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SCIENTIFIC PAPERS

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LESLIE BROWN—SOME MEMORIES[1]

Leslie Brown, who was felled by a heart attack at his home near Nairobi in early August, had become the world's best known expert on birds of prey. How does one write an obituary on such a remarkable man? We could give an inventory of his achievements, but these are well-known to all of us and they are well summarized in the citation accompanying the award of the medal of the British Ornithologists' Union in 1970 (see *Ibis*, 112: 427–428). Not that he rested on his laurels after that, and the last ten years of his life were some of his most productive, despite ill health.

Leslie published half a dozen books on birds of prey and more are to come. He had underway, in joint authorship, books on the Golden Eagle and on the owls of Europe. More technical aspects were dealt with in numerous papers in periodicals. I (D.A.) prize most highly Leslie's first raptor book, titled simply *Eagles* (1955) based on research at his beloved Eagle Hill, where about a dozen species bred, not to mention Peregrines. Nor was Brown's work confined to raptors. He did basic research on, for example, the Lesser Flamingo (*Mystery of the Flamingoes*, 1959), even learning to pilot a plane so he could locate and map its colonies on the sulfurous flats of Lake Natron, where he was once mired and nearly lost his life. He wrote the volume on Africa in the *Continent We Live On* series, perhaps the best of the lot, and even found time for a book on coral reef fishes as observed near his hide-away on the Kenya coast.

How did Leslie Brown, who, after all, was a busy colonial officer in the agricultural service into middle age, accomplish so much? Partly by an unremitting capacity for toil; partly because his mind, while without the superficial flashes of brilliance, was yet so organized and retentive that he could write page after page of manuscript ready for the printer almost without revision.

Physically Brown was a big strapping Scotchman with hair inclined to the reddish and with a bristly beard—the sort of figure one might have found at the prow of a Viking warship. And indeed he was a bit of a rebel. His early experiences in poaching salmon and duck on Scottish estates were hair raising. Leslie often drew a small figure of a cobra with raised hood next to his signature on a letter; the message, just as with the rattlesnake in colonial America, was "don't tread on me." In financial matters, however, he was a typical conservative Scot.

I (P.S.) learned a great deal about Leslie in Scotland. He was an accomplished poacher, but he only poached because it added spice to the chase. I wonder how many can kill a cock pheasant in flight with a catapult? He loved his food and was very knowledgeable about wines. He had the gift of tongues and in later years I remember his impatience with me when I could not read a paper in Spanish on the Booted Eagle—"Why don't you learn it? I did." He loved classical music. His general knowledge exceeded that of any man I know. As a raconteur he had no peer. How I wish I had space to repeat some of his hilarious stories. Perhaps his greatest ability was to commit his thoughts directly to paper in clear readable prose. It was as if he carried the whole plan of a book in his head. Few people can produce a first draft that requires almost no alteration. He could.

Leslie suffered from more than his share of physical afflictions: terrible asthma, two operations for skin cancer, and cardiac attacks. All this did not seem to slow him down—if anything the reverse—but it did make him a trifle irritable at times. He dismissed artists, no matter how talented, who did not deliver as many plates as they promised as "hopeless dilettantes." Nor did he make any concessions as to food and drink. He once told me that if I (D.A.) ate a "decent breakfast" I wouldn't start glancing at the clock about 11:30 to see if it was lunch time. For Leslie a "decent" breakfast was perhaps 3 eggs, a large helping of ham, 3 or 4 slices of toast heavily spread with sweet butter and jam, all washed down with an ample amount of coffee, by preference laced with heavy cream.

Leslie Brown also found time to do consulting work for UNESCO and other agencies, especially in Ethiopia. I (D.A.) conclude with his final experience in that country some 6 or 7 years ago, which gives a little further insight into Brown's character. He was making an aerial ecological survey in the company of 4 or 6 Swedes, those most tireless of international do-gooders, when, as Leslie put it, "The bloody incompetent fool of a pilot" became disoriented and flew off into Somalia, then, and perhaps still, at war with Ethiopia. When nearly out of fuel they saw a tiny airstrip with a village and put down. Arrest came immediately and it was about 5 weeks before the party was released. The others in the group literally worried themselves sick but Leslie, who as the only Englishman was in the greatest danger, strode up to their captors and in effect said: "If you're going to shoot me, get it over with, if not give me some pencils and paper." He bluffed them into doing so, and by the time they were released had written the entire text of a charming little book, recently published, each chapter of which relates to an unusual experience Leslie had with one species or another of animal—ranging from the chimpanzee to the huge whale-shark which one day swam around and beneath his tiny boat as he drifted off the Kenya coast.

In his last year Leslie was a very sick man, but he continued to drive himself relentlessly. He died just before his book on the *African Fish Eagle* appeared and he was preparing a major work on the birds of Africa. At the end it was almost as if he had the words of Dylan Thomas in mind:

> "Do not go gentle into that good night.
> Rage, rage against the dying of the light."

Leslie Brown—truly we shall not gaze upon his like again.

Leslie near Eagle Hill, July 1969, with John Hopcroft (left) and Sally Spofford (center)

Leslie at Eagle Hill in July 1969 with Njeru (left) and an unidentified younger man.

Leslie at a Golden Eagle nesting site in the Adirondack Mts., New York in May 1961 with Dean Amadon (left) and David Peakall (right).

[1]Editor's note. This memorial is the combined work of Dean Amadon and Peter Steyn. The photos were supplied by Walter R. Spofford. I have taken excerpts from Steyn's article, published in Bokmakerie 32:86, 1980 with permission of Steyn and the Editor of Bokmakerie. We are grateful to these men for their knowledge of and camaraderie with Leslie and their shared experiences.

CAPTIVE PROPAGATION OF BALD EAGLES AT PATUXENT WILDLIFE RESEARCH CENTER AND INTRODUCTIONS INTO THE WILD, 1976-80

by
Stanley N. Wiemeyer
U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel, Maryland 20811

Abstract

One to 5 pairs of the Bald Eagle (*Haliaeetus leucocephalus*) were in the captive propagation project at Patuxent Wildlife Research Center during 1976–80. Four pairs produced viable eggs or young by natural mating in one or more years. Pairs laid second clutches 9 of 11 times when their first clutches were collected within 8 days of clutch completion. Sixty-nine percent of fertile artificially incubated eggs hatched; 93% of fertile parent-incubated eggs hatched. Eleven eaglets from artificially incubated eggs were hand reared. Age of birds at the time they were acquired from the wild was not a factor in their reproductive success.

Ten hand-reared and 2 parent-reared young were fostered to adult Bald Eagles at active wild nests; 11 were accepted and survived. Eleven parent-reared young were provided to hacking projects. Egg transplants to wild nests were conducted, but discontinued because of poor success. Double clutching of captive pairs has not resulted in substantially increased numbers of eaglets. Additional research is needed in artificial incubation, artificial insemination, and nutrition and care of hand-reared eaglets.

Introduction

Bald Eagles have been maintained in captivity, primarily in zoos, for many years but few attempts have been made to propagate them. The lack of interest in breeding this species in captivity probably relates to its infrequent use in falconry. Most captive propagation attempts before 1973 were summarized by Hancock (1973). Other successful propagation attempts have also been reported (Anonymous 1969, Wellenkamp 1973, Johnson and Gayden 1975, Maestrelli and Wiemeyer 1975, Minnemann 1976). These breeding attempts resulted in the production of less than 30 eaglets, most of which were produced at the Buffalo Zoo between 1910–16 (Annonymous 1909, Hancock 1973) and by a pair held by an individual in Toledo, Ohio in the 1880's (Hulce 1886, 1887).

The first successful captive breeding of Bald Eagles at Patuxent Wildlife Research Center, Laurel, Maryland was in 1973 when one pair produced two eaglets (Maestrelli and Wiemeyer 1975). This pair produced three young from a single clutch in 1974 and four young from two clutches in 1975, two by hand rearing and two by parent rearing (Wiemeyer, unpublished). The pair (male from Alaska; female from Alabama) was separated following the 1975 breeding season; new mates were of more similar geographic origin. Limited information on the reproductive behavior of this pair and one additional pair, both of which were present in 1973, was reported by Gerrard *et al.* (1979).

The purposes of this paper are to present information on procedures used and results obtained in propagating Bald Eagles at the Center, and in introducing eggs and eaglets into the wild for the years 1976–80. The primary purpose of this project was to produce eggs and eaglets for supplementing production in depressed wild populations and for reintroduction attempts where Bald Eagles have been extirpated. This breeding project was funded by the Environmental Contaminants Evaluation Program of the U.S. Fish and Wildlife Service. It was transferred to the Endangered Wildlife Research Program in October 1980.

Source of Birds and Age at Acquisition

The eagles were acquired from a number of sources (Table 1). Some individuals were obtained through zoos; their histories were often incomplete. Others that had been taken from the wild following sickness or injury were obtained from law enforcement authorities. All birds were capable of flying about in the breeding pens without difficulty.

Table 1. Source and age of Bald Eagles in the breeding project.

