). During the next 22 min, the number of males in the nest area fluctuated between two and four; throughout this period these males behaved aggressively toward each other.

At 1456 H osprey A flew to a pole along the railroad bed and perched. Next, another male (osprey B) flew to the ground, picked up a small rock in its talons from the railroad bed, flew approximately 1 m above osprey A, and dropped the rock on osprey A. Osprey A, which appeared startled but unhurt, flew down to the ground immediately. Osprey A then flew to another pole and perched. Osprey B flew at osprey A again and displaced it from the pole. Osprey A then flew inland, away from the nest area. Osprey A returned at 1459 H to perch again at the side of the railroad bed, but left the area within 2 min. It still had the alewife in its talons when it left.

By 1502 H the female on the nest had stopped calling and osprey B was the only male that remained in the area.

Because the female had stopped calling while osprey B was still in view, it is likely that osprey B was her mate; the female generally called in the presence of intruders and never called when only her mate was present. In addition, osprey B behaved aggressively toward all of the males entering the nest area. Osprey B left the nest area without returning to the nest, however, so the identification of osprey B is not certain.

The use of a rock as a tool by an osprey has not previously been reported. Rock-dropping behavior has been reported in Egyptian vultures (*Neophron percnopterus*), which drop rocks on ostrich (*Struthio camelus*) eggs to open them (J. Alcock 1970, *Ibis* 112:542). Rock dropping has also been reported by Janes (1976, *Condor* 78:409), who observed nesting common ravens (*Corvus corax*) dropping rocks on human intruders. Hypotheses explaining the osprey's rock-dropping behavior include the following: (1) if osprey B was the breeding male at the Wilcox West nest, it may have used the rock to displace an intruding male from the nest area, or (2) the rock-dropping behavior may have been displacement activity, irrelevant behavior produced by the interplay of conflicting drives (J.L. Gould 1982, *Ethology*, Norton, New York, NY U.S.A.).

Some birds have been observed to demonstrate considerable intelligence (e.g., T.H. Turney 1982, *Bull. Psychon. Soc.* 19:59–62; I.M. Pepperberg 1983, *Anim. Learn. Behav.* 11:179–185); the observed incident of rock-dropping by an osprey suggests the possibility that ospreys are capable of insight learning (see J.C. Welty and L. Baptista 1988, *The life of birds*, Saunders, New York, NY U.S.A.). Osprey B may have redirected a nest-material-carrying mechanism to solve a new problem: that of an agonistic encounter with osprey A. Heinrich (1988, *Condor* 90:271–274) suggested that the rock-dropping behavior observed in ravens by Janes may have been purposeless displacement activity. This hypothesis could also explain the rock-dropping behavior of osprey B.—**John P. Roche, Department of Biological Sciences, Central Connecticut State University, New Britain, CT U.S.A.** Present address: Center for the Integrative Study of Animal Behavior, Indiana University, 402 N. Park Ave., Bloomington, IN 47405 U.S.A.

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#### WINTER CARRION FEEDING OF RED-TAILED HAWKS IN OKLAHOMA

The red-tailed hawk (*Buteo jamaicensis*) is one of the best-known, most widely distributed hawks in North America (P.A. Johnsgard 1990, *Hawks, eagles, and falcons of North America*. Smithsonian Inst. Press, Washington, DC U.S.A.; C.R. Preston and R.D. Beane 1993, *Red-tailed hawk*. Pages 1–24 in *The birds of North America*, No. 52. Acad. Nat. Sci., Philadelphia, PA U.S.A.). Studies of red-tailed hawk diets revealed that the prey was mainly small mammals, but also birds, reptiles, amphibians, and insects (S.K. Sherrod 1978, *Raptor Res.* 12:49–121; Johnsgard 1990; Preston and Beane 1993). Red-tailed hawks usually hunt live prey; incidents of carrion feeding in this species are few and scattered (Sherrod 1978). However, carrion feeding is difficult to document using traditional pellet and stomach content analyses (P.L. Errington 1933, *Condor* 35:19–29; P.L. Errington and W.J. Breckenridge 1938, *Wilson Bull.* 50:113–121; Preston and Beane 1993). Here we report three observed incidences of carrion feeding by adult red-tailed hawks in northcentral Oklahoma during late winter 1993.

On 26 February 1993, at about 1000 H, an adult red-tailed hawk was observed feeding on the decaying carcasses of fish in the backyard of a home in Meeker, Oklahoma. Several domestic cats (*Felis domesticus*) were feeding on the fish when the hawk chased them away. The hawk then fed on the fish for almost 15 min, and it returned several hours later on the same day to continue feeding on the fish. On 1 March 1993, at about 1645 H, an adult red-tailed hawk was seen perched on a freshly killed domestic cat in the middle of a small, two-lane paved road in Stillwater, Oklahoma. The hawk was observed to feed on the cat for about 20 min. On 2 March 1993, at about 1330 H, an adult red-tailed hawk was seen sitting on the carcass of an adult eastern cottontail (*Sylvilagus floridanus*) along the shoulder of a two-lane highway approximately 6.5 km west of Stillwater, Oklahoma. The hawk was observed to feed on the rabbit for about 15 min, interrupted only by passing cars.

