Two-Year-Old Nesting Behavior and Extra-Pair Copulation in a Reintroduced Osprey Population

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ABSTRACT.—A reintroduced population of Ospreys (Pandion haliaetus) in eight counties surrounding Minneapolis/St. Paul, MN was monitored from 1984–2005. We recorded the behavior of marked birds at 306 occupied nests. Two-yr-old Ospreys were involved in nest attempts more often than previously reported. Twelve were observed; eight of these (five males and three females) occupied nests, and the remaining four were floaters. Readily available nest sites and abundant food resources may have been factors in breeding attempts by these young Ospreys. Age at first known occupied nest averaged 4.13 yr for males (N = 38) and 3.36 yr for females (N = 11). Age at first known successful nest averaged 4.39 yr for males (N = 38) and 3.64 yr for females (N = 11). In 2003, two 2-yr-old males fledged chicks. We also observed Ospreys copulating with more than one partner in the same breeding season on 14 occasions (10.52% of nests where eggs were laid). All but one extra-pair visit was observed between 2003 and 2005, when the nesting population of the study area exceeded 33 pairs. Fertility insurance, genetic quality, sperm competition, and parental care may have been factors favoring extra-pair copulation behavior in this population. Because multiple individuals were observed copulating outside the pair bond, the paternity of chicks in these clutches of Ospreys cannot positively be attributed to the social mate.

KEY WORDS: Osprey; Pandion haliaetus; age at first breeding; extra-pair copulation; nesting behavior; subadult; two-year-old nesting behavior.
Ospreys (Pandion haliaetus) historically nested throughout Minnesota including in the Minneapolis/St. Paul (Twin Cities) metropolitan area (Roberts 1932). Nesting birds disappeared in the southern half of the state before 1900, primarily due to persecution and loss of nest sites. From 1984–1995, efforts were made to restore a breeding population of Ospreys to east-central Minnesota by hacking 143 translocated chicks and erecting over 90 artificial nest platforms in suitable habitats (Gillette and Voigt Englund 1985, Voigt Englund and Greene 2005). A high percentage of birds in this restored population were banded.

Poole (1989) indicated that Ospreys become sexually mature and begin nesting at 3 or 4 yr of age. Available research indicates that Ospreys are socially monogamous and that copulations outside the pair bond are uncommon (Poole et al. 2002). In Minneapolis/St. Paul, the presence of a population with a high percentage of individually marked birds allowed us to identify individuals and monitor nesting behaviors such as age at first breeding and extra-pair copulations. We here describe those observations.

STUDY AREA AND METHODS

The Minneapolis/St. Paul study is unique because the population was reintroduced; we have monitored its growth and expansion for over 20 yr, and most chicks were banded. The study area was defined as the eight-county metropolitan area surrounding Minneapolis/St. Paul, MN. Counties included Carver, Hennepin, Ramsey, Anoka, Scott, Dakota, Washington, and Wright. From 1984–2005, all hacked chicks (N = 143) and 86% of wild-fledged chicks (N = 472) were banded with aluminum U.S. Fish and Wildlife (USFWS) or U.S. Geological Survey (USGS) size 8 leg bands. Bands were anodized blue in 1984, gold in 1985–1987, and from 1988–2005 black lock-on bands with a two-place alphanumeric code were used in addition to the aluminum leg bands.

From 1986–2005, we monitored Osprey nesting activity throughout the Minneapolis/St. Paul area. Nests were not distributed evenly throughout the study area, but were found in loose clusters of up to 15 nests. A nest was considered occupied if a pair was present whether or not eggs were laid, active if eggs were documented or a bird was observed in an incubating posture, and successful if at least one chick fledged (Postupalsky 1977). We did not confirm genetically whether the adults tending the nest were the biological parents of the hatched chicks.

We monitored 306 occupied nests to determine the dates of Osprey return, dates of incubation, hatching, fledging, nest productivity, and identification of individuals. Both professional biologists and trained volunteers observed nests throughout the 20-yr study period. Most bands were read more than once per season to assess nest-site fidelity. The oldest nest territories in Hennepin and Carver counties were visited frequently, as often as 2–4 times per wk for 30 min to 3 hr. As the population grew and expanded over the study period, some nests in the adjoining six counties were visited less frequently. Monitoring began ca. 1 wk prior to the date that the ice melted on major lakes, and continued until all chicks had fledged. Most nests were observed for ca. 3 hr during the 2-wk period prior to incubation. Therefore, with a mean of 13 hr of light per day, nests were observed up to 1.4% of the time birds were active.

In most cases, color bands were read from a distance with a 45 or 60× spotting scope. In four instances, USFWS or USGS 8-digit leg bands were read. Five birds from four other states (Michigan, Iowa, Ohio, Wisconsin) were also identified by their bands. From 1992–2005, a number of unbanded birds were identified by behaviors and feather coloration using head drawings (Bretagnolle et al. 1994).