Pair	Date Paired	Sex[a]	Original State of Acquisition	Age When Acquired From Wild[b]	Age When Paired (years)[b]
A	17 Feb. 1976	M	Florida	Immature	6+
		F	Alabama	ca. 3 years	14
B	28 Feb. 1977	M	Alaska	large nestling	11
		F	Wisconsin	large nestling	11
C	28 Feb. 1977	M	Maine	Immature[c]	6+
		F	Minnesota	< 1	6
D	20 Oct. 1977	M	Florida	Nestling?	6
		F	Florida	Nestling or Immature	14
E	23 Jan. 1979	M	Alaska	≤ 3	12+
		F	Michigan	Adult	13+

[a] M = male, F = female.
[b] Some ages based on the time when adult plumage was first obtained in captivity, assuming that it is normally acquired at 4 years.
[c] Originally acquired November 1970. Released in Maryland in January 1973. Found shot and reacquired in Delaware in April 1975.

The age of some birds of prey at the time they are taken from the wild has been an important consideration in determining the probability that they will successfully breed in captivity. Falcons taken as large nestlings and raised with congeners have been productive breeders in captivity, whereas those taken as independent immatures or as adults have done poorly (Cade *et al.* 1977). Eagles in this project that were obtained as large nestlings, immature independent birds, and as adults have bred successfully. In another study, two Bald Eagles taken from the wild as adults laid eggs, incubated and hatched them, but lost both eaglets within 17 days of hatching (Barger 1963).

Sex Determination and Pairing

Most birds in the breeding project were sexed on the basis of past reproductive performance or by laparotomy. The male of pair E was sexed by cloacal examination. The method of sexing eagles with plasma steroid hormones previously used (Dieter 1973) was found to be unreliable.

A male and female of similar geographic origin were placed together to form each breeding pair and hereafter are referred to by letter (Table 1). When most pairs were formed alternate choices for mates were unavailable. The male was placed in the breeding pen for several days to several weeks in advance of the female. This seemed to lessen early aggression initiated by the female.

On 7 December 1979 pair D was separated and removed from the pen. The male produced by pair A in 1976 was introduced into the pen on that date. The female was returned to the pen on 12 December. The male was rejected by the female and he was removed on 25 January 1980. Her original mate was returned on 28 January.

Facilities and Maintenance

The pen design (11 × 22 × 5.5 m high) used by our breeding pairs has been described (Maestrelli and Wiemeyer 1975). Four adjoining pens of this unit were used in one or more of the years 1976–78.

A new row of eight adjoining pens of the same design was constructed in 1978 in an area of the Center isolated from human disturbance. The exterior of the pens was covered with 2.5 × 5 cm mesh welded wire and the interior partitions were of 2.5 × 2.5 cm mesh welded wire. Placement of the nest platform, perches, shelter and feeding blocks was the same as in the older pens. A 3.7 × 3.7 m area of corrugated aluminum roofing was placed on the roof of each pen over the nest area. Wood sides, 34 cm high, were added to the nest platforms to help retain nest material. Nests were then filled with sticks, cattails, straw, and pine bark mulch.

Sticks and straw were placed on the ground of each pen for the adults to add to the nests. Fresh nesting material was placed in the nests each year. Grass and forbs covered the ground of the pens. Both nesting materials provided to the birds and naturally occurring materials were added to the nests by the birds. Woody vegetation and vines in the pens were controlled with herbicides and by mowing.

In 1979 and 1980 the new pens 1, 2, 3, 5 and 7 were occupied by Bald Eagle pairs. Pens 4 and 6 were occupied by single 4-year-old Bald Eagles and pen 8 was occupied by two immature Andean Condors (*Vultur gryphus*) in 1979. In 1980, pen 4 was empty and pens 6 and 8 were occupied by immature Andean Condors.

Eagles were fed 6 days a week during the non-breeding season and daily during the breeding season. The birds were fed through small wire feeding doors adjacent to each feeding block. The diet consisted of laboratory rats, fish (mostly brackish and saltwater varieties), and 3- to 5-week old chickens. Fish and rats were usually fed three times each week. When chickens were available (primarily before and during the breeding seasons) they were fed one or two times a week in place of other items. Hamsters were occasionally substituted for rats and Coturnix quail for chickens. Rodents and fowl were obtained alive, killed with CO_2 and frozen. Fresh fish were obtained and then frozen. Food was thawed as needed. One or more items were placed on each of the two feeding blocks in each pen to avoid conflicts over single items. Leftover food items within reach of feeding doors were removed daily. Items out of reach of feeding doors were removed less frequently. Most birds were very defensive during the breeding season, discouraging entry into the pens for removal of leftover items. A few birds made entry difficult throughout the year.

Water was provided in a stainless steel pan. Pans were placed just inside the door of each pen to facilitate removal for cleaning. Pans were cleaned and refilled once or twice a week as needed. The birds frequently bathed in the pans, especially following cleaning. Drinking was observed very infrequently. There was no electrical service to the new pens, therefore the pans were unheated. Water was periodically provided in winter, but rapidly froze during cold weather.

The birds were observed with a 30x spotting scope from an elevated blind approximately 120 m from the older pens and 67 m from the newer pens. Observations were not conducted on a regular basis and periods seldom exceeded one hour, except in 1980. A mirror over each nest facilitated observations of nest contents from a point immediately in front of each pen. The mirrors were placed so that birds were unlikely to see their reflection. A few birds were observed looking at the mirrors and one bird was seen to briefly attack one mirror on two occasions.

Copulation

Most copulations that were observed occurred from 6 days before to 3 days following the laying of the first egg of the first clutch. The earliest copulation that was observed occurred 37 days before the laying of the first egg of a first clutch. Three pairs were seen copulating following collection of a first clutch. Most instances occurred before or during the laying of a second clutch. For example, in 1978, copulation by pair B was observed three times (3.2 h of observations) 1 day before the laying of the first egg of the second clutch and once on the day of laying, but before the egg was laid. Copulation by this pair was also observed 4 days following the collection of the second clutch in 1979, after it failed to hatch. Pairs C and E were each seen copulating three or more times following the collection of their first clutches in 1980; neither laid a second clutch. Copulation normally occurred at one of the nest perches; pairs A and E were observed copulating on the ground on several occasions.

Artificial Insemination

In 1980, semen collections were made from three males that were not paired. A modified massage technique described by Gee and Temple (1978) was used. Males were netted and then restrained in a standing position with their feet on a log perch. One assistant held the legs of the bird and a second held the wings against its body; both assistants faced the rear of the bird. The operator then stroked the bird and manipulated the cloaca. Occasionally ejaculation occurred. Semen was collected from the ventral lip of the cloaca on the lip of a plugged glass funnel or with a propipette attached to a small pipette. The process from stimulation by the operator to collection of the semen was usually accomplished in less than 30 seconds.

On 14 March 1980 semen was collected from the male produced by pair A in 1976 and from a crippled southern male. The semen was pooled. The female of pair D was netted, restrained, and the semen deposited into her cloaca, within an hour of collection. Insemination into the oviduct would have been better than into the cloaca, but she was difficult to restrain. She laid the first egg of a second clutch of two eggs (see below) on 21 March. Both eggs failed to hatch and appeared infertile when examined. Repeated inseminations would have been preferable, but were not conducted because of the risk of excessive disturbance to breeding birds in nearby pens during capture of the female.

Laying, Incubation and Hatching

Dates of laying of the first egg of the first clutch for each pair are given in Table 2. The initiation of laying may have been delayed in some cases by late dates of pair formation (Table 1) or late return of pairs to their pens following repairs and rebuilding of nests (early to mid-February in 1976–78). The initiation of egg laying by the female of pair C in 1977 and 1978 also may have been delayed as the result of reproductive activities of pairs in adjacent pens.

The time of day of egg laying was noted on two occasions; both occurred between 1530 and 1640. Eggs were laid at a minimum of 2 day intervals. Incubation nearly always began with the laying of the first egg. Many pairs did not stop incubating in the presence of caretakers, making it impossible to determine laying dates of subsequent eggs. The female of pair B laid the first egg of a fertile two egg clutch only 16 days following pair formation in 1977.

Table 2. Dates of laying of the first egg of the first clutch for females of captive Bald Eagle pairs.[a]

	Year				
Pair	1976	1977	1978	1979	1980
A	23 March	14 March	6 March	2 March	28 February
B	(22 March)[b]	16 March	27 February	20 February	3 March
C	(6 March)	17 April	4 April	12 February	2 February
D			27 January	29 January	15 February
E			(20 March)	26 March	21 February

[a] Initiation of egg laying was delayed by dates of pairing and pen maintenance in some years (see text). Some dates approximate.
[b] Dates in parentheses are for years when the females were not paired.

First clutches were collected for artificial incubation (Table 3) from 3 pairs in 1978 and 4 pairs each in 1979 and 1980, approximately 5 to 8 days following clutch completion. Each pair laid a second clutch with two exceptions in 1980 (Table 3). Both members of each pair were normally caught and restrained before the collection of their eggs to prevent attacks upon collectors. Eggs to be artificially incubated were left with the pairs for several days of natural incubation following clutch completion because this has been found to increase the hatchability of wild birds' eggs that were to be artificially incubated (Cade *et al.* 1977). If collection of first clutch eggs is delayed too long the pairs may not relay. No second clutch was laid by pair A in 1977 following collection of the first clutch about 13 to 16 days following clutch completion. The inter-clutch interval (time from collection of the first clutch to laying of the first egg of second clutch) ranged from 18 to 23 days. This interval was similar to the interval between pairing and laying of two pairs (16 days for pair B in 1977 and 18 days for pair D in 1980).