Small amounts (<2% of diet) of mammalian and avian carrion were found in red-tailed hawk winter diets in Iowa, Wisconsin, Minnesota, South Dakota, and California (Errington 1933, *Condor* 35:19–29; Errington and Breckenridge 1938, *Wilson Bull.* 50:113–121; Fitch et al. 1946, *Condor* 48:205–234). Carrion made up only 1.2% of the red-tailed hawk diet from across the U.S. with all 13 cases of suspected carrion feeding occurring between mid-November and

late February (A.K. Fisher 1893, USDA Div. Ornithol. Mammal., Bull. 3, Washington, DC U.S.A.). Carrion feeding by red-tailed hawks may be more prevalent than food habit studies suggest, particularly in winter in locations where favored prey become scarce. However, it remains unclear when carrion becomes acceptable as food to red-tailed hawks. Red-tailed hawks in Arkansas concentrated winter feeding activities around poultry farms where carrion (dead chickens) was readily taken (D. James pers. comm.). However, fresh carcasses located near nests were never used by Alaskan red-tailed hawks, even during food shortages (C.M. Lowe 1978, M.S. thesis, Univ. Alaska, Fairbanks, AK U.S.A.). Red-tailed hawks apparently have a remarkable capacity for modifying their diet to accommodate local prey including carrion. In addition to stomach and pellet content analyses, field observations of feeding red-tailed hawks can shed some light on the types of food red-tailed hawks or other raptor species will take when prey are scarce.

We thank Jim Lish, Charles Preston, and Karen Steenhof for helpful suggestions on an earlier draft of this manuscript and John Couch, Doug James, Marcus Koenen, John Shackford, and Don Wolfe for discussions on red-tailed hawk food habits.—**Steven R. Sheffield and Noble Jobe, Department of Zoology, Oklahoma State University, Stillwater, OK 74078 U.S.A.** Present address of Sheffield: Department of Environmental Toxicology, Clemson University, P.O. Box 709, Pendleton, SC 29670.

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#### FRUIT-EATING BEHAVIOR OF A BARRED FOREST-FALCON

Barred forest-falcons (*Micrastur ruficollis*) are known to prey on reptiles, birds, amphibians, small rodents, and insects (L. Brown and D. Amadon 1989, *Eagles, hawks, and falcons of the world*. Wellfleet Press, Seacaucus, NJ U.S.A.; R.K. Thorstrom et al. 1991, *Condor* 92:237-239; R.K. Thorstrom 1993, M.S. thesis, Boise State Univ., Boise, ID U.S.A.). I am unaware of any published record of this species feeding on fruits. Here, I describe two observations of fruit eating by an incubating female barred forest-falcon in Guatemala.

While studying a population of barred forest-falcons in Tikal National Park, Guatemala (17°13'N, 89°36'W), I observed the same female on 24 April 1989 and 14 April 1991 after she left her nest cavity. On both occasions, after preening for 2 min, the falcon flew to the ground and immediately began feeding on the small fallen fruits of a palo de tzol tree (*Tikalía (Blomia) prisca*). The bird fed for approximately 1 min during each observation. After it finished feeding it flew to a perch near the nest, rested briefly, then flew back into the nest cavity. This fruit-eating behavior occurred at 1-2 wk after egg laying.

Among Falconiformes, frugivory has been documented in swallow-tailed kites (*Elanoides forficatus*; W.H. Buskirk and M. Lechner 1978, *Auk* 95:767-768; T.O. Lemke 1979, *Condor* 81:207-208.), and in a number of diurnal scavenging species including the genera *Milvus*, *Gypohierax*, *Phalcoboenus*, *Polyborus*, *Daptrius*, and *Milvago* (L. Brown and D. Amadon. 1989. *Eagles, hawks, and falcons of the world*. Wellfleet Press, Seacaucus, NJ U.S.A.). Frugivory may be more common in tropical forest raptors than the few reports indicate, but because of dense forest structure and the secretive behavior of most species, it is difficult to observe.

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A PREEN GLAND ABNORMALITY IN A FREE-LIVING  
WHITE-HEADED VULTURE (*Aegyptius occipitalis*)

The uropygial (preen) gland produces oil which enhances the integrity and waterproofing of a bird's plumage. In African Old World vultures, preening, coupled with sunning behavior, plays a part in feather maintenance (D.C. Houston, 1980, *Ibis* 122:366–369). Although examination of the uropygial gland has long been recommended as a routine part of clinical examination of raptors (J.E. Cooper, 1985, *Veterinary aspects of captive birds of prey*. Standfast Press, Gloucester, U.K.), little has been published on preen gland abnormalities in these birds, especially in the wild.

Here pathological findings in the preen gland of a white-headed vulture (*Aegyptius occipitalis*) from Tanzania, East Africa, are reported. The vulture, an adult, was found dead under a tree in Mikumi National Park. No signs of predation or other injury that might have caused its death were noted. The carcass, which appeared to be fresh, had been briefly placed in a freezer at the park. Gross postmortem examination revealed that the bird was a female in good condition (mass 4.5 kg) with substantial subcutaneous fat. Radiographs showed no skeletal changes suggestive of trauma, nutritional/metabolic disorders, or infectious disease. The only external abnormalities noted were damage to the tips of wing and tail feathers and a turgid preen gland from which dirty white toothpaste-like material rather than oil could be expressed.

Histopathological examination of the preen gland revealed some dilated acini and ducts lined by simple, squamous epithelium; elsewhere, the gland showed whorls of keratin, stratified squamous and giant cells in close proximity to secretory material. In a second section there was moderate hyperkeratinization of the epithelium overlying the gland.

On the basis of these findings the abnormality was diagnosed as a preen gland impaction of uncertain etiology. Microbiological culture was not performed but the histopathological findings, in particular the absence of any heterophil infiltrate, would appear to rule out a bacterial infection. The stratified epithelium suggests a metaplastic change in the gland and the giant cells may have been a response to keratin.