We recorded the age at first known occupied nest as well as first successful nest for marked birds. Martell et al. (2002) reported the known age of male Ospreys at their first occupied nest during the first 16 yr of the project. The distinction between first occupied nest (nest building and defending a territory) and first successful nest (i.e., chick fledging) was not made in that study; at that time, 2-yr-olds were not known to fledge chicks successfully.

We gave careful consideration to what constituted copulation outside the pair bond. Mougeot et al. (2002) defined the length of a pair bond to be the number of consecutive years mates bred together. Therefore, copulation visits which occurred prior to the return of a previous mate, as well as while that mate was present on territory, were both considered to be extra-pair (EPC). Each EPC visit recorded in this study represents one or more copulation attempt with an Osprey other than its social mate during one breeding season. Some EPCs were one-time visits to a nest; some involved multiple visits.

RESULTS

Of the 306 occupied nests monitored from 1986–2005, none were in trees. We recorded that 70.3%
of occupied nests (75.4% of active nests) were successful, and 472 chicks fledged. Age at first known occupied nest in this reintroduced, marked population averaged 4.13 yr for males ($N = 38$) and 3.36 yr for females ($N = 11$). Age at first known successful nesting averaged 4.39 yr for males ($N = 38$) and 3.64 yr for females ($N = 11$). Two 2-yr-old males fledged chicks successfully in 2003 and were included in these data. We know of no successful breeding by 2-yr-olds prior to 2003.

**Nesting Behaviors in 2-yr-old Ospreys.** From 1986–2005, twelve 2-yr-old Ospreys were observed (Table 1). Of eight occupied nests, two resulted in fledged chicks. The first nest occupied by a 2-yr-old occurred in 1986 and was the only active nest in the study area that year; a blue-banded male and two unmarked females laid six eggs in a single nest, but none hatched. In 2002 and 2004, two 2-yr-old males were observed tending chicks at separate nests. One tended nestlings on a wind-turbine after the resident male was killed by propellers. The second cared for nestlings on a power pole after the male was found dead shortly after chicks hatched.

We first documented 2-yr-old males nesting successfully in 2003, when the number of occupied nests in our study had increased to 33. These 2-yr-olds were present with the same mate at a nest from courtship through the fledging of chicks. In both cases one chick fledged. At Hyland Lake, the 2-yr-old male and an unbanded female both appeared at a new nest territory on the same date. The female laid an egg within 7 d of arrival. At Mink Lake, an unbanded female arrived at her nest 5 d before the 2-yr-old male. The male using this nest the previous year was not observed at this or any other site. Three wk later, she was observed incubating with the 2-yr-old in attendance.

No other males were observed copulating with the females at these nests during our observations in the 2003 breeding season. However, monitoring prior to incubation occurred less than 2% of the daylight hours.

Three of four 2-yr-old females were observed at occupied nests during this study. They participated in nest building and maintenance activities, but none was ever observed copulating successfully or incubating. In our observations, 2-yr-old females were unreceptive to copulation attempts. They reacted with alarm, with neck extended, feathers flattened, wings raised upward and back, and refused to raise their tails for copulation.

Of the eight 2-yr-olds observed nesting, one male was killed as a 2-yr-old (wind turbine propellers), one male was not seen in subsequent seasons, and six birds returned to nest as 3-yr-olds (three males, three females). Of the four non-nesting birds, two males returned to nest the following year, and two birds were seen again as 3-yr-old floaters (one male, one female).

**Copulation Outside the Pair Bond.** Because Poole (1989) and others suggested that 2-yr-old males were not physiologically capable of producing young, we began investigating the occurrence of EPCs as a possible explanation for fertile eggs in the nests of these young males. From 1999–2005, we observed copulation with more than one partner in a breeding season 14 times at nine different nests. Most EPCs occurred before incubation (Table 2). Males ranged in age from 4–21 yr, and the known ages of females were 3, 5, and 12 yr. This represented 10.22% of all occupied nests ($N = 137$) and 10.52% of all active nests ($N = 133$) during those years.

The most extraordinary extra-pair relationship occurred with the Auburn Lake pair in 2004. The female arrived at the nest a few days after her 20-yr-old mate. Copulatory behavior was observed, but cloacal contact was not confirmed. She was observed the same week copulating multiple times with a different male at a second nest, 2 km away. She remained at this second nest for over a week, and was not seen again at Auburn Lake until the day she began to lay eggs. Three chicks hatched, but were killed by a predator when they were 4 wk old. The following year she left the 21-yr-old male.

### Table 1. Breeding status of 2-yr-old Ospreys observed in the Minneapolis/St. Paul area, MN 1986–2005.

<table>
<thead>
<tr>
<th>Breeding Status</th>
<th>Number of Birds of Each Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floater/did not nest</td>
<td>Male</td>
</tr>
<tr>
<td>Attempted to nest</td>
<td></td>
</tr>
<tr>
<td>Tended young after older male was killed</td>
<td>2</td>
</tr>
<tr>
<td>Occupied nest only (with no eggs laid)</td>
<td>0</td>
</tr>
<tr>
<td>Active but unsuccessful nest</td>
<td>1a</td>
</tr>
<tr>
<td>Successful nest</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
</table>

*a Polygyny; two females laid six eggs in one nest.*
Table 2. Osprey copulation with a bird other than its social mate in the Minneapolis/St. Paul area, MN, 1999–2005.