Eggs to be artificially incubated were placed in Petersime Model 5 incubators at 37.6°C dry bulb and 30°C wet bulb (about 56% relative humidity), and turned automatically every 2 h. (Use of brand names does not imply endorsement by the Federal government.) Eggs were placed on their sides in trays used for duck eggs as modified to hold eagle eggs. It might have been better to place them large end up, but space restrictions between trays prevented this. No eggs were available to experiment with various temperatures and humidities of artificial incubation, therefore those used may not be optimal.

Eggs were placed in the hatching compartment of the incubator when they pipped, and the relative humidity was increased to about 70%, although a higher humidity might have been preferable. Eggs were placed on their sides with pips uppermost. Hatching occurred from 24 to 48 h after pipping. Some eaglets were very carefully helped from the shell if they appeared to not be making any appreciable progress 30 h after pipping. One eaglet in 1979 pipped and hatched, with help, from the apex end of the egg. The eaglet had an external yolk sac (see below). Eaglets were heard vocalizing within the shell at least 12 h before pipping on several occasions.

Twenty-one fertile Bald Eagle eggs were artificially incubated in 1978–80 (Table 3). Three of them were transplanted to nests in the wild and one was given to another captive pair. One egg from pair B in 1980 was buried in the nest lining and was cold when collected. Eleven of 16 remaining eggs (69%) hatched.

For the years 1976–80, 34 Bald Eagle eggs were parent incubated (Table 3). Fertility of parent-incubated eggs was determined by examining their contents after they failed to hatch. Small embryos may have gone undetected. The fertility of three eggs that were transplanted to wild nests was not determined. Fifteen of the remaining 31 eggs were fertile and 14 hatched (93%). The only fertile parent-incubated egg that failed to hatch was not incubated to full term by pair C in 1979, possibly because of interference by a wild adult Bald Eagle at the pens at about the time incubation ceased (Table 3). For those parent-incubated clutches containing at least one fertile egg, 74% of the eggs laid hatched. All pairs incubated their eggs; both members of each pair participated

Table 3. Reproduction by pairs of captive Bald Eagles.

Pair	Year	Clutch	No. Eggs Laid[a]	No. Eggs Fertile	No. Eggs Hatch	Young Raised[b]
A	1976	1	3(P)	1	1	1(P)
	1977	1[c]	3(P)[d]	(1)	—	—
	1978	1[c]	3(A)	3	—	—
		2	2(P)	2	2	2(P)
	1979	1	3(A)	3	3	3(H)
		2	2(P)	2	2	2(P)
	1980	1	3(P)	2	2	2(P)
B	1977	1	2(P)	2	2	2(P)
	1978	1	3(A)	3[e]	1	1(H)
		2	2(P)	2	2	2(P)
	1979	1	2(A)	2	2	2(H)
		2	2(P)	0	0	0
	1980	1	2(A)	2	1	1(H)
		2	2(P)	1	1	1(P)
C	1977	1	2(P)	0	0	0
	1978	1	2(P)	2	2	2(P)
	1979	1	3(A)	3	3	3(H)
		2	1(P)	1	0	0
	1980	1	3(A)	3	0	0
D	1978	1	2(A)[f]	0	0	0
		2	2(P)	0	0	0
	1979	1	2(A)	0	0	0
		2	2(P)	0	0	0
	1980	1	3(A)	0	0	0
		2	2(P)	0	0	0
E	1979	1	2(P)	0	0	0
	1980	1	2(A)	2	1	1(H)

[a] P = Parent-incubated; A = artificially incubated.
[b] P = Parent-reared; H = hand-reared.
[c] Eggs transplanted into wild nests.
[d] Eggs not candled; one hatched in wild nest.
[e] One egg given to pair D after their eggs failed to hatch; they failed to hatch this egg.
[f] One broken.

(Gerrard *et al.* 1979). Both sexes have brood patches. The incubating pairs were quite defensive of humans and of eagles in adjoining pens that approached the partitions.

The major cause of infertility appeared to be lack of copulation. One pair (D) produced six clutches of infertile eggs. The first clutch produced by each of two pairs (C and E) in the first year they were paired (1977 and 1979) were also infertile. In each case copulation was not observed before or during laying of the first clutch. The above factors accounted for 74% of all infertile eggs produced. Additional pairs were not seen copulating before or during the laying of their first clutches (A in 1976, B in 1977 and 1980, C in 1978 and 1980), but each produced one or more fertile eggs in these clutches.

Average clutch size was 2.5 eggs in first clutches and 1.9 eggs in second clutches. One female (A) consistently laid three eggs in each of five first clutches.

Bacteriological cultures were attempted from four fertile eggs that failed to hatch under artificial incubation in 1980. All cultures using as many as six media were negative, including tests for *Salmonella*. Two of these eggs were cultured for adenoviruses; these attempts were negative.

Eaglet Care

One case of an unretracted yolk-sac was observed in 1979. The sac was ligated at the sphincter; an antibiotic salve was applied to the umbilicus area and the sac was allowed to drop off. It might be preferable to cut the sac off immediately following ligation. The eaglet survived.

The eaglets were removed from the hatcher after they had dried. They were then placed in a thermostatically controlled forced air incubator-brooder and the temperature was initially maintained at about 36°C and the relative humidity at about 50%. The temperature was gradually lowered about 0.5°C per day. In 1979 and 1980, when the eaglets were about 1 week old, they were moved to a larger thermostatically controlled brooder. There was no control of humidity in these, however a room humidifier was used to help maintain humidity. When the eaglets were about 3 weeks old and were able to thermoregulate at room temperature, they were placed in large boxes and maintained at room temperature (about 22°C). Correct temperature was determined by observation of the eaglets' behavior. They panted when too hot, chittered and shivered when too cold, and slept quietly when comfortable.

The eaglets were kept in low boxes within the brooders and later inside the large boxes in the room. The inner boxes restricted the movement of the eaglets so that they could not readily come in contact with their feces. Inner boxes, which were slightly larger than the eaglets, were lined with absorbent paper backed with plastic, and with fumigated straw. The birds were kept in depressions in the straw when small, to prevent spraddling of their legs. Brooder liners, boxes and bedding material were changed as needed. Eaglets were raised with their siblings in 1979, usually within the same inner box. If one became excessively aggressive they were kept in separate inner boxes, but in sight of one another.

The eaglets were first fed within 24 h of hatching. They were given small pieces of food with blunt forceps. In 1979 and 1980, the diet consisted of one-half to two-thirds fowl (Coturnix quail, chickens, or ducks) and the remainder fish. The muscle, heart, and liver of fowl and scaled and filleted fish were used. Fish liver was occasionally incorporated into the diet. The items were cut into pieces appropriate to the size of the eaglets. The diet was supplemented with Polyvisol (liquid infant vitamins) at 1–2 drops per 10 g of food. After the eaglets were a few days old, calcium carbonate was added to make up 1 to 1.5% of the diet. Vionate (a vitamin-mineral supplement) was gradually incorporated into the diet when the eaglets were about 1 week old and constituted less than 1% of the diet. When the eaglets were about 3 weeks old the fish were no longer scaled. The food was wet with water before feeding to help the eaglets in swallowing it and to insure that they did not become dehydrated. Food types were mixed at each feeding. Eaglet weights were recorded daily. The amount and types of food were recorded at each feeding. These records were useful in monitoring the health of the birds. Some eaglets began to avoid hand feeding when 5 to 6 weeks old, especially if they were frequently handled.

The eaglets were fed about every 3 h during daylight for the first few days. The frequency of feeding declined to four or five feedings per day at 3 weeks of age. The birds were often fed until gorged in 1979. This was avoided in 1980 by visual inspection and palpation of the esophageal area, as excess food may spoil in the digestive tract and result in poisoning (Cade *et al.* 1977). Feedings in 1980 were normally given on empty or near empty crops.

One eaglet from pair C in 1979 developed a 90° lateral rotation of the tibia. The cause was unknown. All efforts to correct the rotation failed and the eaglet was euthanized.

The hand-reared eaglet from pair E in 1980 developed crooked toes on both feet that curled laterally when about 8 days old. After several initial unsuccessful attempts to straighten the toes, we taped a piece of heavy cardboard the size of the eaglet's foot to the end of a tongue depressor cut to the length and width of the eaglet's tarsus. The eaglet's tarsi were wrapped with cotton and the above devices taped around each tarsus. The toes were placed inside short slit-open pieces of plastic tubing, the interior diameters of which were about the same size as the respective toes. The tubing was aligned on the cardboard so that the toes were straight and then taped to the cardboard. The devices were changed every 1–2 days and adjustments to the components made in response to the growth of the eaglet. The toes were virtually straightened when the eaglet was 25 days old, 1 day before it was sent to New York. When the eaglet was examined 3 weeks later it appeared normal; the toes were still straight, but the middle toe of one foot seemed weak (P. E. Nye, pers. comm.). The cause of the original abnormality is unknown.