The uropygial gland abnormality in this vulture did not appear to have contributed to death nor was it associated with any obvious changes in the bird's plumage. The cause of the impaction was unclear as has been the case in preen gland impactions reported in other species of bird including budgerigars (*Melopsittacus undulatus*; M.L. Petrak, 1982, *Diseases of cage and aviary birds*, Lea and Febiger, Philadelphia, PA U.S.A.), helmeted guineafowl (*Numida meleagris*; Cooper unpubl. data), and merlins (*Falco columbarius*; J.E. Cooper and N.A. Forbes, 1986, *Vet. Rec.* 118:232–235). The only other impaction of this kind diagnosed in an East African raptor by the author involved a live tawny eagle (*Aquila rapax*) which was found trapped, with heavily soiled plumage, on the edge of a soda lake in Kenya (Cooper unpubl. data). The underlying pathogenesis was not elucidated.

I am grateful to the staff of Mikumi National Park and ABRU, especially Sabine Schmidt, Christopher Holmes and JoAnn Dokter, for providing the specimen, and to colleagues at the Faculty of Veterinary Medicine for taking radiographs and preparing histological sections.—**John E. Cooper, Faculty of Veterinary Medicine, Sokoine University of Agriculture, P.O. Box 3021, Morogoro, Tanzania.** Present address: Durrell Institute of Conservation and Ecology, The University, Canterbury, Kent CT2 7PD U.K.

## COMMENTARY

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### ON WINTER RECORDS AND VERTEBRATE PREY IN FLAMMULATED OWLS

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Recent literature has questioned the authenticity of late season sight records and vertebrate prey in flammulated owls (*Otus flammeolus*; McCallum 1994a, b). Herein, I revisit an earlier report (Holt et al. 1987), which has been questioned by McCallum (1994a, b). Additionally, I review and try to clarify other reports of late season sight records and vertebrate prey from flammulated owls that I believe were misinterpreted by McCallum (1994a, b).

#### DATA REVISITED

Holt et al. (1987) reported the following seemingly unusual fall and winter flammulated owl records: (1) In January 1965, a flammulated owl was found helpless in snowstorm and later died; (2) On 21 November 1981, a flammulated owl was observed perched in a tree with a vole in its talons; and (3) On 20 December 1981, a flammulated owl was observed chasing passerines at a bird feeder. These records were scrutinized by me and Philip L. Wright, and all persons making the observations were interviewed. Two of the records in 1981 came from biologists, and the 1965 record was from a birder. The biologist who submitted the report of the owl with a vole is an experienced birder and is familiar with Montana owls. She and her husband observed the owl from a distance of about 8 m for 1 min. A report of a flammulated owl chasing passerines at a feeder was confirmed second hand by a raptor biologist who knew the observer. This observer died before we could speak to him. The person who picked up the flammulated owl in the blizzard kept it in a cage and had an experienced birder confirm its identity using bird field guides. The owl died 1 d later and was discarded.

McCallum (1994a) stated that "If seen, the flammulated owl is easily identified by the unique combination of small size and dark eyes," but then goes on to say that November and December records of flammulated owls in Montana (one with prey, and one chasing passerines at a feeder) are misidentifications. Again, McCallum (1994a) stated that "An unpreserved specimen and two sight records in Montana (Holt et al. 1987) are poorly documented and dubious." Yet he also stated that in "North America, it occurs in lowlands peripheral to breeding habitat in October, sparingly in November, and occasionally in De-

ember" (but see Linkhart and Reynolds 1987). Once again, McCallum (1994a) referring to the Montana records and one Christmas bird count record from Washington, stated that "each of these records is individually unlikely. . . ." He then continues to state that the geographic concentration of these reports carries some weight. The flammulated owl breeds in Montana, and is now known to be much more common than previously believed.

McCallum continues with: "The assertion that small vertebrates are taken has been reported for a century without convincing documentation." But, he then cited conclusive and convincing data: "Smith (1891) took a female whose stomach contained the remains of some small rodents." Bull and Anderson (1978) found a pellet containing the remains of a red-backed vole (*Clethrionomys gapperi*) below an active flammulated owl nest tree and dark-eyed junco (*Junco hyemalis*) feathers in another active nest. This was restated in McCallum (1994b) as "the previous occupants (e.g., northern saw-whet owl [*Aegolius acadicus*], may have taken these prey (E. Bull fide, Cannings pers. comm.)." But Bull (pers. comm.) did not know if northern saw-whet owls or any other species nested in this same cavity the same year prior to the flammulated owls, or in previous years. Linkhart and Reynolds (1994) found a 15–20 g deer mouse (*Peromyscus* sp.) carcass in a flammulated owl nest. The carcass smelled of decay and 11 d had lapsed between visits by the researchers. Although a 1-cm<sup>2</sup> spot of pelage on the mid-dorsal area was missing, no obvious punctures or talon marks were observed. The authors were not able to skin the carcass and examine it for subcutaneous hemorrhages, as an indication of predation (see Holt 1994). Linkhart and Reynolds (1994) offered three alternate explanations, aside from the mouse having been killed by the owl, as to how the carcass got there. They concluded that direct evidence of flammulated owls capturing vertebrates is still lacking. But McCallum (1994a) incorrectly paraphrased their results, and stated that Linkhart and Reynolds (1994) said "another species was responsible for killing it." Linkhart and Reynolds (1994) said no such thing. Although one of their alternate explanations was that a northern saw-whet owl or northern pygmy-owl (*Glaucidium gnoma*) could have brought the deer mouse to the nest in response to food begging calls of the young flammulated owls. It is not unusual for owls to leave uneaten prey in the nest both during breeding and



after dispersal from the nest—particularly cavity nesters (D. Holt pers. obs.).

