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SCIENTIFIC PAPERS

OCCUPANCY AND SUCCESS OF NESTING TERRITORIES IN THE EUROPEAN SPARROWHAWK

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Abstract

Of 150 nesting territories occupied by European Sparrowhawks at least once in a five-year period, 82-110 were occupied in individual years. Certain territories were occupied more often, and others less often, than expected on a chance basis at the population levels found ($P < 0.001$). The most popular territories were those in which nesting attempts were most often successful ($P < 0.001$).

On particular territories, about 75 percent of all males and more than 50 percent of all females were replaced between one year and the next. This high turnover was due partly to movement, for at least 30 percent of all marked birds changed territories between years. Most individuals had different mates for each breeding attempt. Changes of females on territories occurred more often after unsuccessful breeding attempts than after successful ones ($P = 0.0025$), but changes of males occurred at the same high rate regardless of success or failure.

Introduction

For five years we have studied a population of European Sparrowhawks (*Accipiter nisus*) in southern Scotland. This paper reports on (a) the occupancy of particular nesting territories in relation to nest success and (b) the rate of replacement of territory owners from year to year. It is a preliminary analysis of work in progress, and both aspects will be developed and presented in greater detail in the future. The term "nesting territory" is used for the area around the nest that is defended and does not include more distant hunting areas. An "occupied territory" is one on which a new nest is built. A "successful nest" is one from which young fledged.

The study area of about 700 km^2 was centered on the River Annan in Dumfries County. It included a section of valley bottom and the hills on either side. The valley was up to 17 km across and presented a flat but varied landscape of mixed farms, woods, villages, and small towns. The hills around were mainly open and used for grazing sheep but also supported several large plantation forests. Sparrowhawks nested in both valley woods and hill forests but also hunted in other habitats, preying almost entirely on small birds. They were nonmigratory in this region, but at least some individuals deserted their nesting territories in the winter. Nonetheless, the same nesting territories were used in different years, but a new nest was usually built each time. In 1971-75 we believe we found every new nest in the study area, and from each we recorded success or failure (see Newton 1976 for methods and other details). On territories which lacked new nests, no indication at all was found that Sparrowhawks were present at any time during the breeding season. We also attempted on a number of territories to catch both birds each year for banding and subsequent recapture. We did it by putting a baited cage trap within 30 m of the nest tree, usually in the period before egg-laying.

Occupancy of Territories in Relation to Nest Success

In the study area as a whole, 150 nesting territories were used at least once in the five-year period, with 82-110 occupied in individual years. The breeding population declined between 1971 and 1975, but nest success fluctuated from year to year with no clear trend (table 1). The reasons for declining numbers and fluctuating success were not obvious, but neither could be attributed to direct human interference, which was slight (Newton 1976). Over the five years, some territories were occupied only once, and others two, three, four, or five times. We therefore asked whether occupancy of territories was random or whether preferences were apparent. This question was examined by calculating, for the population levels found, the expected number of territories that would be occupied one, two, three, four, or five times in the five years, assuming they were occupied on an equal chance basis. Then, the expected values were compared with the observed frequency of occupation (figure 1). The two distributions differed to a highly significant degree ($X_4^2 = 118.8; P < 0.001$). In particular, many more territories were occupied in only one year and in all five years than expected by chance. This finding suggests that Sparrowhawks avoided certain territories to some extent and favored others.

Their preferences were related to nest success. In table 2, territories were arranged according to whether they were occupied in one, two, three, four, or five years. The total number of breeding attempts in each category was calculated, together with the proportions of attempts that were successful. On the average, the most popular territories showed the greatest success. Table 2 also shows the expected number of successful attempts if all grades of territories had the same chance of success. Again the observed and expected distributions differed significantly from one another ($X_4^2 = 20.18; P < 0.001$). Evidently, the birds most often used those territories in which their chances of success were greatest. The question of what constitutes a good nesting territory is under investigation; one factor of obvious importance is the local food supply. In general, territories in small valley woods showed significantly better success than those in large hill forests (Newton 1976) where prey was shown to be scarcer (Moss 1976).

Turnover of Territory Occupants

Females proved easier to catch and provided larger samples than males. Also, on some territories we were unable to catch the occupants every year, but only at two-, three-, or four-year intervals. Our recaptures (table 3a) showed that of 20 territories in which males were caught at one-year intervals, they were different birds on fifteen occasions. Of 46 territories in which females were caught at one-year intervals, they were the same birds on only 21 occasions. For each sex a similar high turnover was also apparent for territories in which birds were caught at longer intervals.

That this turnover was not entirely due to mortality was evident from the records of particular birds (table 3b). Of 32 females caught at one-year intervals, 21 were on the same territory. Of nine caught at two-year intervals, seven had shifted. And of four caught at three- or four-year intervals, two had shifted. The samples for males were small, but showed similar movements between territories. At least 30 percent of marked birds moved from one year to the next. However, we could not estimate the true proportion because the chances of recapture were greater among birds that stayed than among birds that moved. Some may have left the trapping area completely. For this reason the data in table 3b are not strictly comparable with those in table 3a.

No bird was definitely known to occupy the same territory for more than three successive years, though two females were caught on the same territory four years apart. In one of these instances the territory had been used by different birds in the interim, and in the other the occupant had not been caught in the interim.

The distances moved in relation to distances between territories are shown in figure 2. For many birds the shifts between years represented more than a movement to a neighboring territory. Most territories in the study area were less than 1 km from their nearest neighbor, but most Sparrowhawks moved more than 1 km – up to 8.5 km. Opportunity to record long movements was limited by the extent of the study area.

Without a good estimate of adult mortality we could not calculate what proportion of pairs could remain intact from year to year. From five territories in which both partners were caught in different years and in which the female was the same both times, the male was the same in two. And of seven females that moved, and whose mates were caught both times, each time the male was different in the second year. Hence most birds had a different mate each year, and the two which kept the same mate were also on the same territory.

Turnover in Occupants in Relation to Nest Success

We next considered whether, on any given territory, a change of occupants was more likely to follow an unsuccessful (failed) breeding attempt than a successful one (table 4a). Of 12 successful nestings the same male remained the following year in only three of the territories involved. Of eight failed nestings, the same male remained in two territories (no significant difference). Of 34 successful nestings, the next year the same female was present in 20 territories. Of 12 failed nestings, the same female was present in only one. The difference was statistically significant ($P = 0.0025$, Fisher's Exact Test) showing that successful breeding attempts were less often followed by a change of female than were failed ones.

This result could be due to either greater mortality or greater movements among failed than among successful breeders (table 4b). Too few males were caught for analysis. However, of 28 females that bred successfully, the next year 20 were on the same territory. Of four females that failed, only one stayed on the same territory. The difference suggests that failed breeders moved more often than successful ones, but statistical significance was lacking ($P = 0.106$, Fisher's Exact Test).

Discussion

Sparrowhawks nested most often in those territories where breeding attempts were most often successful. The implications were that (a) not all territories were of equal quality, i.e., not all offered the same chance of successful breeding; and (b) the birds reacted to these differences and more often used the "better" territories. It is possible that birds competed for territories and that the best birds got the best territories. The observed nest success would then result from a combination of territory quality and bird quality and would accentuate any difference that might have arisen from territory quality (habitat) alone.

On any one territory a change of female was more likely to occur after a breeding failure than after a success. This result could have arisen either (a) because a high turnover of occupants and poor success were correlated or (b) because of a behavioral response –individuals were more likely to shift after a failed attempt than after a successful one. From the data available we could not distinguish between these possibilities.

We know of no other published work on the replacement rate of marked raptors on particular nesting territories, but Hammerstrom (1969) discussed the homing of Marsh Hawks *Circus cyaneus* to her study area in Wisconsin. As in *Accipiter nisus*, successful birds more often returned than failed ones, and mate fidelity was rare. The only other work known to us which related the occupancy and success of nesting territories is that of Hagar (1969) on Peregrines *Falco peregrinus.* His results parallel ours, with greater occupancy on cliffs where success was greatest. In Peregrines territory quality was associated with features of the nesting cliff itself and the degree of security it offered. Several other authors have related nesting success to local food supplies (see Date 1961 and Picozzi and Weir 1974 for *Buteo buteo*).