The parent eagles with young were provided extra food items so that sufficient food was always present for them to feed their young. Food was often provided to them twice a day so that a fresh item was available more frequently. When the eaglets were less than 1 week old a saliva-like fluid was seen dripping from the tip of the upper mandible of the adult feeding the young, thereby providing extra moisture and possibly digestive enzymes to the young with the pieces of food. This has also been observed for the White-tailed Sea Eagle (*Haliaeetus albicilla*) (Fentzloff 1978). A female Golden Eagle (*Aquila chrysaetos*) fed pieces of food to a small chick that she had partially swallowed (Hamerstrom 1970). The adult females provided the great majority of food to the eaglets in comparison to the males. The parent eagles successfully reared all of the young hatched by them to 3 to 9 weeks of age at which time the eaglets were needed for transplant to wild nests or for hacking.

Egg Transplants

Eggs to be transplanted to wild nests, including eggs that were collected during transplant operations and during some eaglet introductions, were placed in an oversized attache case (45 × 32 × 17 cm). The case was lined with styrofoam. Eggs were placed in depressions cut in the styrofoam. The temperature in the case was maintained with hot water in two hot water bottles that laid on a sheet of styrofoam separating them from the eggs. Holes in the styrofoam sheet allowed passage of heated air. The sheet prevented contact between the eggs and the killing temperature of the hot water bottles. Temperature in the case near the eggs was monitored with a dial thermometer that was inserted through a small hole in the case near the handle with the dial on the exterior. The temperature was maintained within a range of 32–37°C for up to 4 h, providing the case was not opened, without changing the water in the bottles. Cases of similar design have been used to transport bird eggs of several species (Erickson 1981).

Captive-produced Bald Eagle eggs were transplanted into active nests in the Chesapeake Bay region in both 1977 and 1978 (Table 4). The recipient nests had histories of reproductive failure for several years or high levels of contaminants in eggs produced in the previous year. Three eggs from pair A were used in transplants each year. The eggs transplanted in 1977 had been incubated by the captive pair for 2 to 3 weeks when collected; it was not known if all eggs were fertile or viable. Those transplanted in 1978 were in the fourth week of incubation, 3 weeks of which were under artificial incubation; all were fertile and appeared viable.

Only one introduced egg was known to hatch; the eaglet survived and fledged (Table 4). Four of five of the remaining eggs failed to hatch, presumably because of nest abandonment (Mason Neck 1978) and chilling of the eggs from delays in the resumption of incubation by the wild birds. The cause of failure to hatch of the fifth egg (Mason Neck 1977) was unknown.

Four of the six wild-produced eggs removed from nests during egg transplant operations were non-viable. One hatched under artificial incubation, but the eaglet died. The remaining egg was thought to have been non-viable because of a floating air cell (probably caused by a handling mishap), but appeared viable when opened.

Table 4. Transplants of captive-produced Bald Eagle eggs into wild nests.

Recipient Site	Wild-produced Eggs		Captive Eggs Introduced	Eggs Hatched in Wild Nests
	Present	Removed		
	1977			
Mason Neck, VA	1	1[a]	2	1
Holly Forks, VA	2	2[b]	1	0
	1978			
Mason Neck, VA	1	1[c]	2	0
Bombay Hook, DL	3	2[a]	1	0

[a] Eggs non-viable; failed to hatch under artificial incubation. All contained high levels of environmental contaminants.

[b] One non-viable egg cracked and one viable egg probably damaged (floating air cell) as a result of a handling mishap at the nest.

[c] Egg hatched under artificial incubation. Eaglet died of chronic bronchio-pneumonia when 33 days old. It also had secondary osteomalacia, possibly as a result of changes made in its diet in an effort to keep it eating during its long (18 day) illness.

Eaglet Introductions into Wild Nests

Ten hand-reared and two parent-reared captive-produced eaglets were fostered to wild adults in active nests, usually with long histories of reproductive failure, when they were 2.5 to 6 weeks old during the years 1978–80 (Table 5), Eaglets younger than 2.5 weeks may not be able to thermoregulate for extended periods while awaiting care by wild adults, and thus may become excessively chilled. Hand-reared eaglets in excess of 6 weeks may not have enough time to overcome imprinting on humans before fledging

Table 5. Fostering of captive-produced Bald Eaglets to adults at wild nests 1978–80.

Recipient Site	Nest Contents: Eggs	Nest Contents: Young	Nest Contents Removed[a]	Captive Young: Introduced[b]	Captive Young: Fledged	Captive Source Pair	Disposition of Nest Contents Removed
				1978			
Bonum Cr., VA	0	1	1Y	2(P)	2	A	Eaglet moved to Jones Pond, VA nest; placed alongside young of similar size. Both fledged.
Hemlock L., NY	1	0	1E	1(H)	1	B	Egg non-viable.
				1979			
Dahlgren, VA	0	1	1Y	2(H)	2	A	Eaglet moved to Chantilly, VA nest; placed alongside young of similar size. Both fledged.
Coles Neck, VA	0	1[c]	0	1(H)	1	A	—
Hemlock L., NY	0	0	—	2(H)[d]	—	B	—
Pymatuning L., PA	(2)	0	(2E)	1(H)	1	B	Goose eggs had been placed in the nest to maintain incubation; discarded.
Brandy Pond, ME	2	0	2E	1(H)	0[e]	B	One egg non-viable. The other was thought to have been non-viable when candled, but appeared to have been viable when opened later.
Swan Is., ME	2	0	2E	1(H)	1	C	Both eggs hatched under artificial incubation. One eaglet died. The other eaglet was hand-reared and placed in a nest near Steuben, ME alongside a wild-produced young of similar size. Both fledged.

(Cont. on next page)

Table 5 (cont.)

Machias, ME	1	0	1E	1(H)	1	C	Egg hatched under artificial incubation. Eaglet hand-reared and placed in nest near Passadumkeag, ME alongside a young of similar size. Both fledged.
				1980			
Ottawa, OH	0	1[c]	0	1(H)	1	B	—
Hemlock L., NY	(1)	0	(1E)	1(H)	1	E	Dummy egg in nest removed.

[a] Y = young; E = egg.
[b] P = parent-reared; H = hand-reared.
[c] Eaglet left in nest with introduced young; both fledged.
[d] Eaglets not accepted by wild pair. The pair had been seen in incubation posture in the nest, but the nest was found to be empty when eaglets were introduced. The eaglets were later removed and introduced into nests elsewhere.
[e] Eaglet killed by wild adult.

from wild nests. Three kinds of nests were used: those with eggs (including goose eggs and dummy eggs placed in empty nests to maintain incubation), with wild-produced young of similar size (which were left in the nest), and in place of wild-produced young of different size, which were in turn moved to other wild nests with young of their size. Eaglets were transported in cardboard cartons or wood crates (that were lined with clean straw as bedding material) by auto, single engine government aircraft and commercial aircraft. Eleven of 12 fostered eaglets were accepted by wild adult eagles, and were either seen in advanced stages of development in nests or were known to have fledged. All wild-produced eaglets in manipulated nests were also seen in advanced stages of development and presumably fledged. Captive-produced White-tailed Sea Eagles have also been fostered to wild adults (Fentzloff 1978).

One 5-week-old eaglet introduced into a nest at Brandy Pond, Maine (Table 5) was killed by a wild adult eagle. It had been introduced into the nest in place of two eggs and was standing in the nest when the wild adult returned and landed on a limb about 2.5 m from the nest 10 minutes after the climbing crew left the tree. The eaglet spread and flapped its wings. The adult immediately left the limb, flew off, circled, came back to the nest in a stoop with outstretched talons and killed the eaglet, knocking it out of the nest (R. B. Owen, Jr., pers. comm.). The adult presumably mistook the eaglet for a predator or intruding eagle.

A second hand-reared eaglet of similar age, even though hungry, refused food from its caretakers before being placed in the Machias, Maine nest (Table 5). It begged for food from a wild adult upon the adult's arrival at the nest, even though it had never before seen an adult eagle.

Eaglet introductions in the Maine nests in 1979 (Table 5) were all conducted in territories with long histories of reproductive failure. Three of five eggs removed from the three nests hatched under artificial incubation. Two eaglets survived hand rearing; the third, very small at hatching, died. The two surviving eaglets were introduced into Maine nests alongside wild-produced young of similar size. All were seen in advanced stages of development and presumably fledged.

Captive-Produced Young Sent to Hacking Projects

Eleven captive-produced parent-reared young 7 to 9 weeks old were provided to hacking projects between 1977–80 (Table 6). Seven young were provided to New York and were hacked successfully to the wild at Montezuma National Wildlife Refuge (P. Nye, pers. comm.) where Bald Eagle hacking procedures were first developed by Milburn (1979). Four young were provided to the Georgia Department of Natural Resources; they were hacked successfully to the wild at Sapelo Island, Georgia (R. Odum, pers. comm.). Hacking has also been used in the reintroduction of White-tailed Sea Eagles in Scotland (Love and Ball 1979).

Table 6. Captive-produced Bald Eagles provided to hacking projects.

Hacking Project	Year			
	1977	1978	1979	1980
New York	2(B)[a]	4(B,C)	–	1(B)
Georgia	–	–	2(A)	2(A)

[a] Source pairs given in parentheses.