Cannings (1994) received a dead flammulated owl on 15 November 1988, from southern British Columbia, Canada, which contained the remains of a dusky shrew (*Sorex monticolus*). Cannings concluded that it was the first definite record of flammulated owls eating vertebrate prey (but see Smith 1891). Finally, McCallum (1994a) himself reported the legs of a juvenile mountain chickadee (*Parus gambeli*) in a flammulated owl nest. He concluded "that some flammulated owls over-winter in northern areas by subsisting on vertebrates cannot be completely discounted." In Colorado, mean body mass of breeding female and male flammulated owls was 65.6 g (SD = 10.85,  $N = 25$ ) and 54.7 g (SD = 3.28,  $N = 27$ ), respectively (Reynolds and Linkhart 1987). Mean body mass of the similar-sized northern pygmy-owl females is 73.0 g ( $N = 10$ ) and males 61.9 g ( $N = 42$ ) (Earhart and Johnson 1970). Yet northern pygmy-owls kill and consume a wide range of vertebrates from shrews (*Sorex* spp., 3 g) to flickers (*Colaptes* spp., 167 g), with mean mass about 38 g for both avian and mammalian prey (Holt and Leroux 1996). It has been said that flammulated owls have "weak" feet (McCallum 1994b), and this has been assumed to be one reason why they cannot kill vertebrate prey. I know of no quantitative data to support or refute this statement. However, raptorial feet are used for seizing prey (although lethal wounds cannot be ruled out) and it is often the bill that delivers the killing bite to the occipital region of the skull or by snapping the cervical vertebrae.

#### NEW DATA

K. McKeever (pers. comm.) reported that when offered a choice of insects or dead lab mice (*Mus musculus*) weighing 12–20 g, a captive-breeding female flammulated owl almost always took the mice. Similarly the male, almost always took 12–15 g mice back to the nestlings. And both always took the larger mice over smaller ones. McKeever has also observed that 20 g mice were difficult for the owls to eat, but 12–15 g mice were effectively consumed. This is not proof of killing, but certainly the willingness and ability to consume mice. Carl Marti (pers. comm.) found two dried juvenile *Peromyscus* carcasses in a flammulated owl nest after the young owls had fledged. No evidence of the mice nesting in the box was evident, and they were not there prior to flammulated owl nesting. Cause of death could not be determined.

In October 1994, the Montana Verification Record Committee accepted another fall record for a flammulated owl—10 November 1993. And, on 19 November 1994, a flammulated owl was observed and very well described by a hunter in western Montana. This record is currently under review.

Why have researchers been so cautious in accepting that flammulated owls may occasionally eat vertebrate prey and occur during fall and winter particularly in the northern part of the species' range where we know very little about their natural history? Noctuid moths—a primary food item in Colorado (Reynolds and Linkhart 1987)—are commonly found throughout November in Montana (D. Holt pers. obs.). Furthermore, in Colorado, postnesting adult flammulated owls remain on their breeding

grounds (about 2400–3000 m elevation) to about 12 October (Linkhart and Reynolds 1987). R. Reynolds (pers. comm.) stated that flammulated owls are able to withstand very cold spring nights, provided food is available. Dietary analysis of flammulated owls has been conducted primarily from May through October in Colorado (R. Reynolds pers. comm.), but see McCallum (1994a, b) for other studies. No studies have yet addressed the diet of flammulated owls in the northern limits of their range. Although captive situations and laboratory experiments may be helpful in determining if flammulated owls can capture, kill and consume various-sized vertebrate prey, caution should be taken in extrapolating from these results.

In retrospect, Holt et al. (1987) could have provided more data, even direct quotes concerning these records. McCallum's concerns likely stemmed from the vertebrate prey reported, and the lack of specimens and photographs. I believe scientists should be judicious, but I also feel that we cannot only believe ourselves—there are many qualified people in the field.

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DIURNAL SIGHT RECORDS OF FLAMMULATED OWLS  
AND POSSIBLE VERTEBRATE PREY IN WINTER:  
THE CASE FOR CAUTION

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Holt (1996) questions my questioning (McCallum 1994a, b) of three Montana sight records of the flammulated owl (*Otus flammeolus*) published by Holt et al. (1987). He goes on to promote the plausibility of those records by revisiting two poorly understood facets of flammulated owl biology: winter range and facultative carnivory. Further discussion of these unusual records, and of flammulated owl biology, is entirely salutary, particularly if it leads to more research on these questions. My main concern in retaining my cautious stance with regard to diurnal sight records in winter in Montana, as well as more general inferences of active carnivory, is that we do not falsely attribute to this owl a level of ecological flexibility that it does not possess.