Acknowledgments

We are grateful to W. Murray for help in the field, to D. Moss for help with statistics, and to Dr. D. Jenkins for encouragement and criticism of the manuscript.

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Table 1. Occupancy and success of 150 nesting territories.

	No. (%) occupied	No. (%) which produced young
1971	110 (73%)	67 (61%)
1972	105 (70%)	56 (53%)
1973	94 (63%)	46 (49%)
1974	97 (65%)	63 (65%)
1975	82 (55%)	49 (60%)

Table 2. Success of nesting territories in relation to frequency of occupation.

No. years occupied	Total attempts observed	Observed number successful	Expected number successful
1	26	10 (38%)	15
2	58	23 (40%)	33
3	60	28 (47%)	35
4	124	79 (64%)	71
5	220	141 (64%)	127

Table 3. Turnover and movements of breeding sparrowhawks.

(Data are presented in terms of "bird-years" or "territory years." Individual birds or territories may thus figure more than once.)

a. Trapping results from particular nesting territories at intervals of one, two, three, and four years.

	One year		Two years		Three years		Four years	
	Same Bird	Different Bird	Same Bird	Different Bird	Same Bird	Different Bird	Same Bird	Different Bird
Males (n=28)	5	15	1	4	0	3	0	0
Females (n=75)	21	25	2	14	1	5	1	6

b. Trapping results from particular birds at intervals of one, two, three, and four years.

	One year		Two years		Three years		Four years	
	Same territory	Different Territory	Same territory	Different Territory	Same territory	Different territory	Same territory	Different territory
Males (n=10)	5	0	1	2	0	2	0	0
Females (n=46)	21	11	2	7	1	1	2	1

Table 4. Turnover of birds in relation to breeding performance.

a. Trapping results from particular nesting territories at an interval of one year.

	Male in next year		Female in next year	
	Same bird	Different bird	Same bird	Different bird
Nest successful	3	9	20	14
Nest failed	2	6	1	11

b. Trapping results from particular birds at an interval of one year.

	Male in next year		Female in next year	
	Same territory	Different territory	Same territory	Different territory
Nest successful	3	0	20	8
Nest failed	2	0	1	3

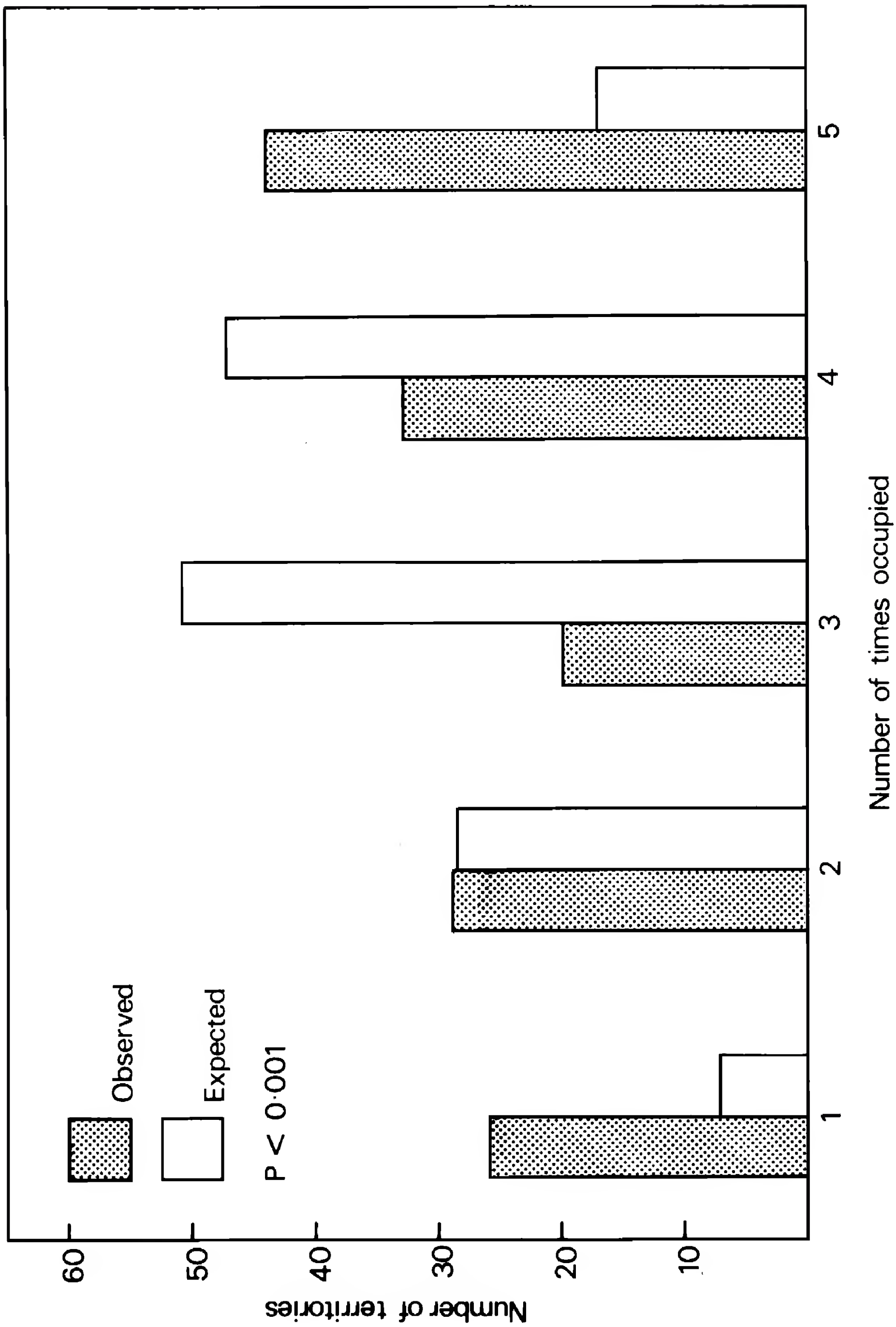

Figure 1. Observed and expected occupancy of Sparrowhawk nesting territories in a five-year period.