Discussion and Conclusions

Considerable progress has been made in the captive propagation of Bald Eagles in the last 10 years. Current knowledge and effort have made possible the production of modest numbers of eaglets for reintroduction attempts and supplementing production of depressed populations. Information and experience gained during these years has been helpful in assessing the value and potential of various techniques.

Bald Eagle egg transplants should not be considered as a productive method of supplementing the production of depressed populations. Major problems encountered in the use of this technique in this study were the outright abandonment of introduced eggs and excessive delays in the resumption of incubation following transplants. These problems were also encountered in transplants of wild-produced Bald Eagle eggs from the Great Lakes states to Maine in 1974–76 (F. Gramlich, C. Madsen and P. Nickerson, pers. comms.). These problems might have been lessened in a few isolated cases in these studies by reductions in time spent at recipient nests by egg introduction teams. The strong desire to determine if and when a wild pair returns to its nest following an egg transplant may be counter-productive in some cases. An observer even at a distant observation site might cause a delay in the resumption of incubation, resulting in chilling of eggs and death of embryos. Perhaps efforts to obtain such information should be abandoned. An aerial check of the nest 1 h following an egg transplant could provide information on acceptance or abandonment of eggs. Even with these modifications egg transplants should be considered only when other techniques cannot be used. The placement of goose eggs or dummy eggs in nests shortly following the loss of wild-produced eggs or in the nest of a pseudo-incubating non-laying pair can hold pairs on their nests until eaglets become available for introductions, as occurred in Pennsylvania in 1979 and New York in 1980.

Double clutching of captive pairs at this Center has not resulted in substantially increased numbers of eaglets. If all 16 fertile eggs that were artificially incubated to termination (see above) had been left with the parents (no double clutching) and all had hatched and eaglets survived (similar to actual success for parent-incubated fertile eggs), the production would have been the same as that actually observed from these pairs with double clutching. Modest improvements in hatchability of artificially incubated eggs and consistent laying of and production from second clutches are needed before double clutching will result in increased production. The time and expense of hand rearing first clutch young must be balanced with the need for increased production, with the manager making appropriate decisions with regard to available resources and the value placed on the birds. Double clutching could be reserved for unpaired females that are to be artificially inseminated or individual pairs that fail to incubate their own eggs or rear their own young. It could also prove beneficial with specific pairs that consistently produce viable first clutch eggs and young from second clutches, especially if modest improvements in hatchability of artificially incubated eggs are realized.

Knowledge of proper nutrition and care of hand-reared young has not been perfected, as suggested by the occasional appearance of skeletal abnormalities. No abnormalities of these types have been seen in parent-reared eaglets. Eaglets should not be hand-reared for more than 5 weeks because of problems in the acceptance of food from caretakers. If eaglets must be hand-reared for longer periods they should be allowed to pick up pieces of food on their own. Hand-reared young should not be used in hacking projects because they most likely will become imprinted on humans.

Very little work has been done with artificial insemination of bald eagles. Artificial insemination techniques with Golden Eagles were previously described (Hamerstrom 1970, Grier 1973). The technique should prove valuable when working with females that are imprinted on humans and with unpaired egg-laying females. Forced semen collections did not prove to be difficult in very limited attempts. Methods of preserving eagle semen for later use could be explored.

Modest to major contributions to Bald Eagle production have resulted from the fostering and hacking of captive-produced eaglets into the wild. In New York, 7 of 22 Bald Eagles successfully hacked to the wild in the years 1976–80 were produced at this Center, whereas fostering of eaglets into a wild nest accounted for all and one-half of the total production from wild nests in the state in 1978 and 1980 (P. Nye, pers. comm.). In Georgia, no young were produced by wild eagles during 1979 and 1980 when four captive-produced eaglets were hacked to the wild (R. Odum, pers. comm.). The fostering of one eaglet in Ohio in 1980 accounted for 25% of the total production of Bald Eagles for the state (D. Case, pers. comm.). In Pennsylvania in 1979, the fostering of one eaglet accounted for all of the production in the state (M. Puglisi, pers. comm.). Fostering of captive-produced young in Virginia in 1978 and 1979 accounted for 10 and 13% of the total eaglet production (Dittrick and Clark 1978, Pramstaller and Clark 1979) whereas in Maine in 1979 it accounted for only 5% of total eaglet production (F. Gramlich, pers. comm.).

The ultimate success of any captive breeding program with release of progeny occurs when released birds successfully reproduce in the wild. Two wild-produced bald eagles that were hacked to the wild in New York in 1976 paired and produced young in 1980 (P. Nye, pers. comm.). The earliest that this could occur for this program would be in 1981 when those young released in 1977 could first reach sexual maturity, assuming survival. Larger numbers of released young should first become sexually mature in 1982 and 1983. It may be difficult to locate released birds at maturity because only those released at hacking projects carried adequate color markers for individual identification. There are few breeding birds in the hacking areas (New York and Georgia) thereby making easier the detection of new breeding pairs.

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ARTIFICIAL BURROWS PROVIDE NEW INSIGHT INTO BURROWING OWL NESTING BIOLOGY

by
Charles J. Henny and Lawrence J. Blus
Patuxent Wildlife Research Center
480 SW Airport Road
Corvallis, Oregon 97330

Introduction

The breeding biology of Burrowing Owls (*Athene cunicularia*) is poorly understood, primarily because of the difficulty of studying an underground nesting species. Before the use of artificial burrows (Collins and Landry 1977), few attempts were made to intensively study Burrowing Owl nesting because of the nest destruction problem. Twenty artificial burrows, similar to those used by Collins and Landry (1977), were installed in eastern Oregon (Umatilla and Morrow counties) in the spring and summer of 1979; however, sandy soil and wind erosion resulted in only 12 burrows being relocated in 1980. In 1979 and 1980, we made observations on four nesting attempts by Burrowing Owls using these burrows. Our objective was to collect additional information on the breeding biology of this species. The points made in this paper all come under the basic heading "know the species" which is essential before attempting to develop a *census* procedure, or even a method for evaluating *productivity* of a species.

Results

The observations recorded during this study are presented separately for each burrow, although the food habits information is pooled.

Burrow No. 1 (1979)

An artificial nest was placed in a burrow being excavated on 4 April 1979. The site was rechecked on 11 April and contained an owl incubating 10 eggs of which 1 was collected for pesticide analysis. Thus, the Burrowing Owl laid 10 eggs in no more than 8 days; it seems unlikely that a second female contributed eggs to the clutch as additional adults were not observed near the burrow. On 9 May eight young (about 1–2 days old) were in the nest; this suggested an incubation period of about 27–28 days. Seven young were banded in the box on 22 May (Fig. 1). On 6 June (young about 1 month old) two of the banded young were in the nest box in which the eggs were laid, and four of the banded young were in another box about 45 m away. Prey was found in both boxes.

Burrow No. 1 (1980)

The burrow discussed above was first checked on 19 March 1980; two adults were flushed from the burrow. It contained no eggs. On 7 April six cold eggs were present and one was collected for pesticide analysis. No prey was found in the box with eggs, but prey was found in the box 45 m away. On 26 April 11 eggs were in the nest. On 15 May at least six young were in the nest, but some were also in the tunnel. On 22 May no owlets (about 10 days old) were in the box where the eggs were laid, nor were they in the adjacent box. Other natural burrows were known to be in the vicinity. However, on 27 May 10 young were in the nest in which the eggs were laid; these were banded. On 6 August one adult and at least five young were seen nearby.

Burrow No. 2 (1980)

This burrow was first checked on 8 April 1980. An adult flew from the nest, but its mate remained inside. One cold egg was also in the nest. On 14 May the nest was revisited and contained 10 eggs, most of which were pipped, and one had hatched. If the 10 eggs were laid in 8 to 10 days, the incubation period for the clutch was 28 to 30 days. Revisits on 2 and 9 June revealed no young in the box, although they could have moved to a natural burrow nearby; an adult was seen in the vicinity on one visit.

Burrow No. 3 (1980)

On 14 May 1980 an adult was near the entrance, and the female was inside incubating eight eggs of which one was collected. On 2 June seven young, about a week to 10 days old, were in the nest, and they were all banded on 9 June.

Prey species found in the burrows during the nesting season included the following: Ord kangaroo rat (*Dipodomys ordi*) (13), deer mouse (*Peromyscus maniculatus*) (5), vole (probably *Microtus* sp.) (3), northern pocket gopher (*Thomomys talpoides*) (2), Great Basin pocket mouse (*Perognathus parvus*) (2), young mountain cottontail (*Sylvilagus nuttalli*) (1), young black-tailed jackrabbit (*Lepus californicus*) (1), house mouse (*Mus musculus*) (1), and young Ring-necked Pheasant (*Phasianus colchicus*) (1). Numerous authors, using pellet studies, have noted the importance of insects in the diet of Burrowing Owls (e.g., Maser et al. 1971). We also found pellets in mid-August that contained mostly insect remains. Insects, however, would be less likely to be found in burrows because they probably are eaten immediately.