Four regions of the USDA Forest Service classified this forest owl as sensitive (Verner 1994), independently of my review of the literature (McCallum 1994b) and conservation assessment (McCallum 1994c) of the species. Although this species appears to be common in some ponderosa pine (*Pinus ponderosa*) and semiarid montane mixed conifer stands throughout the western U.S. and southernmost British Columbia, I found three major reasons to be concerned for the future of the flammulated owl: (1) All known clutches contained 2–4 eggs, and hence this species appears to lack the capacity, possessed by some other owls (e.g., snowy owls [*Nyctea scandiaca*], Parmelee 1992 and barn owls [*Tyto alba*], Marti 1992), to produce large clutches when food is superabundant. Coupled with a possible preference for older forests (Reynolds and Linkhart 1992), this demographic inflexibility suggests a species that may not recover quickly from disturbance or habitat alteration. Indeed, Marshall (1988) found only two territories in 1986 in a logged area that had supported 18–20 territories in 1938 (Marshall 1939). (2) Almost all independently verifiable evidence indicates that the flammulated owl subsists entirely on arthropods in the wild. Broad spectrum insecticides used in intensive forest management may have a negative impact on reproductive success if they severely reduce the abundance or diversity of the owl's prey base. (3) Winter (1974) concluded, after a thorough review of available evidence, that the species is a trans-latitudinal migrant. Following a review of evidence obtained more recently, I concurred with Winter's conclusion. If it is true that the flammulated owl is a trans-latitudinal migrant, and further that the bulk of the population winters no further north than central Mexico, as the very limited

evidence presently available suggests (McCallum unpubl. data), then the fate of the species may hinge on habitat quality outside the United States.

The sight records under discussion (Holt et al. 1987, Holt 1996) are inconsistent with items 2 (lack of vertebrates in diet) and possibly 3 (migratory behavior) above. This inconsistency does not mean that they were erroneous. It does suggest that the data presented in support of such records should be beyond question. While I would like very much to believe these records, because their truth would imply that the flammulated owl is much more flexible ecologically than I fear, I do not think the supporting data are beyond question.

What we need for records that extend the verified northern margin of the winter range of the species from the deserts of Arizona and California (American Ornithologists' Union 1983) as far north as Montana is not second-hand sight records, regardless of the qualifications and experience of the observers, but photographs, recordings, and specimens. Only data that can be independently verified should be allowed to change the range of the species so drastically. The same argument holds for diet. Such caution is dictated by both the conservation implications of these records, and by standard scientific practice. Items 2 and 3 above constitute null hypotheses against which the Montana records must be tested. I cannot reject those null hypotheses with anything approaching 95% confidence.

The January 1965 record is the most believable of the three, because it involved extended observation of a bird in captivity by an experienced birder with field guides in hand. Indeed, grounded flammulated owls are often picked up after snowstorms (e.g., Ligon 1968, Webb 1982). The major doubt about this record is its date, because memory can become inaccurate over long periods of time. Holt (pers. comm.) informs me that the person who found it remembered the date unhesitatingly as January, when interviewed in the 1980s. In fact, my only negative comment about this record was that it was "dubious" as compared to several specimen records. One can hardly disagree with such a comparison.

The dates of the two 1981 records are not overly problematical, as November sight records have been accumulating from throughout the U.S. breeding range of the species in recent years (McCallum unpubl. data). It is the implication of active hunting of vertebrates that is prob-

lematical. In his commentary, Holt (1996) reviews records of vertebrate remains associated with flammulated owls, particularly in their nests. It is clear that captive birds will readily consume vertebrate remains, but I have made this point clearly myself (McCallum 1994a, b). In two cases, vertebrate remains have been found in flammulated owl stomachs (McCallum 1994a, b, Holt 1996). In several cases vertebrate remains were found in or below active nests. In none of these cases, however, was a flammulated owl seen to capture or even attack a vertebrate, including the new data supplied by McKeever (Holt 1996). Even the shrew found in the stomach of a British Columbia bird in November (Cannings 1994) could have been found dead while the owl was foraging in the leaf litter for earwigs, which also were present in the stomach.

The 20 December 1981 record is the only report of active hunting of vertebrates known to me. Perhaps this bird was not hunting, but instead had been flushed by mobbing passerines. F.R. Gehlbach and I witnessed mobbing of a flammulated owl that we flushed from a nest in New Mexico. Without more details, one cannot be confident that the owl in this case was attempting to capture another bird. This and the other 1981 record are the only reports known to me of foraging in full daylight by this completely nocturnal species. Although time of day was not mentioned in the published account (Holt et al. 1987), Holt has confirmed (D.R. Holt, pers. comm.) that both were diurnal. Given the uniqueness of these records if they are true, I would expect more confirmatory details, on such features as iris color, overall shape, flight characteristics, number of times passerines were "chased," etc.

In his commentary, Holt (1996) has scrutinized my writings for inconsistencies, rather than providing confirmatory details. Inconsistencies in my review of the topics of the killing and eating of vertebrate prey (McCallum 1994a, b) stem from the inconsistency of the evidence. The evidence for these behaviors is both scanty and entirely circumstantial (in the case of killing). Yet, I chose not to censor these anecdotes. Indeed, I went as far as repeating some very dubious statements by Karalus and Eckert (1974), in the interest of completeness. Having reported all the data I could find that supported carnivory, I was unconvinced by the strictly circumstantial evidence they provided. Holt's (1996) implied argument that flammulated owls should be able to kill vertebrates because similar-sized northern pygmy-owls (*Glaucidium gnoma*) do so is even less convincing. I consider extrapolating from *Glaucidium* to *Otus* extremely risky. Even the larger *Otus* species are mainly insect eaters according to Marshall (1967), so the size similarity between northern pygmy-owls and flammulated owls is not so relevant as their phylogenetic differences.