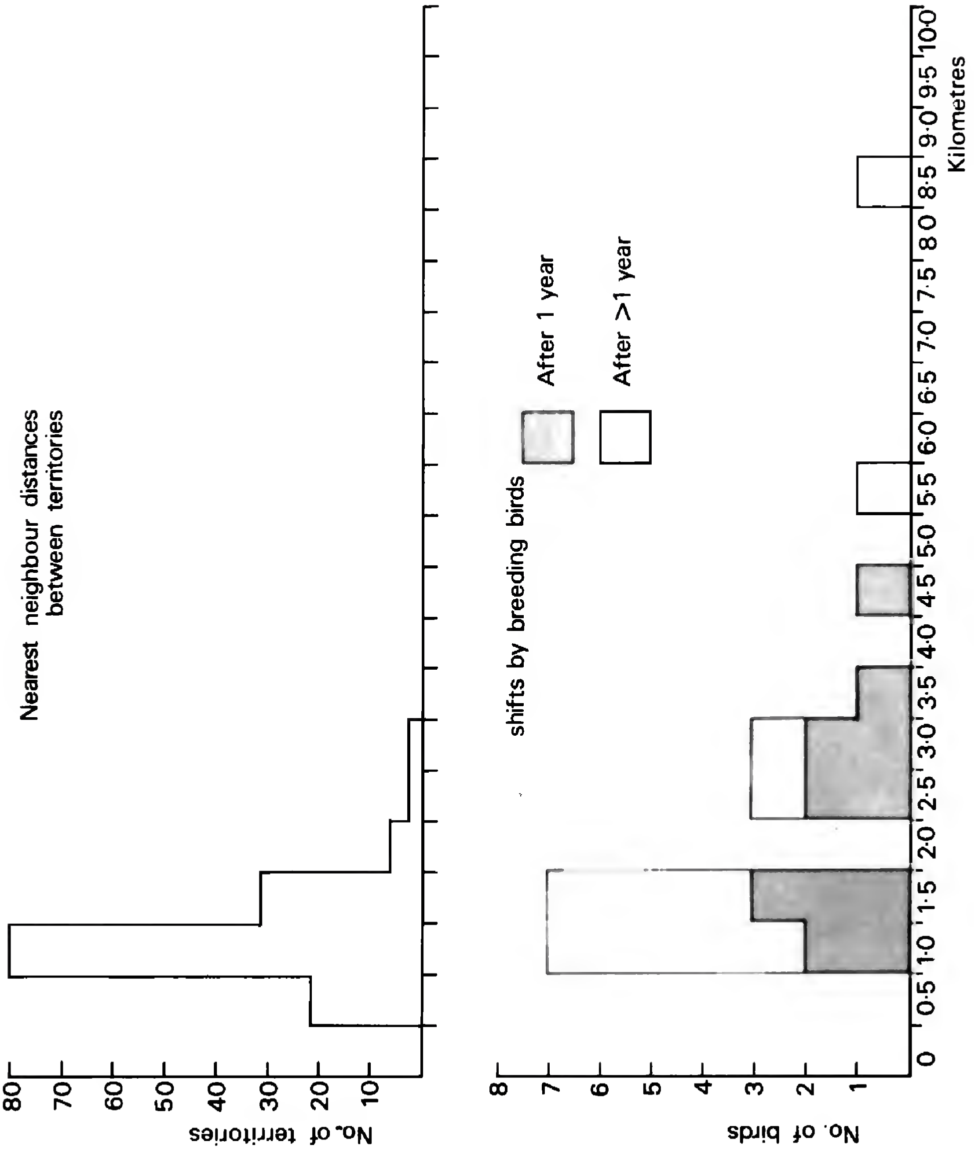

Figure 2. Movements made by breeding birds in successive years in relation to nearest neighbor distances between territories.

SOUTH AFRICAN SYMPOSIUM ON PREDATORY BIRDS

The Northern Transvaal Ornithological Society, a branch of the South African Ornithological Society, is planning a symposium on African predatory birds to be held at the Transvaal Museum, Pretoria, Republic of South Africa, August 29-September 1, 1977. The program is planned to cover any aspects of the biology or management of predatory birds. A day's outing to local areas of raptor concentration and an exhibition of paintings of predatory birds will be included. If you are interested in attending the symposium, contact Mr. T. C. van Eeden, Hon. Secretary, NTOS, P.O. Box 4158, Pretoria 0001, Republic of South Africa. If you would like to present a paper at the symposium, also contact Dr. A. C. Kemp, Transvaal Museum, P.O. Box 413, Pretoria 0001. Further details can then be sent to anyone who is interested.

PUBLIC EDUCATION INFORMATION EXCHANGE COMMITTEE

In 1975 at the RRF meeting in Boise, Idaho, a resolution was unanimously passed to initiate the formation of a special committee concerned with education of the public on raptor conservation. Some of the intended goals include the production of an official RRF pamphlet and questionnaire dealing with public education, a centralized catalog of slides of raptor material, and, perhaps, a raptor coloring book for children.

There will be no membership list as notice of available educational material will be sent to all RRF members. However, if you are interested in serving on the public education committee, please send your name, address, and pertinent talents to David M. Bird, Macdonald Raptor Research Centre, Macdonald Campus of McGill University, Quebec HOA 1CO.

THE HAWK TRUST OF ENGLAND

Many of us involved in raptor work in North America are unaware that another raptor organization composed of roughly 600 members exists in Great Britain. The Hawk Trust of England is presently involved in captive breeding, public education, and wardening of eyries of endangered birds of prey. All members receive an annual report and newsletters concerned with international raptor news. If you are interested in further information, please contact David M. Bird, Macdonald Raptor Research Centre, Macdonald Campus of McGill University, Quebec HOA 1CO, or write to Caroline Hunt, P.O. Box 1, Hungerford, Berkshire, Great Britain.

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THE GATHERING OF NESTING MATERIAL BY OSPREYS

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The nest of the Osprey (*Pandion haliaetus*) is composed primarily of large sticks (usually 0.5-1.5 m in length). The sticks are picked up off the ground, or dead limbs are broken from trees while the Osprey is in flight. Although breaking sticks from trees is a well-documented behavior of European Ospreys (e.g., Waterston 1961, Green 1974), it apparently has not been observed often in the United States or Canada. Brown and Amadon's report (1968: 199) that Ospreys take sticks from trees and less often from the ground seems to be based on observations of European Ospreys, judging from their bibliography. Chapman (1908) mentions that Ospreys on Gardiner's Island, New York, broke sticks from trees, and Bent (1937:354) cites Wheelock's report of similar behavior for Ospreys in California. However, Ames (1964) says that he has never seen the behavior and suggests that it occurs rather infrequently. This note comments on the frequency with which Ospreys gather nesting material in the United States by taking sticks directly from trees.

From 2 June through 10 July 1975 I observed Ospreys with unfledged young for 252 hours in York and Mathews counties, Virginia. Sticks and nest-lining material (usually clumps of eelgrass [*Zostera marina*] picked up from the shore) were brought to the nest throughout the summer. Males brought 44 sticks and 12 clumps of eelgrass to their nests. I saw the males collect 3 of the sticks; 2 were pulled from trees, and the other was picked up from the ground. Females brought 41 sticks and 27 clumps of eelgrass to their nests; I saw 3 sticks collected, and all were pulled from trees. Additionally, on 3 May 1975 I observed a male and a female Osprey pulling sticks from pine snags after high winds had damaged many nests in the region. If the instances when I have observed Ospreys gathering sticks are indicative of Ospreys' behavior in general, then a substantial portion of the sticks carried to the nest must be pulled directly from trees.

I thank Mitchell A. Byrd and John C. Ogden for their critical reading of an earlier draft of this note.

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FOOD-CACHING BEHAVIOR IN OWLS

by
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Abstract

Captive individuals of several species of tytonid and strigid owls have been observed to cache excess food items. This activity appears to differ from the frequently recorded stockpiling of food items at nest sites in that individual items are carefully hidden, generally in separate places, and subsequently retrieved. It appears to be an adaptive strategy for the nonnesting season.

Excess uneaten food items have been recorded at nest sites of numerous species of owls of both the Tytonidae and Strigidae (Bent 1938, Ligon 1968, Höglund and Lansgren 1968, Kaufman 1973, pers. obs.). Most prey items were vertebrates, but in at least one case an accumulation of invertebrates was reported (Ligon 1968:32). Such stockpiling of food is thought to be a response to perhaps localized or temporary abundances of food rather than to the surplus killing reported for other types of carnivores (Kruuk 1972). Caching of food where prey items are actively concealed rather than simply stockpiled at a nest or nest cavity has been less often recorded. The following observations on captive individuals seem to be instances of such food caching.

On several occasions during March 1963, I observed an adult female Hawk Owl (*Surnia ulula*) tethered to an indoor log perch apparently caching food items. In each case, partially eaten rats (*Rattus* and *Sigmodon*) and mice (*Peromyscus*) were pushed against the baseboard of a nearby wall or against the base of the perch, an indication that they had been placed there, and not casually or accidentally dropped in that position.

This conclusion was confirmed by the following observations summarized from my notes made on 2 March 1963. At approximately 0945 the Hawk Owl picked up one of two mice (*Peromyscus floridanus*) given it an hour earlier and ate the head and one forelimb. The owl then hopped off its perch, carrying the mouse, and approached the wall about four feet away. The mouse was laid belly down on the floor near the wall and nudged several times with the beak to push it tight against the baseboard. The owl then returned to the perch, looked intently at the clearly visible "cached" prey, and then settled down quietly facing another direction. As also noted by Tordoff (1955), the actions during food caching "could best be described as furtive." The second mouse was partially eaten around 1130 and then cached against the base of the perch. The remains of both mice were eaten by 1800 that same day.