Discussion and Conclusions

Egg laying occurred from early through late April. The clutches were large (12, 10, 10, 8) with the latest clutch initiated being the smallest. Burrowing Owls appear to produce the largest clutches of any North American raptor. Murray (1976) gathered clutch size data of various owls from museums and egg collections and found that the mean size of 439 Burrowing Owl clutches was 6.48 (range 1–11). Eggs in a nest from this study were laid at a rate of more than one per day (assuming two females were not involved), which is in contrast to reports for most owls (see review, Welty 1962) and a Burrowing Owl in captivity (Howell 1964). Incubation lasted about 4 weeks (27–28 days and 28–30 days) at two nests in this study, which agreed with Zarn (1974), but differed from Bendire's (1892) statement of about 3 weeks. Bendire stated that incubation did not appear to begin until a clutch was nearly completed; that agrees with the findings of this study—a cold, incomplete clutch of six eggs was recorded, and a nearly synchronous hatching of eggs occurred in another clutch. In contrast, Thomsen (1971) assumed that incubation began with the laying of the first egg, based on size of young at first emergence.

Although 1 egg was collected from each clutch, 10, 7, and 7 young reached about 2 weeks of age in 3 nests; however, some attrition appeared to occur over the next 2 weeks. Owlets only 10 days old were known to move among nest burrows, thus making productivity studies difficult. Further, banded young from one nest were found in two different burrows at the same time, making casual counts of young in front of burrows a somewhat tenuous method of obtaining productivity (a minimum count only). Even with artificial burrows, we were uncertain about the outcome of Nest No. 2. The young may have moved to natural burrows. From the literature, the number of young produced per pair is varied, but in some studies it was much lower than the average clutch size. Estimates of attrition of young from the egg stage to fledging may be highly inflated if measurements are not corrected for the movement of young to adjacent burrows.

Following pair formation, Thomsen (1971) reported that some pairs were seen at only one burrow, while others were seen at more than one burrow before choosing one as a nest site. In the present study, even during the egg laying period, some adults used at least two burrows and brought prey to each. The phenomenon even tends to complicate the counting of active nesting pairs—a task originally thought to be relatively straightforward. These cautions are important because the recent concern for Burrowing Owls may result in a number of future studies. Detailed studies of Burrowing Owls are much more difficult than we, and probably most workers, anticipated.

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Figure 1. Seven young (14–15 days old) in Burrow # 1 on 22 May 1979.

HARRIER NEST-SITE VEGETATION

by
Frances Hamerstrom
Rt 1, Box 448
Plainfield, Wisconsin 54966

and
Mark Kopeny
717 E. Thomas St.
Arlington Heights, Illinois 60004

The Northern Harrier (*Circus cyaneus hudsonius*) is highly adaptive as a nester. It utilizes essentially all niches used by the three European harriers (*C. c. cyaneus*, *C. aeruginosus*, and *C. pygargus*) with the exception of the rather recent adaptation by *C. c. cyaneus* to forest nesting in Scotland (Watson 1977). The Northern Harrier has adjusted to significant changes in available vegetation for nest sites on the Buena Vista Marsh, Central Wisconsin, over the last 19 years. The plants recorded in the immediate vicinity of 184 Harrier nests reflect these changes.

Our 16,000-ha. study area lies mainly in the Buena Vista Marsh, but includes some of the surrounding upland. The marsh was drained, and both it and the upland parts of the study area are now mostly farmland with a high proportion of non-marshy grassland. The low spots tend to become sedge (*Carex* spp.) and willow (*Salix* spp.) swales (Hamerstrom 1969).

We recorded the three most prominent plants within approximately 2 ft. (ca. 60 cm) of the nest cup in order of dominance. Our primary purpose was to facilitate nest finding. We rarely measured vegetation height and density. The woody species, aspen and willow, were present as brush rather than trees. We could not identify sedges, goldenrods (*Solidago* spp.) and willows to species so lumped them as groups; some grasses were specifically recognized and are shown in Table 1, unidentified grasses are lumped together as a group (*Graminae*). Of different cover species or groups at 184 nests (Table 1) at least 16 were dominants. (We use the term "dominant" here to mean the single most prominent cover plant within 2 ft. of the nest.) The six most frequent dominants (i.e. at more than 5 nests) were willow (*Salix* spp.), grasses (*Graminae*), meadowsweet (*Spirea alba*), goldenrod (*Solidago* spp.), sedge (*Carex* and *Scirpus* spp.), and stinging nettle (*Urtica dioica*). Even when not dominant, these six were among the important cover plants at a disproportionate number of nests (Fig. 1). We recorded 56 nests surrounded by only one cover species, discounting those species present in only trace amounts (Table 1). All but three nests were in one of six dominant cover types listed above.

There has been a shift in the relative abundance of certain nest-site species on the study area, due in considerable extent to herbicide spraying to improve Prairie Chicken (*Tympanuchus cupido*) habitat. Changing patterns of farming have also played a part. Since 1959 the Wisconsin Department of Natural Resources has effectively sprayed a substantial portion of the study area to control brush. One result of this program has been a decrease in willows, which, along with sedge, was the most common vegetation at Harrier nests during the first half of this study (Period I: 1959–1968). But *Spirea* unex-

Table 1. Vegetation found in the immediate vicinity of 184 Harrier nests, 1959-1978.

Cover	Present at Nest Site		Dominant at Nest Site		Monotype at Nest Site[c]	
	N	%	N	%	N	%
Willow (*Salix* spp.)	65	35.3	40	21.7	15	8.2
Grasses (Graminae)[b] total	(58)	(31.5)	(42)	(22.8)	(23)	(12.5)
Timothy (*Phleum pratense*)	12	6.5	7	3.8	3	1.7
Reed-canary (*Phalaris arundinacea*)	6	3.3	3	1.6	1	.1
Poa ssp.	8	4.3	6	3.3	4	2.2
unidentified	32	17.4	26	14.1	15	8.2
Sedge (*Carex* spp., Scirpus spp.)	57	30.9	20	10.9	3	1.6
Goldenrod (*Solidago* spp.)	56	30.4	32	17.4	8	4.3
Meadowsweet (*Spirea alba*)	46	25.0	33	17.9	3	1.6
Stinging Nettle (*Urtica dioica*)	18	9.8	7	3.8	1	.1
Swamp Milkweed (*Asclepias incarnata*)	13	7.1	0	0.0	0	0
Aspen (*Populus tremuloides*)	10	5.4	2	1.1	0	0

Other species or groups found at nest sites (each found at less than five nest sites): Bluestem (*Agropyron smithii*); Redtop (*Agrostis alba*); Bluejoint (*Calamagrostis canadensis*); *Bromus* spp.[a] incl. *B. inermis*; Oats (*Avena sativa*[a]; Woolgrass (*Scirpus cyperinus*); *Polygonum* spp. incl. False Climbing Buckwheat (*P. scandens*); *Rosa* spp.[a]; Strawberry (*Fragaria* sp.); Raspberry (*Rubus* sp.)[a]; Yellow Sweet Clover (*Melilotus officinalis*)[a]; Dogwood (*Cornus* sp.); Wild Bergamot (*Monarda fistulosa*); Woundwort (*Stachys palustris*); Elderberry (*Sambucus canadensis*); *Aster* spp.[a]; Yarrow (*Achillea millefolium*); Thistle (*Cirsium* sp.); Fleabane (*Erigeron* sp.)

[a] Dominant at at least one nest.
[b] Parentheses show total of all grasses identified and unidentified.
[c] Plus Oats, *Bromus* sp., Raspberry, and Yellow Sweet Clover at one nest each.

pectedly increased. The Harriers adjusted to this change and nested more commonly in *S. alba* and also in *Solidago* spp. (Fig. 2) in the later years (Period II: 1969–1978). In this latter period, *S. alba* increased in dominance at nest sites by more than tenfold over the earlier period and increased by almost sixfold in the number of nests at which it was present. *Solidago* spp. showed a similar trend, whereas *Salix* spp., *Populus tremuloides*, and to a lesser extent *Carex* spp. declined. Fewer nests have been placed in grasses since Period I, particularly with grasses as the dominant cover.

By the time nesting Harriers have eggs—roughly the beginning of June—the most common cover plants of both Periods I and II (excluding some of the grasses) normally appear in tall or dense patches, or both. These characteristics may reduce exposure to both mammalian and avian predators. Dense patches of vegetation are not normally used for travel lanes by mammals. From the air the "hole in the field" is conspicuous, but the taller the vegetation, the more directly an avian predator must fly over a nest in order to see it.

Brown and Amadon (1968) report that Harriers commonly build their nests in low shrubby vegetation, tall weeds, or reeds rather than in very open sites. Our data agree, and also indicate that the Harrier is highly adaptive as a nester, as evidenced by its adjustment to the changes that have taken place on their breeding grounds on the Buena Vista Marsh.

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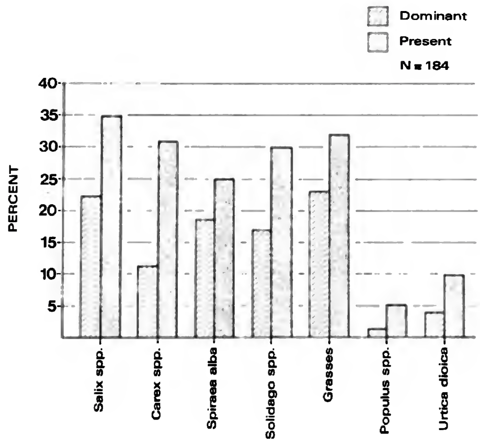

Figure 1. Percentage of nests at which each cover type was dominant or present.