In summary, I must say that I remain less than totally convinced that the birds seen clutching a vole and "chasing passerines" during broad daylight were flammulated owls. Although I tend to believe the account of the bird found

in a blizzard, my personal opinion is that it is insufficiently documented to become part of the record of the range of this species. McKeever's observation that a pair of captive, breeding flammulated owls prefer large dead mice to insects (Holt 1996) supports the idea that carcasses of vertebrates found in flammulated owl nests in the wild may have been taken there by adults of this species. Ironically, such an interpretation argues against active hunting and/or killing. If dead vertebrates (e.g., mice) are preferred, the most plausible reason they so seldom appear in the diets of adults and nestlings (McCallum 1994a, b) is that live vertebrates are uneconomical or impossible to obtain. Clearly, an experimental study of both prey preference and the ability to capture and kill vertebrates would be highly desirable. Indeed, I hope that the major outcome of the present discussion will be increased efforts by ornithologists and birders to learn whether flammulated owls can and do kill vertebrates, and whether they winter regularly anywhere inside the United States.

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## BOOK REVIEWS

EDITED BY JEFFREY S. MARKS

*J. Raptor Res.* 30(1):52

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**Raptor Migration Watch-Site Manual: A Cooperative Strategy for Protecting the World's Migratory Raptors.** Edited by Keith L. Bildstein and Jorje I. Zalles. 1995. Hawk Mountain Sanctuary Association, Kempton, PA. vi + 177 pp. Paper, \$20.00. English and Spanish versions available from: Hawks Aloft Worldwide, Hawk Mountain Sanctuary, R.R. 2, Box 191, Kempton, PA 19529.—Pennsylvania's Hawk Mountain Sanctuary has been a leader in the conservation of migratory raptors for more than 60 yr. Recognizing that the need for protection transcends international boundaries, in 1988 the Sanctuary established a cooperative global conservation initiative called Hawks Aloft Worldwide. Two important goals of the project are the identification of raptor migration sites throughout the world and the training of local conservationists to oversee activities at these sites. Toward achieving these goals, the Sanctuary prepared this manual as a guide to operators of hawk-watching sites.

The manual contains 13 chapters, each with a thorough list of references. The introductory chapter provides a brief history of Hawk Mountain Sanctuary, identifies general threats to migrating raptors, and discusses the Sanctuary's upcoming *World Atlas of Raptor Migration Watch-Sites*. Chapters 2–5 are devoted to biological issues. "Raptor Migration and Conservation Biology" (Chapter 2) gives a general overview of taxonomy, classification, migration behavior, and legal protection, and includes a list of globally threatened raptors. "Investigating Raptor Migration Biology and Ecology" (Chapter 3) provides an annotated list of scientific topics suitable for investigation at migration watch-sites. Chapter 4 ("Monitoring the Abundance and Distribution of Migrating Raptors") discusses methodology, including identification, counting techniques, and monitoring population trends. Chapter 5 ("Managing Data") provides a useful introduction to data management techniques.

Chapters 6–10 consider the human aspects, in-

cluding environmental education, ecotourism, and membership and volunteer programs. The "Watch-Site Diagnostic" (Chapter 11) is a tool for generating "a detailed description of the physical setting, institutional framework, resource base, and overall situation of a watch-site." The closing chapters contain a comprehensive bibliography of papers on raptor migration in Latin America (Chapter 12) and abstracts from seven Latin American projects that were discussed at the recent Hawks Aloft Worldwide workshop held in Veracruz, Mexico (Chapter 13).

Clearly, much care and thought went into producing this manual. It provides an abundance of information that will be of interest to raptor enthusiasts in general, and it will be virtually indispensable to anyone who is contemplating operating a migration watch-site.—**Jeff Marks, Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812 U.S.A.**

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**The Northern Goshawk: Ecology and Management.** Edited by William M. Block, Michael L. Morrison, and M. Hildegard Reiser. 1994. *Studies in Avian Biology*, No. 16. vi + 136 pp., 39 figures, 57 tables, 2 appendices. ISBN 0-935868-76-3. Paper, \$16.00.—This collection of papers is the result of a Cooper Ornithological Society symposium held in Sacramento in April 1993 and organized by R. T. Reynolds, D.A. Boyce, Jr., and the above-named editors. The symposium included 31 oral presentations. After peer review, 22 papers were published in the proceedings: six under a section entitled "Research Approaches and Management Concepts," nine under "Resource Ecology," and seven under "Population Ecology." The introduction states: "The current situation with the northern goshawk (*Accipiter gentilis*), a raptor typically dependent on mature

forests, bears an uncanny resemblance to that of the northern spotted owl [*Strix occidentalis*] a decade ago. Within the past five years, evidence has arisen to suggest that populations of northern goshawks are declining, particularly in the western United States . . . This collection of papers represents the current state of knowledge on northern goshawks."

I will start by relating some of the important new information for a range of topics in the proceedings. Owing to space limitations, I will not critique individual papers. I conclude with an evaluation of the degree to which the proceedings represent "the current state of knowledge" on goshawk ecology and management.

Under "Research Approaches," C. Boal offers an excellent and much-needed guide to the appearance and behavior of nestling goshawks at different ages. S. Joy et al. provide a wealth of data and concepts for anyone interested in improving effectiveness and efficiency in surveys of forest hawks.

Under "Resource Ecology," C. Hargis et al. and D. Bright-Smith and R. Mannan reported mean home ranges (95% harmonic mean) of about 15 km<sup>2</sup> during summer. Radio locations were generally in stands that had larger trees with denser canopies than typical for the study area. Unlike some researchers, Bright-Smith and Mannan recognized that their birds were not a random sample of the study population; thus, they compared habitats at radio locations with habitats available within each bird's home range. P. Kennedy et al. present data on movements of young birds in northern New Mexico. They suggest managing for a postfledging area (PFA) of about 168 ha. Theory on the ecological basis for PFAs could be strengthened by a telemetry study that tracked adults and their young simultaneously.