Great Horned Owls (*Bubo virginianus*) were watched caching food under more natural conditions (J. Aron pers. comm.). Throughout the spring of 1972 a pair of these owls were maintained in a 20' x 12' x 6' enclosure. Starting in mid-May two owls approximately two weeks old were also housed in the same cage. After 6 weeks, when food was placed in the enclosure, the adult female quickly fed herself and then began to feed the two young owls. When the young owls were satiated and no longer begged for food, the female began to take food items to various parts of the cage and cache them. At first, items were simply placed against the base of the cage in a remote corner. Subsequent food items, including small rats (*Rattus*) and mice (*Mus*) and pieces of chicken neck, were placed under or behind rocks or logs.

No more than one food item was ever cached at any one location by the Great Horned Owls. Only the beak was utilized to position the food item in the hiding place. A thorough visual inspection by the owl usually followed, and on several occasions food items were retrieved only to be cached again at a new location. In one instance, when an observer attempted to remove a cached food item, the female flew to the site, fluffed out her feathers in a threat posture, and excitedly clacked her beak. When the observer left, she quickly retrieved the food item and concealed it elsewhere in the enclosure. Despite the care taken by the owl in caching food items, few were left for any length of time, and all were consumed within 12-24 hours.

When the two young owls were 20 weeks old, and several days after the adults had been removed, they also showed food-caching behavior. Food items were simply shoved into a hole at the back of the cage or placed against the sides of the cage. However, unlike the adult female, the young birds never went back to utilize the cached food, perhaps because they had an ad libitum food supply.

Observations by Kaufman (1973) of nonbreeding captive Barn Owls (*Tyto alba*) indicated that when excess food in the form of live mice was supplied, all the mice were killed, and most were "stockpiled" at nine locations in the pen. Unlike the other owls which carefully hid each item in a separate location, the Barn Owls placed from two to four mice at each location. In this respect their behavior was more similar to the stockpiling of prey at nests than to the food caching reported here.

Food caching by a captive Saw-whet Owl (*Aegolius acadicus*) was reported by Bendire (1877 in Bent 1938:234). Mumford and Zusi (1958:190) saw a Saw-whet Owl on winter territory retrieve a decapitated mouse which it had left on a branch. This observation might be taken as evidence that food caching occurs in free-living owls and is not strictly an artifact of captivity. It is also possible that it was simply a case of a raptor's returning to a kill which was not wholly consumed at the first meal. The furtiveness usually associated with caching behavior makes it unlikely that caching would be observed frequently in the wild.

Mueller (1974) observed caching by five species of owls in captivity and suspected that caching is found in most species of owls. Food caching has been reported for a wide variety of other birds, particularly members of the Corvidae (Simmons 1968, Croze 1970, Chisholm 1972, Balda and Bateman 1972).

Among the falconiforms it appears to be uncommon in the Accipitridae but well known for members of the genus *Falco* (Beebe 1950, Mueller 1974). The most detailed accounts are those of Tordoff (1955) and Mueller (1974) who observed food caching in the American Kestrel (*Falco sparverius*).

Tordoff's observations of free-living and captive individuals indicated the same use of both ground and elevated storage sites, furtiveness associated with the storing activity, belly-down placement of the prey item, and close visual scrutiny of the storage site characteristic of the above observations of owls. Mueller's (1974) experiments with captive American Kestrels indicate that caching behavior was correlated with deprivation interval but did not exhibit a circadian rhythm. Retrieving of cached food items was both frequent and accurate. Caching behavior appeared spontaneously in hand-reared birds as similarly noted here for the young Great Horned Owls.

The capacity to exploit brief or seasonal abundances of food would be clearly adaptive to most birds, particularly carnivores. Simply stockpiling excess food at the nest, which is usually actively defended, may suffice during the nesting season. At other times of the year concealing individual food items in separate locations would decrease the possibility of their being stolen by individuals of the same or other species, thus making food caching an adaptive strategy.

I am grateful to Jim Aron for contributing his observations to this study.

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DUKE AND REDIG RECEIVE PRESTIGIOUS AWARD

Dr. Gary E. Duke and Dr. Patrick Redig, both of the College of Veterinary Medicine, University of Minnesota, received a joint American Motors Conservation Award on November 23, 1976. Presentation was made at the Fall Awards Convocation of the Veterinary College. The citation states in part:

"Duke and Redig are among seventeen men and five women from seventeen states named to receive 1976 Conservation Awards. They have been presented annually since 1954 to professional and nonprofessional conservationists for outstanding contributions in the field of renewable natural resources. Winners receive bronze sculptured medallions and honorariums of $500.

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THE USE OF A ROTOR-WINGED AIRCRAFT IN CONDUCTING NESTING SURVEYS OF OSPREYS IN NORTHERN IDAHO

by
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Abstract

Use of a helicopter to collect data on active nests, clutch sizes, hatching successes, and nestling counts of Ospreys nesting in northern Idaho are described. This method is economically practical, allows for the collection of nesting data over a large area in a short period of time, and enables researchers to collect data impossible to obtain by other methods. No adverse effects to the nesting success of this population were noted. Productivity levels were essentially equivalent to those of past years. Disturbance, reaction of adults, visibility of eggs and nestlings, costs, and validity of data are discussed. Recommendations are offered for future aerial surveys of nesting Ospreys.

Introduction

Lake Coeur d'Alene (130 km^2), Lake Pend Oreille (390 km^2), streams flowing in and out of the two lakes, and small adjacent lakes provide suitable habitat for a large Osprey (*Pandion haliaetus*) breeding population. Research efforts have continued since 1970 to identify the structure, size, and nesting success of this Osprey population (Schroeder 1972, Melquist 1974). Nesting data have been collected on 204 different pairs of Ospreys within the study area. Nesting surveys were conducted on foot, with vehicles, and by boat. Accessibility and observation of many nests were limited, often making data collection difficult and time consuming. Inspection of many of these nests was prohibited by their construction in dead or dying trees, most of which were unsafe to climb (fig. 1). As a result, clutch size and hatching success were determined for only a small number of nests. It is likely that an occasional nestling was not counted during the productivity survey because of the difficulty in observing certain nests. During the 1975 nesting season, we attempted to alleviate these problems, decrease the time factor involved in collecting data, and gain more inclusive data by using a rotary-winged aircraft (helicopter).

White and Sherrod (1973) reported on helicopter use for aerial surveys of raptors nesting on cliffs or hillsides in open terrain, but not of tree-nesting species. This paper describes the use of a helicopter in collecting data on Ospreys nesting primarily in trees. We hope this information will benefit other researchers who might consider using a rotary-winged aircraft in conducting similar raptor surveys.

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DUKE AND REDIG RECEIVE PRESTIGIOUS AWARD

Dr. Gary E. Duke and Dr. Patrick Redig, both of the College of Veterinary Medicine, University of Minnesota, received a joint American Motors Conservation Award on November 23, 1976. Presentation was made at the Fall Awards Convocation of the Veterinary College. The citation states in part:

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"Dr. Duke, a professor of physiology, and Dr. Redig, a veterinarian, are making a major contribution to understanding and preservation of birds of prey and other large nongame birds through establishment of a unique rehabilitation clinic at the University of Minnesota. They have combined their skills in physiology, surgery, and pharmacology in the treatment of hundreds of sick or injured birds, ranging from eagles to falcons to many other kinds of raptors."

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Methods

A turbocharged Bell 47G-3B-1 helicopter was used for the surveys. It seats a pilot and two passengers. As a high performance aircraft, the Bell helicopter can maneuver in the difficult situations often encountered in this type of survey.

The study area was divided into two watersheds: Coeur d'Alene and Pend Oreille. Because only one watershed could be flown per day, a complete survey of the nests in the study area required two days. Two surveys were made during the nesting season: one in mid-May to determine clutch size and to count active and occupied nests (activity survey), and a second in mid-July to determine nesting success and to count nestlings (productivity survey). Flights began at midmorning and ended when the watershed was satisfactorily surveyed. Each required approximately four hours of flying time. Tentative flight plans were laid out prior to each flight in order to reduce unnecessary flying. Some in-flight adjustments were necessary owing to refueling needs and unfavorable weather (wind) conditions.