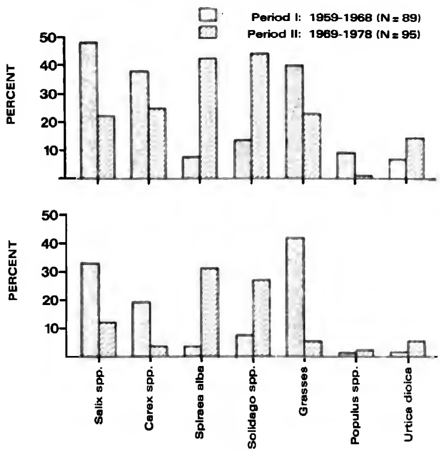

Figure 2. Fraction of nests at which each cover type was present (top) and dominant (bottom). The period 1959–1968 compared with 1969–1978.

HAVE THE EGGS OF THE ORANGE-BREASTED FALCON (*FALCO DEIROLEUCUS*) BEEN DESCRIBED?

by
Douglas A. Boyce Jr.[1]
School of Natural Resources
Humboldt State University
Arcata, California 95521

and
Lloyd F. Kiff
Western Foundation of Vertebrate Zoology
1100 Glendon Avenue
Los Angeles, California 90024

The only published description of Orange-breasted Falcon (*Falco deiroleucus*) eggs known to us is that of Coltart (1952), who presented details on two sets of eggs said to be of this species collected for G. D. Smooker in Trinidad. One of these sets, a clutch of 3 taken on 28 March 1937 in the Aripo Savannah, is now in the collection of the Western Foundation of Vertebrate Zoology (WFVZ cat. no. 15,728); the other, a set of 2 collected on 21 April 1930 in the Coroni Marshes, is in the collection of the Zoological Museum, University of Helsinki, Finland (ZMUF cat. no. 15,721).

The authenticity of these eggs has been questioned by ffrench (1973) because of their small size compared to the body size of the species. The 3 eggs in the WFVZ collection measure 40.6 × 34.7, 41.8 × 35.6, and 39.9 × 34.6 mm, and the 2 eggs in the ZMUF set measure 43.0 × 35.0 and 42.2 × 34.7 mm. All of these measurements fall within the range given for eggs of the Aplomado Falcon (*Falco femoralis*) by Bent (1938) and Brown and Amadon (1968) and are only slightly larger than the extreme measurements known for eggs of the much smaller Bat Falcon (*Falco rufigularis*) (Brown and Amadon op cit., Kiff unpubl. data). Eggs of several falcon species, including one of Smooker's Trinidad eggs, are shown in Figure 1 to illustrate their comparative sizes.

Heinroth (1922) first demonstrated the fundamental relationship between egg weight and body weight in birds, and this was further refined by Huxley (1923–1924). Amadon (1943), Lack (1968), and Rahn et al. (1975) have presented evidence that suggests that each group of related birds (at least to the subfamily level) has a characteristic proportionality constant, which expresses the rate at which egg size increases to that of body size increase. It is possible, therefore, to derive individual regression equations to express the relationships between these parameters for particular groups of birds and to predict fairly closely body weight from egg weight, or vice-versa.

We obtained data on egg size and female body weight for 12 *Falco* species, representing the entire size range found in the genus (Table 1), and plotted the log of female body weight against the log of egg length (L) × egg breadth (B), a size index that is highly correlated with actual egg weight (Anderson and Hickey 1970). The resulting regression line ($r^2 = 0.92$) is shown in Figure 2. The Orange-breasted Falcon data point lies well away from the regression line. Based on the mean weight of 605 g ($n = 7$) for

[1]Present address: 4445 Old Gravenstein Highway, Sebastopol, CA 95472

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female Orange-breasted Falcons, the log LB for the species (assuming a sample size of 20) should be 3.26. When this figure is plotted against egg breadth a value of 37.5 mm for Orange-breasted Falcon egg breadth is predicted. When that figure is divided into the product of L × B, an estimate of 48.0 mm for Orange-breasted Falcon egg length is obtained. The 95% prediction interval for these values range from 44.0 to 52.1 mm (L) and 33.8 to 40.0 mm (B); Smooker's sets fall outside this range in length and just inside in breadth.

Table 1. Mean egg size and female body weight of *Falco* species.

Species		Code	Egg Size (mm) (Length × Breadth)	Log L·B	♀ wt. (g)		Log wt.	Source
American Kestrel	*F. sparverius*	A	35.15 × 28.92	3.007	142.2	(13)	2.15	6
Red-footed Falcon	*F. vespertinus*	B	35.34 × 29.59	3.038	182.2	(5)	2.26	3
European Kestrel	*F. tinnunculus*	C	39.82 × 31.37	3.097	230.4	(20)	2.36	3
Merlin	*F. columbarius*	D	40.21 × 30.84	3.094	212.0	(14)	2.33	2
Bat Falcon	*F. rufigularis*	E	40.80 × 31.81	3.118	220.0	(13)	2.34	4
European Hobby	*F. subbuteo*	F	41.82 × 32.86	3.138	229.0	(10)	2.36	9
Eleonora's Falcon	*F. eleonora's*	G	41.92 × 34.30	3.160	388.0	(11)	2.59	7
Little Falcon	*F. longipennis*	H	44.48 × 33.14	3.169	310.0	(4)	2.49	5
Aplomado Falcon	*F. femoralis*	I	44.26 × 34.79	3.188	406.0	(8)	2.61	10
Brown Hawk*	*F. berigora*	J	51.66 × 39.28	3.308	505-635	(4)	2.89	5
Prairie Falcon	*F. mexicanus*	K	52.01 × 40.18	3.320	863.0	(31)	2.94	8
Peregrine Falcon	*F. p. peregrinus*	L	51.27 × 40.72	3.320	1010.0	(17)	3.00	5
Gyrfalcon	*F. rusticolus*	M	59.17 × 45.92	3.434	1470.0	(10)	3.17	1

*We used the Brown Hawk egg data only in Fig. 3 and Eleonora's Falcon data only in Fig. 2. Code letters are those used in Figs. 2 and 3. Egg sample size is 20 per species; sample sizes for female body weights are given in parentheses. Sources of data: 1 = Mattox (1970), 2 = Cramp (1980), 3 = Dementiev and Gladkov (1954), 4 = Kiff (unpubl. data), 5 = Brown and Amadon (1968), 6 = Porter and Wiemeyer (1972), 7 = Walter (1979), 8 = Enderson (1964), 9 = Glutz von Blotzheim et al. (1971), 10 = Hector (pers. comm.)

In addition to the small size of the eggs, there are other reasons to doubt their authenticity. In a long paper on the habits of Trinidad and Tobago birds which Smooker co-authored (Belcher and Smooker 1934–1937), the only allusion to breeding in the Orange-breasted Falcon account is the tentative statement, "we think it a resident," despite the fact that the 1930 set had been taken years earlier. The Orange-breasted Falcon has always been regarded as exceedingly rare in Trinidad, and there is as yet no additional evidence that it breeds there (ffrench 1973). Both sets of eggs were taken for Smooker by a native, apparently the same one in each instance, and Smooker may never have seen the nesting birds personally. Several other instances of misidentification of eggs in the Belcher-Smooker Trinidad collection have been reported (ffrench 1973, Kiff in press), probably resulting from errors by native helpers, rather than dishonesty on the part of the collectors.

Three falcon species, the Aplomado Falcon, Bat Falcon, and American Kestrel (*F. sparverius*) are known to nest in Trinidad. The eggs of the latter are so much smaller than the ones in question that it can safely be ruled out as a candidate for laying them. The Smooker eggs are most similar in size to those of Aplomado Falcons and plotting the measurements of the questionable eggs against mean female Aplomado Falcon body weight yields a point very close to the one seen for the species (Fig. 2). Both nests, however, were said to be in cavities, one (WFVZ no. 15,728) being "30 feet up in a knot-hole in a ceiba tree," whereas the other was "in the hollow at the base of a palm-branch about 40 feet up" (Coltart 1952). According to Dean Hector (pers. comm.), who has studied the species intensively, there is no recorded instance of Aplomado Falcons nesting in such cavities. The nest descriptions are virtually identical to those which Smooker gave for sets of Bat Falcon eggs collected for him in Trinidad and now in the WFVZ collection, but the eggs would be unusually large for that species. We plotted egg breadth against egg length for twelve species of falcons and constructed a 90% prediction interval for the genus. The set deposited in the WFVZ lies outside this interval (Fig. 3) and the other set lies on the line. This suggests that these purported eggs may not even belong to the genus! Interestingly, the eggs are most similar in color and size to those of the Yellow-headed Caracara (*Milvago chimachima*) (a genus related to *Falco*), but that species is rare in Trinidad and is not known to breed there (ffrench 1973). We constructed a 95% confidence interval for a random sample of Yellow-headed Caracara eggs (n = 20) and noted that the Orange-breasted Falcon eggs lie on both sides of the lower limit (42.59 × 34.56 mm).

Thus, it is impossible to identify Smooker's alleged Orange-breasted Falcon eggs unequivocally, but it is virtually certain that they are not eggs of the Orange-breasted Falcon and that the eggs of that species await formal description.