F. Doyle and J. Smith tracked a goshawk population through a "cycle" of prey availability (mostly snowshoe hares [*Lepus americanus*]) in the Yukon. During both nesting and winter seasons, goshawk densities fluctuated by an order of magnitude with the highs and lows of the hare cycle. Fledgling production averaged 2.8 per occupied nest during the apex of prey abundance but dropped to zero after the numbers of key prey species collapsed.

J. Younk and M. Bechard describe goshawk nesting biology in high-desert aspen (*Populus tremuloides*) groves in northern Nevada. The groves averaged 25 ha and usually contained a creek or spring. Unusually high proportions of breeding females were in first- or second-year plumage, perhaps a response

to a recent increase in the availability of ground squirrels. It will be instructive if these birds can be monitored throughout the next decline in ground squirrel numbers.

Under "Population Ecology," P. Detrich and B. Woodbridge related that 72% of breeding adults located in consecutive years retained their mates from the previous year. Eventually, 18% of adult females and 23% of adult males were found nesting 4–13 km from the territories where they were marked. In northern Arizona, Reynolds et al. found that mean intraterritory movement between alternate nests in consecutive years was 266 m (range 100–635 m). Nests produced an average of 2.3 fledglings when both parents were in full adult plumage but only 1.1 fledglings when one parent was in subadult plumage.

As evidenced above, this publication presents many important research results as well as theories worthy of testing. However, because the proceedings fail to present information and theories from the full array of goshawk researchers and management agencies, the goal of representing the "current state of knowledge on northern goshawks" is not achieved. One problem is that only two papers are from outside of the contiguous western United States. No European researcher was included, presumably because of the symposium objective "to assemble researchers and managers from across the *country*" (emphasis mine). Yet, I believe that much could be learned by examining similarities and differences in goshawk ecology between continents.

Although several researchers presented papers that were not published in the proceedings, other North American goshawk workers were absent altogether. For example, Arizona Game and Fish Department researchers had studied goshawks for years, and their data (especially on canopy coverage and territory occupancy) would have been a nice addition to the proceedings.

Moreover, during the 2 yr preceding the symposium, the Southwestern Region of the U.S. Forest Service was engaged in acrimonious debate with state and federal wildlife agencies in Arizona and New Mexico over alternative hypotheses regarding goshawk ecology and forest management. Both sides had conducted extensive literature reviews and analyses. Although the views of wildlife agencies were not presented at the symposium, two papers in the proceedings (Graham et al. and Bassett et al.) described and expanded on the Forest Service strategy

for goshawk management in the Southwest (viz., Reynolds et al. 1992, USDA For. Serv. Gen. Tech. Rep. RM-217, Fort Collins, CO U.S.A.). Discussion of forest management for goshawks also would have benefited from participation of scientists who had published journal articles on the subject, as well as biologists funded by the timber industry and those who wrote the petition to list the goshawk as an endangered species in the Southwest. A broader array of opinions would encourage managers and scientists to consider and test alternative hypotheses on goshawk ecology and forest management.

The primary sponsor of the proceedings was the U.S. Forest Service. Also, four of the five symposium organizers were Forest Service employees, and three were authors of the Forest Service strategy. Additional views would have been presented if other agencies and groups had cosponsored the symposium. I am not suggesting any intentional bias on the part of the symposium organizers, but apparently the effort was inadequate to obtain a comprehensive array of scientific opinion.

In conclusion, the proceedings' goal to represent "the current state of knowledge" was not achieved. The effort would have benefited had the proceedings included more papers from beyond the western United States (especially Europe) and presented a wider variety of habitat management opinions. The proceedings also would have been enhanced by three overviews of goshawk ecology and management, one each from western North America, eastern North America, and Europe. Despite my criticisms, *The Northern Goshawk: Ecology and Management* presents significant new research and theories. Given its relatively low cost, it should be acquired by everyone interested in accipiters and made available at most libraries.—**D. Coleman Crocker-Bedford, 243 Wood Road, Ketchikan, AK 99901 U.S.A.**

cover, 16 black-and-white photographs, 27 figures. ISBN 0-662-22791-3. Paper, available free from above address.—Among falconiforms, the osprey (*Pandion haliaetus*) may be the first species to have benefited from the provisioning of artificial nests. As early as the nineteenth century, farmers in the northeastern U.S. were placing old cartwheels atop poles to encourage ospreys to nest near their homesteads in the belief that these birds would drive away other hawks (Abbott 1911). In recent years, man-made nest structures have become so important an aspect of osprey conservation and management that in some areas, most nests now occur on artificial sites.

With this construction manual, Ewins has produced the most comprehensive compilation of artificial nest platform designs available. He draws not only on published sources, but on some obscure agency reports and unpublished material. The stated emphasis is on designs "best suited to the habitats found in Canada." Some comparisons with an earlier work (Martin et al. 1986) may be appropriate. Ewins incorporates the designs from the Martin et al. publication, but includes twice as many different designs. His "Further Reading" contains 14 references, however, whereas Martin et al. list 49 titles.