To facilitate maneuverability and control of the helicopter, we approached nests into the wind whenever possible. One observer kept watch on the location of the adult birds while the other observer recorded clutch sizes and nestling numbers. White and Sherrod (1973) advise approaching from upwind as birds flushed into the wind may wing back into the helicopter. We did not experience this problem while approaching from downwind, possibly because the helicopter air speed was practically zero near the nest.

Disturbance

In order to collect certain kinds of data, it is inevitable that nesting Ospreys will be disturbed, whether the survey is conducted from an aircraft or by other means. Fortunately, the Osprey is very tolerant of human disturbance. In 1972, a nest constructed on a railroad bridge crossing the Pend Oreille River was successful, even with trains passing at frequent intervals below (Melquist 1974). Numerous other nests located within 50 m of where hundreds of recreational boats pass during the breeding season are consistently successful. The possibility seems remote that our activity caused nest desertion.

Several pairs had not commenced egg-laying when we flew the activity survey, yet they were quite aggressive. This period is critical for some species of raptors which will often abandon the nesting attempt if disturbed (Bloom 1974). None of these pairs abandoned their nests.

When approaching an Osprey nest, we have always observed that the incubating birds stand up before flying from the nest (fig. 2). Because of this behavior and the depth of the nest bowl, it is highly unlikely that eggs would be dragged from the nest during hasty departures. However, the observation of a nest containing three eggs, where one egg was situated at the edge of the nest, suggests that eggs can be and are displaced at times.

Osprey nests are normally located so that it is difficult to surprise the birds by a sudden appearance. The approaching aircraft is usually detected by nesting birds long before they become alarmed. Under these circumstances, there is little chance that the incubating bird will puncture or break an egg when leaving the nest.

Both surveys were made during favorable weather conditions. This procedure is important to the welfare of the passengers, as well as decreasing the possibility of eggs being chilled or nestlings suffering heat prostration. The short period of time that the adults were kept from the nest (usually under one minute) had no apparent detrimental effect on the nesting effort.

The second survey was conducted when nestlings were near fledging age. This check was to determine productivity: number of young fledged per active and occupied nest. The flight was made when most nestlings were near fledging age in order to reduce the possibility of nestling mortality following our count. Even with the nestlings almost fully grown, the approach of the helicopter and alarm call from the adults resulted in the typical response of the young's lying motionless in the nest. As a result, we did not cause premature fledging at any nest. At this age, should the nestlings stand up and spread their wings in a defense posture–as they normally would do when investigators climb to the nest–there would exist the possibility of blowing them from the nest with the draft created by the rotor.

Reaction of Adults

During the activity survey in May, incubating birds usually flushed when the helicopter approached within 50 m of the nest. Typically they would circle above or to the side of the helicopter. Occasionally an Osprey (usually the female) would fly directly toward the helicopter, veering off well in advance of a collision. Most birds returned to the nest immediately after the helicopter departed. When a second approach to the nest was necessary, the birds always managed to keep a safe distance from the rotor. Only twice during the activity survey did a bird appear to be in danger of being struck by the helicopter. One near miss was due to the helicopter's rising in the direction of an undetected bird hovering above. The other occurred when an Osprey rose up from below into the flight path. A quick maneuver by the pilot prevented a collision in each case.

On several occasions, incubating birds exhibited a great deal of nest tenacity. Several could not be flushed off of the eggs, despite a close approach, and vigorous, noisy tactics. As a result, clutch-size data could not be obtained from these nests. "Prop wash" had no effect on the nest structure and did not disturb the eggs.

White and Sherrod (1973) state that Peregrine Falcons (*Falco peregrinus*), Bald Eagles (*Haliaeetus laucocophalus*), and Gyrfalcons (*Falco rusticolus*) have been noted to attack helicopters. According to Don Jenni (pers. comm.), Ospreys were prone to attack a helicopter during a survey along the Clearwater River in north central Idaho. Our experience suggests that adult Ospreys are most aggressive during the time nestlings are very young. As nestlings mature, the adults become less aggressive. Since the productivity survey was conducted when most nestlings were quite large, the only problems with aggressive parents occurred at sites where the birds either nested late or renested, and the nestlings were still quite young.

Visibility of Eggs and Nestlings

Determination of clutch size was relatively easy since most eggs were readily visible through binoculars or with the naked eye. Heavily pigmented eggs occasionally made determination of clutch size more difficult (fig. 3). Because of the helicopter vibrations, egg counting was often easier without binoculars.

Nestlings were more difficult to count because of the cryptic coloration of juvenile plumage. Nestlings respond to the adult's alarm call by lying motionless in the nest. Young birds less than five weeks of age were the easiest to see since the white down feathers of the spinal tract were easily visible (fig. 4). As the birds grow older, cryptic contour feathers made them more difficult to see.

Costs

Helicopter rental is quite costly. However, the reduction in time, greater validity of data, as well as increased quantity of data acquired offset this cost. Approximately 16 hours of flying time were required to complete both the activity and productivity surveys (less time if clutch size is not desired). In order to conduct the same surveys by foot, boat and vehicle, at least 28 man days and 8,000 vehicle miles would have been necessary, and less data would have been obtained. We believe the use of an aircraft is, therefore, easily justified (see table 1).

Validity of Data

The use of a helicopter provides a means of obtaining a larger sample size and also increases the precision of the data. With the helicopter we were able to collect data normally unavailable by previous methods. Clutch size data for all but a few nests are impossible to obtain without an aircraft, because of the extreme height of most nest structures and depth of the nest bowl. Without clutch size data, hatching success cannot be determined.

Nestling counts are time consuming without an aircraft (Johnson and Melquist 1973). If the adult birds are alarmed by the observer's presence, the nestlings respond by lying motionless in the nest and cannot be seen. In the past, as much as one hour was required at a single nest to successfully count all the nestlings. Additionally, nestlings that hatched late were even more difficult to see. Repeat trips to such nests must then be made if good reproductive data are to be collected.

Conclusions

The use of a helicopter for collecting Osprey reproductive data provides reliable data and safety to nesting birds and their young. In addition, it is usually less expensive than other sampling methods. No indications of reduced productivity due to nest desertion, disturbance, damage to eggs and/or nest, or increased predation occurred as a result of its use. Productivity levels were essentially equivalent to those of past years. Clutch size for 117 nests averaged 2.79 eggs per nest. In 1972 and 1973, clutch size for 29 nests was 2.80 eggs per nest (Melquist 1974). The use of a helicopter has, therefore, substantiated data previously collected by normally less effective methods. Finally, the use of a helicopter has allowed us to collect these data over a shorter period of time, thus increasing the accuracy of the results.

Recommendations

Low-power binoculars (less than 7X) are recommended for use in helicopter surveys to minimize the effects of vibration.

Observation of eggs and nestlings is easier with the doors off the helicopter.

To minimize the possibility of egg and nestling mortality from exposure, flights should be avoided during inclement weather.

Flights should be made during times of reduced wind (usually in the morning). Because of turbulent air conditions in late morning and early afternoon, close observation of certain nests may be impossible.

Although we did not experience any problems, discretion should be used when approaching occupied nests where egg-laying has not commenced, in order to avoid possible nest abandonment.

To further reduce costs, a fixed-wing aircraft could be used to determine nest activity during the mid-May activity survey. A helicopter would be necessary for those surveys where clutch size and hatching success data are essential. The cost of a fixed-wing aircraft is approximately 25-35 percent of that of a helicopter, and the greater air speed of fixed-wing aircraft would be advantageous for extensive surveys. Incubating Ospreys are rather easily detected on the nest, even at elevations of 50-75 m; thus, disturbance to nesting birds by fixed-wing aircraft would be minimized. We believe, however, that nestling counts cannot be made with reliability from a fixed-wing aircraft.

Acknowledgments

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Table 1. Cost comparison of Osprey activity and productivity surveys: 1974 and 1975.