Acknowledgements

We are grateful to Dean Hector and Dave Craigie for commenting on the manuscript and to Clark Sumida for preparing Figure 1. Hector, G. Clark, and M. Kirven provided us with unpublished weight data. Juhani Terhivuo provided us with data from the Zoological Museum of the University of Helsinki. Julie Kiff assisted in measuring eggs. This note was supported by the Western Foundation of Vertebrate Zoology.

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Figure 1. Falcon eggs arranged in order of increasing female body weight from left to right (American Kestrel, Bat Falcon, Aplomado Falcon, Orange-breasted Falcon, Peregrine Falcon, Gyrfalcon). Note the incongruity of the Orange-breasted Falcon egg location in the sequence.

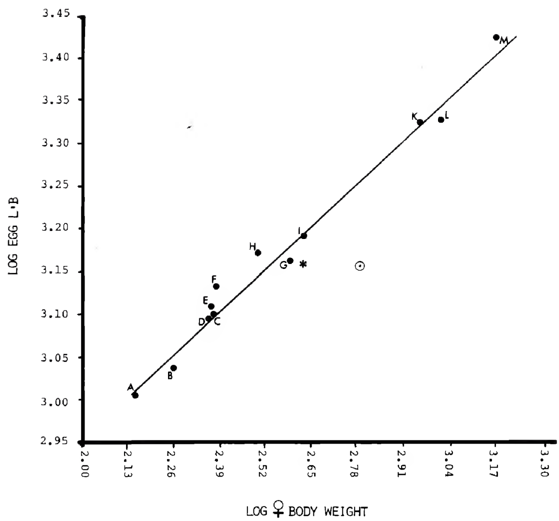

Figure 2. Regression line of log egg length times breadth (L•B) with log female body weight for several *Falco* species. Open circle shows the deviant data point for the Orange-breasted Falcon based upon Smooker's purported eggs. The asterisk shows the location of these eggs plotted against Aplomado Falcon weight. Egg size of the Orange-breasted Falcon based on female weight should fall on the regression line immediately above the purported clutch. See Table 1 for letter codes.

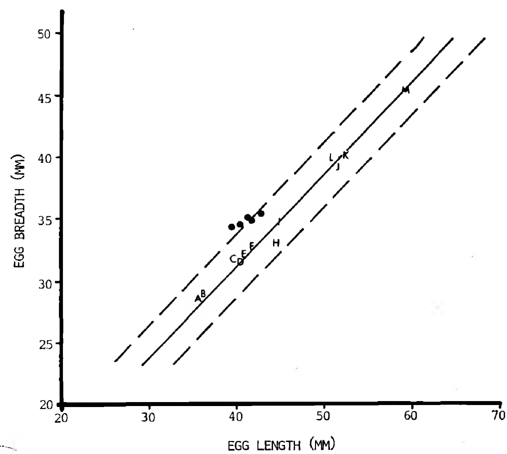

Figure 3. *Falco* egg breadth regressed with egg length. The dotted lines show the 90% prediction interval for the genus. Note that three Orange-breasted Falcon eggs (black dots) lie outside the line and two lie on the line. The three outlying eggs are in the WFVZ collection. For letter codes see Table 1.

MERLINS AS NEST PREDATORS

by
L. Henry Kermott
James Ford Bell Museum of Natural History
10 Church Street, SE
Minneapolis, MN 55455

The hunting tactics of the Merlin (*Falco columbarius*) and its preference for small birds as primary prey are well documented (Rowan 1921–22, Allen and Peterson 1936, Bent 1938, Lack 1971, Page and Whitacre 1975, Brown 1976, Oliphant and McTaggart 1977, Hodson 1978, Newton et al. 1978). Most reports of Merlin prey are based on analyses of nest remains and pellets; few are based on direct observations of hunting birds. I could find no published reports of Merlins taking nestlings directly from the nests of the prey, as has been reported for the closely related American and European Kestrels (*Falco sparverius* and *Falco tinnunculus*) (Tinbergen 1946, Drinkwater 1953, Freer 1973, Windsor and Emlen 1975). Although the occurrence of nestlings in the diet of Merlins has been reported (Armitage 1932, Roberts 1962, Sperber and Sperber 1963), the data were gathered from nest remains, not by direct observations of hunting birds.

During late May and early June 1980 at Big Sky, Gallatin County, Montana, I frequently saw a pair of Merlins on the valley floor (elevation 1990 m) in an area of sagebrush (*Artemisia* sp.) divided by a stream flowing out of nearby mountains, with several beaver ponds and neighboring willows (*Salix* sp.). A golf course was situated amidst these surroundings, with vacation homes and condominiums scattered around the periphery. Many small conifers had been planted on the lawn around these dwellings. On 3 June I noticed a male Merlin seemingly foraging in these conifers—flying from tree to tree. Immediately on landing in a three-meter-high spruce (*Picea* sp.) the Merlin was vigorously attacked by a pair of Robins (*Turdus migratorius*) and flew off carrying an unidentified object in its talons. I searched the tree and found a Robin nest containing two unfeathered living young. I withdrew and watched from about 20 m away.

The Merlin returned in about 30 minutes, flying in low and fast around the corner of a building, and landed in the same tree. The adult Robins resumed their attack and the Merlin turned and defended itself, but shortly flew off again with an object in its talons. A check of the nest revealed a single nestling. I did not see the Merlin again that day, but the next morning the nest was empty.

Further investigation in the vicinity revealed many adult Robins and Robin nests in small conifers, but I could find only a single nest containing one well feathered young and saw only one fledged juvenile. Other small birds, especially Cliff Swallows (*Petrochelidon pyrrhonata*), were common in the area. I once saw a Merlin pursuing a swallow, but it would seem that nestling Robins were easier prey.

I wish to thank R. M. Timm and H. B. Tordoff for reading the manuscript.

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BOOK REVIEW

The Peregrine Falcon. Derek Ratcliffe. 1980. Buteo Books, Vermillion, South Dakota ($42.50) and T. & A.D. Poyser (£12) 416 pages, 4 color plates 32 bl. and white plates.

Few books have been more eagerly awaited than Derek Ratcliffe's major opus on the Peregrine. It has been well worth waiting for; it is a superb book, by far the best monograph on a bird of prey yet published.

As might be expected Ratcliffe has handled the difficult task with great skill, concentrating almost entirely on the North American/European races: *F. p. pealei, anatum, tundrius* and *peregrinus*. The remaining races are all briefly described in Chapter 15 at the rear of the book. This means that the text is allowed to flow freely, unhampered by continual reference to the behaviour of other races.

The book opens with a realistic account of man's relationship with the Peregrine, be he egg collector, falconer, pigeon fancier or ornithologist, followed by a discussion on population trends and a detailed summary of the distribution in the British Isles. This is so detailed that one is tempted to try to recognize individual eyries. Information has been gleaned from a wide variety of sources and the author gives generous tribute to all those who made a contribution.

For me the book gained momentum from Page 126 onwards when the subject switches to feeding habits, nesting habitat and the breeding cycle. The spectrum broadens and comparisons are made between the behaviour of *peregrinus* and *pealei*, much of the latter information coming from Wayne Nelson's thesis on the Lanagra peregrines.

On Page 170 Joe Hickey's system of grading cliffs in suitability for nesting is quoted. But is this system now valid? Dwindling populations may tend to survive longer on high cliffs remote from constant human presence. However, in parts of Great Britain where recolonisation is taking place, recolonising pairs often show a strong tendency to pick contiguous territories to a successful breeding pair despite the paucity of the cliff. Furthermore it has been suggested that these birds may be related to the dominant pair and this could be a factor for reducing aggression between them. However, why some first class cliffs remain vacant and some third class ones are tenanted year after year must remain a subject for speculation.

The pair bond in winter is a fascinating subject on which more light needs to be shed. Are certain Peregrines more faithful to their favourite cliff than their mates? My own experience suggests that perhaps they are. One tiercel that I know well has been present both winter and summer on the same stretch of cliff for over 6 years and has had at least 2 different mates if not 3. But the behaviour of individual pairs is so variable no hard and fast rule can be made.

The most compulsive reading in the book is the chapter entitled "The Pesticide Story." Here the author's sense of personal involvement shines through the text. He is the master detective telling his own story.

The photographs are, without exception, new to me and all of a very high order. Donald Watson provides many sketches which are a delight to the eye—full of atmosphere. The presentation is excellent and well up to the standard we have come to expect from these publishers. This reviewer has no hestitation in saying that if you are a raptor enthusiast then you must have the book. I shall not be lending my copy to anyone.

R. B. Treleaven

RRF Annual Meeting

The 1981 meeting of the Raptor Research Foundation will be held Friday, October 30 through Monday, November 2, 1981, in Montreal, Quebec, Canada. All sessions and workshops will be held in the Sheraton Mt.-Royal Hotel. The tentative schedule includes workshop sessions on Friday, paper sessions from Saturday through Monday (if necessary) and tours of the Macdonald Raptor Research facilities. Evening films and an art exhibit featuring Canadian artists will also highlight the event.

For more information, contact:

Dr. David M. Bird, Program Chairperson
Macdonald Raptor Research Center
Macdonald Campus of McGill University
Ste. Anne-de-Bellevue, Quebec
CANADA H9X 1C0

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