A brief introduction is followed by one-page sections on "Site Selection Considerations" and "General Notes on Construction." The main portion describing individual platform designs is divided into three sections according to the type of supporting structure. The first covers single poles (seven designs), and the second deals with "Other Structures" (including tripods, tree platforms, a ring platform, a metal grid, and methods for reinforcing duck blinds that currently support osprey nests). All of these designs are illustrated with detailed drawings and/or photographs, and for some designs the required construction materials are listed in a box. The third section deals with osprey nests on power transmission towers and utility poles. Also included is a decision chart for assisting utility managers in selecting an appropriate course of action when ospreys nest on power transmission structures. Several modifications are suggested to either allow nests to persist while eliminating (or greatly reducing) the incidence of short circuits between live wires, or to prevent nest construction on poles after nests have been moved to nearby sites. Two additional platform designs are shown in this section.

One troubling omission is that no attempt is made to critically evaluate the efficacy and durability of



the various designs. While such information may not be available for all structures, the usefulness of the manual would have been enhanced had more use been made of the practical experience that already exists. For example, the metal-grid platform used by the U.S. Coast Guard on navigational aids in the St. Mary's River has proven to be quite inadequate due to a lack of any means of holding nests in place. Nests on these platforms remain relatively shallow, and several have been blown off entirely. In one such instance, two small chicks perished when their feet became entangled in the metal grid. Although using a wider mesh, as Ewins suggests, would help anchor sticks to the platform, it would also increase chances of finer material in the center of the nest falling through and thus exposing eggs or chicks to unnecessary risk. All platforms must have some structural feature designed to keep nesting material in place.

I have found that ospreys nesting on platforms over water and far from shore tend to build only shallow nests, especially during the first 1–2 yr a platform is used. Apparently, availability of suitable nesting material, and the distance over which it must be carried, influence the size and quality of the nest. On the shallow offshore nests, the eggs in the nest bowl often rest on the bare wood of the platform. Hatching rates of such eggs are low, possibly owing to inadequate incubation temperatures. One would expect that this situation would be at least as severe on wire-mesh substrates. This problem can be alleviated by nailing a piece of carpet (about 30 cm<sup>2</sup>) to the center of a solid-base platform. On a metal-grid platform, a similar-sized piece of fine wire mesh can be fastened at the platform center.

Our Michigan platforms (Postupalsky and Stackpole 1974) were initially equipped with wooden dowels to hold nests in place. Because the dowels eventually deteriorated and broke off, they were replaced with upright rectangular boards attached to angle brackets. Similar modifications may become necessary for other platform types that use wooden dowels.

In the preceding paragraphs, I have attempted to evaluate several artificial nest designs, drawing on my three decades of experience with osprey nesting platforms. Others undoubtedly can offer additional suggestions on improving these and other designs. Despite the shortcomings mentioned above, this manual serves its purpose rather well. The manager or osprey enthusiast is offered a series of designs that are appropriate for many different local conditions. Anyone contemplating construction and installation of artificial nest structures, or facing problems arising from conflicts between ospreys and utility lines, will profit from consulting this manual.—**Sergej Postupalsky, 1817 Simpson, Apartment 201, Madison, WI 53713 U.S.A.**

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## MANUSCRIPT REFEREES

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Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 27(4), and are available from the editor.

## 1996 ANNUAL MEETING

The Raptor Research Foundation, Inc. 1996 annual meeting will be held jointly with the American Ornithologists' Union annual meeting on 13–17 August at Boise State University, Boise, Idaho. Details about the meeting and a call for papers will be mailed to Foundation members in the spring of 1996 and can be obtained from Peter Lowther, Scientific Program Chairman, Field Museum of Natural History, Roosevelt Road at Lakeshore Drive, Chicago, IL 60605-2496, (telephone 312 922-9410 ext. 461; Fax 312 922-2572; e-mail [lowther@fmnh.org](mailto:lowther@fmnh.org)) and Marc Bechard and Alfred Dufty, Local Co-chairs, Department of Biology, Boise State University, Boise, ID 83725 (telephone 208 385-3262; Fax 208 385-3006; e-mail [rbibecha@idbsu.idbsu.edu](mailto:rbibecha@idbsu.idbsu.edu) or [adufy@claven.idbsu.edu](mailto:adufy@claven.idbsu.edu)).

### RAPTOR RESEARCH FOUNDATION, INC., AWARDS Recognition for Significant Contributions<sup>1</sup>

- The **Dean Amadon Award** recognizes an individual who has made significant contributions in the field of systematics or distribution of raptors. Contact: **Dr. Clayton White, 161 WIDB, Department of Zoology, Brigham Young University, Provo, UT 84602 U.S.A.** Deadline August 15.
- The **Tom Cade Award** recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. Contact: **Dr. Brian Walton, Predatory Bird Research Group, Lower Quarry, University of California, Santa Cruz, CA 95064 U.S.A.** Deadline: August 15.
- The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Contact: **Dr. David E. Andersen, Department of Fisheries and Wildlife, 200 Hodson Hall, 1980 Folwell Avenue, University of Minnesota, St. Paul, MN 55108 U.S.A.** Deadline: August 15.

### Recognition and Travel Assistance

- The **James R. Koplín Travel Award** is given to a student who is the senior author of the paper to be presented at the meeting for which travel funds are requested. Contact: **Dr. Petra Wood, West Virginia Cooperative Fish and Wildlife Research Unit, P.O. Box 6125, Percival Hall, Room 333, Morgantown, WV 26506-6125 U.S.A.** Deadline: established for conference paper abstracts.
- The **William C. Andersen Memorial Award** is given to the student who presents the best paper at the annual Raptor Research Foundation Meeting. Contact: **Ms. Laurie Goodrich, Hawk Mountain Sanctuary, Rural Route 2, Box 191, Kempton, PA 19529-9449 U.S.A.** Deadline: Deadline established for meeting paper abstracts.

### Grants<sup>2</sup>

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