1974 estimated costs–vehicle, boat, foot survey	
Man days–1 observer for 28 days @ $52.50 per day	$1,470.00
Vehicle mileage–8000 miles @ .15 per mile	1,200.00
Boat rental–10 hours @ estimated $5.00 per hour	50.00
Subsistence–Lodging and meals for 10 field days	250.00
Total	$2,970.00
1975 actual costs–helicopter surveys	
Man days–2 observers for 4 man days each @ $63.00 per man day	$ 504.00
Helicopter costs–Approximately 16 hrs. @ $145.00	2,320.00
Subsistence–No cost	– –
Total	$2,824.00

Figure 1. Osprey nest in cottonwood snag on St. Joe River, Idaho.

Figure 2. Incubating Osprey standing at nest edge as helicopter approaches.

Figure 3. Osprey eggs showing pigment variation.

Figure 4. Opsrey nestlings showing white vertebral stripe.

BALD EAGLE REHABILITATION TECHNIQUES IN WESTERN WASHINGTON

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Abstract

A technique is described for returning injured Bald Eagles (*Haliaeetus leucocephalus*) to the wild. Criteria for judging whether an eagle is capable of release are discussed. The movements of several successfully released eagles are described, together with the advantages of winter release. A survey of zoos and government facilities in the United States shows that at least 44.4 percent of all captive Bald Eagles suffer from man-caused injuries.

Introduction

In many areas of the United States and Canada the Bald Eagle (*Haliaeetus leucocephalus*) population has undergone a decline since the 1940s (Broley 1951, 1958; Sprunt 1969; Sprunt et al. 1973, Grier 1974; Weekes 1974). This decline has been attributed to several factors, including the destruction and elimination of habitat, the effects of pesticides, and the continued shooting of eagles by irresponsible persons.

Many eagles that have been shot are not initially killed and are brought to zoos and other facilities for care and treatment. In 1975 we surveyed 52 zoos and government facilities concerning the number of Bald Eagles in captivity and the injuries and origin of each eagle (table 1). The 27 replies indicated that at least 92 Bald Eagles were in captivity in the United States. Of these, at least 41 (44.4 percent) were in captivity on account of man-caused injuries, and at least 31 (36.0 percent) had been shot.

There is a need to return to the wild eagles that have recovered and are capable of surviving. This paper deals with the techniques developed and used successfully to release rehabilitated Bald Eagles in western Washington.

Methods

Of the twelve injured Bald Eagles received from 1972 to 1975 at the Seattle Woodland Park Zoo, six have been returned to the wild. Eagles were judged releasable according to (1) proper wing condition and use, (2) flight and tail feather regrowth or potential regrowth, and (3) proper foot and leg condition and use. The possible cumulative effect of several small injuries on the potential survival of the eagle was considered in each case.

Feather damage was often present and was usually due to improper handling prior to arrival at the zoo and/or as a direct result of the injury. When flight feathers were broken or damaged, they were repaired by imping. If the feather follicle or blood supply was damaged, the eagle was held through one molt. Then, if follicle damage was permanent in the large flight feathers and would inhibit flight, the eagle was not released.

Eagles with broken legs were released if the leg was usable after healing and there was no tendon damage. Criteria used to judge leg function were the ability to place full body weight on the leg and the ability to grasp effectively with the foot of the injured leg. Missing toes were not cause for permanent captivity unless more than two toes were missing on one foot.

All eagles were released on the Skagit River near Rockport, Washington, a traditional wintering area for Bald Eagles. About 100 to 180 Bald Eagles winter there each year, and the area is now protected as an eagle sanctuary by the Nature Conservancy and the Washington Game Department. Bald Eagles are attracted there by large numbers of salmon that spawn and then die in the river each year (Servheen 1975). Rehabilitated eagles are usually released in December and January when salmon carcasses are most abundant.

Eagles are fed salmon for at least 2 weeks prior to release to condition them to their coming food source. At the Seattle Zoo, eagles are held in flight cages in groups of up to five. Every effort is made to keep the released eagles as wild as possible. Handling is minimized to prevent trauma, and eagles are not trained through falconry techniques. The flight cages are shielded from public view except for small viewing ports. Thus, contact with humans is reduced.

Just prior to release orange patagial tags, radio transmitters, and Fish and Wildlife Service riveted aluminum bands are placed on each eagle. Radios are mounted either as backpacks or as tail-feather mounts. When an abundant supply of salmon carcasses is available in the release area, as verified by field checks, the eagles are hooded and wrapped to prevent injury and are transported to the Skagit site. They are released on a gravel bar where food is plentiful and human disturbance is minimal. The eagles are actually released on a bar away from open water so that there is a reduced possibility that they will attempt their initial flight over water.

They are monitored closely for several weeks to observe their adaptation to the wild and their movements in the area. Food availability is also monitored during this initial period, and, if it becomes low, salmon carcasses from the state salmon hatchery are distributed. Notices are sent throughout western Washington and British Columbia describing the project and encouraging the public to become involved by reporting sightings of the released eagles.

Results

Six Bald Eagles have been released in the past 2 years using these rehabilitation methods. All have apparently returned to the wild successfully and have left the release area. Long-term followups have not been possible, but the data obtained represent a large measure of success.

The first eagle, released 3 January 1975, stayed in the immediate release area until 19 January, when it moved 2 miles upriver. It was next seen on 26 February 1975, 14 miles from the release site. It was last seen on 5 March 1976 south of Bellingham, Washington, approximately 45 air miles west of the release site.

The second eagle released was initially found in the Skagit area suffering from a gunshot wound in the right pectoral muscle area. The bullet had not broken any bones and had exited without entering the body cavity. This eagle was released on 25 February 1975, just 2 weeks after it was shot. It lost 24 ounces in the 2 weeks of captivity even though it ate salmon during that time. This eagle remained in the release area for 6 days, left abruptly, and was not seen again.

On 5 January 1976, four eagles were released. Some of them were regularly seen within twelve miles of the release site until 12 March. On 18 March one was seen on San Juan Island, approximately 65 air miles west of the release site. This eagle was seen regularly on San Juan until 25 March. On 18 May one of the four was seen on Orcas Island, approximately 18 miles northeast of the San Juan sightings. It is possible that it was the bird seen on San Juan. All these eagles appeared healthy and were able to fly proficiently as evidenced by their movements over large areas of open water on Puget Sound. The last eagle of this group seen in the release area was observed on 29 March several miles east of the release site.

Because wintering Bald Eagles on the Skagit are gregarious at feeding and roosting sites (Servheen 1975), we were concerned with the potential effects of brightly colored patagial markers on the behavior and acceptance of the released eagles by the wild population. Special attention was given to observing the behavior of wild eagles that came in contact with the marked birds. No behavioral abnormalities were noted among either the marked or the wild eagles as a result of the patagial markers. Marked eagles interacted normally with wild eagles at feeding areas, and marked and wild eagles perched and roosted side by side.

The released eagles differed in their ability to adjust to freedom. The difference was probably due to individual variation and the amount of time the bird had been in captivity. Most of the eagles fed on salmon soon after release, in some cases within 1-2 hours. All eagles bathed soon after release. Some birds attempted to fly immediately, and others did not move for several days from the gravel bar where they were released.

All eagles displayed a marked reduction in flight ability upon release, mainly due to loss of muscle tone in captivity. The eagles usually misjudged the distance and height they could fly on initial flights and landed in the river or in the brush below or short of intended perches. No injuries resulted, however. Human activity and interference was minimal in the release area, so the eagles were not in danger while they were there. Flight ability rapidly improved with exercise, and usually within 3-4 days the eagles were perching in trees 10 to 15 meters above the ground.

Conclusions

Success of this rehabilitation technique depends on the availability of abundant, easily obtained food in the release area and a minimum of human disturbance when the eagles are regaining their powers of flight, allowing them to develop muscle strength at their own pace.

Release in a wintering area eliminates dangers of territorial aggression from resident adults and allows the rehabilitated birds to learn secure feeding and roosting sites by following the wild population. Since the rehabilitated eagles are released several months before the abundant food supply dwindles, they have sufficient time to develop the strength and skill to compete in the wild state once again.

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Table 1

A sampling of Bald Eagles in captivity in the United States classified by injury and cause of injury [1]

Injury	Cause of Injury	Number
Broken wing	Shot	33
Flesh wound	Shot	1
Broken wing	Hit by car	1
Broken wing	Fell from nest	1
Broken wing	Unknown	14
Injured wing	Powerline	1
Broken leg	Fell from nest	1
Puncture wound	Unknown	1
Injured body	Hit by airplane	1
Poisoned	Unknown	2
Injured leg or foot	Animal trap	3
Blind in one eye	Unknown	1
Infection	Unknown	1
No injury	----	23
Captive raised	----	8
Total number of birds		92

[1]Of the 52 zoos and facilities questioned, 27 replied.

WILD RED-SHOULDERED HAWKS READILY ACCEPT ADDITIONAL NESTLINGS

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Construction of a dwelling immediately adjacent to a Red-shouldered Hawk (*Buteo lineatus*) nesting site in central Maryland necessitated the removal of three large, downy young. These nestlings were subsequently placed into two active nests of this species located 19 km (12 mi) east of the donor site.

The initial transplant involved a nestling found uninjured beneath its nest on 9 May 1976 and held in captivity until 11 May. At 24 days of age, this hawk was placed into another nest containing two nestlings, 13 and 17 days old. In the second transplant, the remaining two young were removed from the donor site on 11 May at 22 and 26 days of age. These were placed into a foster-parent nest with a single 23-day-old nestling.

The first nestling was observed being fed by an adult on 12 May. Acceptance of the two new young at the other nest was equally rapid. Weights and wing measurements taken at that nest on 17 May showed that all three nestlings were growing normally. Occasional visits were made to both sites through 3 June. On that date both nests were occupied by only one young although two fledglings were observed flying from the first nest. Both nests were empty on 7 June, and it appeared that all six young had been raised successfully. We have found a few natural nestings in which the siblings were separated in age by as much as 11 days, but it usually occurs when four or five eggs are laid. Often not all survive in such large broods.

Interest in fostering and cross-fostering raptor eggs and nestlings has gained prominence during recent years both as a research technique and as a method of maintaining or restoring threatened populations. Our experience with the Red-shouldered Hawk indicates that fostering is a practical technique for use where such young cannot be reared to fledging by their parents.

LEG-LOWERING BEHAVIOR OF RAPTORS DURING STATIONARY FLIGHT

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On 16 September 1975, while watching for migrating raptors, I observed two adult Red-tailed Hawks (*Buteo jamaicensis*) flying south above a series of north-south ridges near the foothills of the Front Range of the Rocky Mountains east of Lakewood, Colorado. The wind, from the northwest at 19.5 km/hr as measured by a hand-held anemometer, struck the ridges, creating strong upcurrents along the windward side. One of the hawks turned into the wind over the crest of a ridge, partly folded its wings, and lowered its pitch to about 20° below the horizontal. The force of the upcurrents caused it to be blown backwards along its path for about 1 m, after which it lowered its legs. This action caused the hawk to remain stationary with respect to the ground, but the position differed from hovering in that the wings were held in a semifolded position, not flapped, and the tail was folded, not fanned.

The hawk remained stationary with its legs extended for about 1 minute and scanned the hillside below before folding its wings more and diving. The dive was not completed, and the hawk raised its legs and turned to fly south along the ridge.

Pennycuick (*Ibis* 114:190) observed vultures lowering their legs in order to keep from being carried too high while flying through strong, closely spaced thermals. Lowered legs increase the drag and sinking speed of birds. The Red-tailed Hawk was probably using the same method to keep from being blown away from the ridge by the upcurrents while he hunted the hillside.

The only other published record I have found of a raptor lowering its legs in flight was a note (Conner, *Bird Banding* 45:269) on Red-tailed Hawk courtship behavior. Subsequently I have seen other Red-tailed Hawks, a Ferruginous Hawk (*Buteo regalis*), a Golden Eagle (*Aquila chrysaetos*), and American Kestrels (*Falco sparverius*) lower their legs while flying stationary under circumstances similar to those described above. This behavior appears to be fairly common among raptors but has not been well documented.

OSPREY INCUBATION TEMPERATURES: STUDIES WITH A TELEMETERING EGG

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Varney and Ellis (1974) described the construction of a radio-telemetering "egg" which could be used to study aspects of the incubation and nesting biology of large, free-living birds. The radio-egg could transmit information about its surface temperature, internal temperature, and whether or not light was reaching a surface photoelectric cell. Here we report the results of a study using similar radio-eggs to investigate aspects of the incubation biology of the Osprey (*Pandion haliaetus*).

Using the plans of Varney and Ellis (1974), two transmitters were built (by GB). The transmitters were set into domestic duck (*Anas platyrhynchos*) eggs which were then painted to resemble Osprey eggs. The signals from the radio-eggs were experimented with in the laboratory to establish how different temperatures and light conditions affected the signal printout. Multiple regressions of the laboratory data were calculated on the College of William and Mary's IBM 370 computer using the program in the Statistical Analysis System (Barr and Goodnight 1972). Deterministic equations were constructed which related the signal printout to the temperature and light conditions stimulating the radio-egg.

On 6 May 1975 a radio-egg was placed in a nest containing three natural eggs on a pier at Cheatham Annex Naval Supply Station near Williamsburg, Virginia. On 13 May the radio-egg was found to be malfunctioning because of battery failure and was replaced with the second radio-egg. Additionally, the Ospreys had moved the loop antenna from around the cup of the nest to the edge of the nest where it was not picking up any radio signals. The loop antenna was replaced around the cup of the nest, where the Ospreys left it for the duration of this study. On 27 May the nest had two chicks 1 and 3 days old, a natural egg which subsequently hatched, and the radio-egg; the radio-egg and antenna were removed from the nest. All three chicks subsequently fledged.

When the signal printout was subsequently analyzed, it was discovered that the motor driving the printout tape had not run at a constant speed. Consequently, it was impossible to accurately calculate incubation constancy of the Ospreys. However, it was possible to determine incubation temperatures. We have excluded the final 3 days because of the presence of the hatched chicks, and there were about 64 hours for which there is no record because at some egg positions the radio signal was not picked up by the antenna. Based on about 200 hours of signal printout, the mean incubation temperature of the radio-egg in the Osprey nest studied here was $35.9 \pm 0.3^{\circ}$C (standard error), ranging from 34.2 to 37.9°C. Although both male and female Ospreys incubate the eggs (Garber and Koplin 1972, Stinson and Bean unpubl.) no changes in incubation temperature which might be attributed to male/female differences were discernible.

The only other field study of falconiform incubation temperatures of which we are aware is Huggins's (1941) report that Marsh Hawks (*Circus cyaneus*) incubated their eggs at an average temperature of 32.3°C with a range of 28.3-35.4°C.

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MANAGEMENT PRACTICES FOR CAPTIVE KESTRELS USED AS SEMEN DONORS FOR ARTIFICIAL INSEMINATION

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Abstract

Detailed information pertaining to artificial insemination (AI) of American Kestrels (*Falco sparverius*) has already been presented elsewhere (Bird et al. 1976, Bird and Buckland 1976). In continuation of the study, further data have been collected on Kestrels in an attempt to determine both effective management procedures for male birds of prey used as semen donors and short-term storage conditions for semen.

Materials and Methods

All birds were maintained on a diet consisting mostly of day-old cockerels, and semen was collected as described by Bird et al. (1976).

Three groups of randomly selected males were involved in the study. The first group was composed of males isolated from visual contact with females. In 1974 eight birds were tethered in falconer's fashion; in 1975, 17 birds were housed in box cages as previously reported by Bird et al. (1976). In both years, we attempted to ejaculate these males three times a week beginning the first week of March. After mid-April, they were massaged only once a week. The number of massages resulting in measurable semen volume was compared between the two years. Only trials attempted on each male after the first successful massage are included here. In 1975 only, the outcome of each attempted massage was recorded as resulting in semen, urates, a combination of the two, or nil.

The second group in 1975 consisted of 12 males paired with females and held in breeding pens as described by Bird et al. (1976). To minimize disturbance, these males were massaged once a week only after egg-laying had completely ceased.

Finally, the third group was comprised of seven males held colonially with three females in a large, sanded pen with three nestboxes. The males were massaged once a week during the same time period the paired males were massaged.

These three groups of males were compared in terms of their production of semen, urates, or nil, as well as their semen characteristics which have been defined and explained elsewhere by Bird and Laguë (in press).

Observations on both frequency of collection and duration of sperm motility (motility ranged from a high of 5 to a low of 0) under storage conditions were also recorded.

Results

There was no appreciable difference in the number of successful massages between 1974 and 1975 (77.4 and 71.4 percent, respectively). Of a total of 500 trials over both years, 74.2 percent resulted in measurable volumes of semen.

Table 1 summarizes the percentages of collections yielding semen, urates, and nil in 1975. The percentages of collections yielding semen alone was greatest in the months of April and

May, dropping considerably in June. The percentages of collections yielding urates, however, was greatest in March, declining to less than half in the remaining months. The percent collections yielding nil in June was almost four times the overall mean of the other three months.

The semen characteristics of the males isolated from females, the colonial males, and the paired males during the period May 27 to July 10 are presented in table 2. The colonial males were by far the lowest in all traits with the exception of a high motility found in the two samples collected. The isolated and paired males were closely comparable in all traits except for sperm count per ejaculate, where that of the isolated males almost doubled the sperm count of the paired group. In each group of males, the percentage of collections resulting in urates almost equaled that resulting in nil (table 3). The colonial males were again by far the highest in both percentages with the paired males ranking second in production of urates.

With respect to frequency of collection, semen collections performed on two consecutive days resulted on the second day in a decrease in semen volume 6 out of 7 times and in decreases in sperm concentration and sperm count per ejaculate volume 4 out of 4 times. A second collection on the same day resulted in reductions of semen volume and sperm concentration 6 out of 9 times and a decrease in sperm count per ejaculate volume 7 out of 9 times.

The mean motility of three samples of pure semen held under refrigeration (i.e., 4.4 to 10.0°C) dropped from 5 to 3.5 after 12 hours and then to 2.3 after 24 hours. Barely motile sperm were still observed at 96 hours. At room temperature the mean motility of three similar samples dropped from 5 to 2.7 after 12 hours, and slight motility was visible up to 72 hours. The mean motility of sperm in three semen samples mixed equally with Wilcox phosphate buffer (16.34 gm NA_2HPO_4, 5.16 gm $NaH_2PO_4 .H_2O$ per liter, pH 7.2) (Wilcox 1958) declined after 12 hours from 5 to 3.7 under room and refrigerated temperatures. After 24 hours it decreased to 3.5 in two samples held at room temperature and to 3 in three samples stored in the refrigerated temperature. In samples mixed with Wilcox phosphate buffer, barely visible motility was seen up to 72 hours in one held at room temperature and up to 84 hours in another kept under refrigerated temperatures.

Discussion

The little difference in percentage of successful massages from year to year suggests that experience with the technique of semen collection does not play a large part in the successful procurement of semen. In 1974 many different individuals, some with no experience, collected semen. In 1975 this role was undertaken by one person. The importance of experience is mainly in the collection of good quality semen free of urates, as already demonstrated in chickens (Burrows and Quinn 1938).

The high percentage of collections resulting in urates in the month of March was likely due to the feeding of males prior to collections on collection days. This percentage was decreased by more than half by simply not feeding the males until all collections were performed that day.

It is commonly known in poultry that males will respond to the massage technique exceptionally quickly after a period of practice. On four occasions Kestrel semen was ejaculated with little or no massage required, indicating that some of the males were being conditioned to the technique. In two of these instances the semen examined was contaminated with as much and more debris than samples collected previously from the same bird by full massage. This is not in agreement with the finding of Kamar (1958) that cock semen obtained by collection without milking is relatively free of contaminants compared to that milked from the bird.

The results of table 2 seem to indicate that males kept in small quarters isolated from females are superior to both paired males and colonial males in almost every semen characteristic including percentage of successful massages. This finding is not congruent with the work of Lorenz et al. (1956) who found no significant differences in semen volume or sperm concentrations between paired and nonmated turkey toms. The results reported here may not be conclusive, however, as the isolated males were handled regularly prior to May 27, whereas the paired and colonial males were not. In support of the results are the observations of Burrows and Quinn (1937) in fowl and Owen (1941) in pigeons that males kept in large pens or males paired with females may be ejaculated regularly but give smaller yields of semen.

There are two advantages to keeping males in small quarters either tethered in falconer's fashion or held in box cages. Firstly, feeding is more easily controlled, and thus one can reduce the percent collections contamined with urates. In this regard the single males held in box cages had lower percentages than either paired or colonial males. Secondly, the stress and trauma associated with catching males in large pens is considerably reduced by keeping males in quarters where they can be easily caught. Although Rowan (1928) in his early work on juncos suggested that exercise promotes gonadal development in birds, Bissonnette (1931) observed no such effect in his starlings with additional exercise. In this study, restricted space, hence possible lack of exercise of the single males, had no negative influence on their semen production.

Since semen collection in 1974 was rarely examined microscopically, it is virtually impossible to compare semen quality between 1974 and 1975, when the food of the males was supplemented by additions of calcium and phosphorus in the form of bone meal. Although the percentage of successful massages was higher in 1974, the fertility from the AI birds was considerably lower that year (Bird et al. 1976). Ganders, when fed a high calcium diet, gave increased sperm concentration and viability (Molnar et al. 1971, Kovacs 1972) and, when fed a high phosphorus diet, gave increased sperm concentration and ejaculate volume (Kovacs 1972). From these results, it is possible to conclude that the increased dietary calcium and phosphorus of Kestrel males may have been responsible for the greatly increased fertility seen in 1975 (Bird et al. 1976).

The few observations on the effects of frequency of collection did indicate that both daily and twice daily collections reduced the semen volume, concentration of spermatozoa (nos./cu mm), and sperm numbers per ejaculate. This finding is in complete agreement with those reported for fowl (Penquite et al. 1930, Sampson and Warren 1939), for turkeys (Lorenz et al. 1956, McCartney et al. 1958, Nestor and Brown 1971), but only partially for hawks (Temple in Grier et al. 1972) as daily collections in goshawks did not appear detrimental to semen quality (Corten 1973). The decrease in sperm numbers in twice daily collections also lends support to Owen's (1941) feelings that regular collections more than once a day cause male pigeons to become aspermic. To obtain good semen quality in Kestrels, minimum and maximum intervals between collections appear to be two days and roughly one week, respectively. The same recommendations exist for chickens (Smyth 1968) and turkeys (Lorenz et al. 1956).

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Table 1

Percent collections yielding semen, urates, and nil in 1975.

Type of yield	March 12-31	April 1-30	May 1-31	June 1-30	Mean
Semen (S)	25.7 (37)	66.9 (89)	71.4 (105)	54.9 (45)	54.7 (276)
Urates (U)	59.7 (86)	23.3 (31)	15.6 (23)	22.0 (18)	30.2 (158)
SU	5.6 (8)	6.8 (9)	6.8 (10)	1.2 (1)	5.1 (28)
Nil	9.0 (13)	3.0 (4)	6.1 (9)	22.0 (18)	10.0 (44)
Total attempts	(144)	(133)	(147)	(82)	(506)

Table 2

Semen characteristics of sex segregated, colohy, and paired male Kestrels during the period May 27-July 10

Male group	Percent successful massages	Mean semen volume (µl)	Mean sperm conc. x10³/mm³)	Mean sperm count (x10³)	Mean motility score	Mean semen colour score	Mean percent contamination
Segregated	55 (57/104)	10.0	31.4	384.9	3.1	2.3	70.0
Paired	44 (30/ 68)	8.3	31.5	196.9	2.8	2.8	78.8
Colony	7 (2/ 30)	3.7	28.0	106.2	5.0	1.0	30.0

Table 3

Percent collections yielding urates and nil in sex segregated, colony, and paired male Kestrels during the period May 27-July 10

Male group	Percent collections resulting in urates	Percent collections resulting in nil
Segregated	23.1 (24/104)	22.1 (23/104)
Paired	32.4 (22/ 68)	23.5 (16/ 68)
Colony	50.0 (15/ 30)	43.3 (13/ 30)

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