<table>
<thead>
<tr>
<th>Timing of Copulation</th>
<th>Number of Birds of Each Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Prior to selecting a single social mate&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>Prior to an established mate’s return&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3</td>
</tr>
<tr>
<td>Mate present on territory&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1</td>
</tr>
<tr>
<td>After first mate disappeared</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

<sup>a</sup> Each male copulated with multiple females early in the season before selecting a single mate.

<sup>b</sup> One established pair abandoned their nest early-season; both birds fledged chicks at new nests with different mates the same year.

moved to the second nest, and paired with the male responsible for the EPCs.

Another notable EPC visit occurred in 2005 by the female at the King’s Point Road nest. Her 18-yr-old mate of 10 yr was late in returning to nest in the spring. Prior to his return, she made three documented excursions to the Auburn Lake nest 5 km away to copulate with that 21-yr-old male. She returned to her own nest after each visit until her mate arrived. She was observed incubating, but no eggs hatched.

We noted that females participating in EPCs had mates that were significantly older than the mean age of males. The mean age of cuckolded males in our population was 16.2 yr (N = 7), while the mean age of marked males in the overall breeding population was 8.3 yr (N = 67).

**Discussion**

Our objective was two-fold: (1) to report 2-yr-old Ospreys at active and successful nests and (2) to report multiple EPC visits observed while monitoring the Minneapolis/St. Paul Osprey population. Our only explanation for chicks fledging at nests tended by 2-yr-old males is that the 2-yr-olds were reproductively mature, or their mates engaged in EPCs and extra-pair fertilization resulted. We are not suggesting that these two phenomena are related; we are reporting both behaviors and offering a possible explanation for fertilized eggs in the nests of 2-yr-olds. Our research suggests that both 2-yr-olds at active nests and EPC visits are underreported in Ospreys.

**Nesting Behaviors in 2-yr-old Ospreys.** We found 2-yr-old Ospreys at occupied nests more often than previously reported. Poole’s (1989) summary of age at first breeding does not mention 2-yr-olds and Postupalsky (1989) reported no evidence that they attempted nest building or breeding. Rymon (1989) observed three marked 2-yr-olds at hack sites in 1984, and three 2-yr-olds interacting with established pairs in 1986 (L. Rymon unpubl. data). He believed this behavior may have been due to the artificial conditions created by his reintroduction project. We feel this was most likely the case for our study as well.

Henny and Van Velzen (1977) also suggested that Ospreys do not begin breeding as 2-yr-olds. They established that some 2-yr-olds return to the breeding grounds as floaters, and estimated that they made up 5–10% of stable populations. However, they were uncertain if any of these birds were associated with active or successful nests. Our observations suggest that 2-yr-olds compose a larger percentage of nesters than previously reported. Henny (pers. comm.) suggested that in a stable nesting population 2-yr-olds might represent less than 1% of breeding birds. In our growing population, this proportion was larger (5.30%).

Poole (1989) reported that the mean age of first nesting was lower (3.6 yr) where pairs nested close together, safe nest sites were readily available, and food was abundant. Mean age at first nesting in Minneapolis/St. Paul was comparable to Poole’s report, at 3.50 yr in females and 4.26 yr in males. Nest density in our study area also increased over 20 yr. In 1988, there were only two active nests within 4 km of the first nest at Carver Park Reserve; by 2005, there were 12 nests within the same area. In addition, the study area has a number of available, secure nest sites. Artificial nest platforms, transmission lines, distribution lines, and cell phone towers are widespread throughout central Minnesota, as are shallow lakes with abundant fish. Seemingly, neither the availability of nest sites nor food has been a limiting factor in the growth of this reintroduced population.

However, we noted that successfully breeding 2-yr-olds were not in the densest, most established clusters of the population, but were at outlying nests. The nest at Mink Lake was more than 40 km from the Carver County cluster of 12 nests, and only one of four active nests in Wright County. The closest nest to the Hyland Lake pair was 10 km away.

In 2003, the Mink Lake female may have paired with the available 2-yr-old to ensure parental care in the absence of her mate. Postupalsky (1989) found
most young Ospreys in the Michigan population bred for the first time with older birds. At the Mink Lake nest, the female did not lay an egg until 3 wk after the 2-yr-old male arrived at the nest. No other males were seen during daily observations. There was adequate time between arrival and egg-laying for this 2-yr-old male to have fertilized an egg; however, genetic paternity was not confirmed.

The pair at Hyland Lake arrived together in 2003, and began incubating within 7 d. Poole et al. (2002) report that pairs with established nests can lay eggs as early as 7 d after returning to nest. We observed incubation in as few as 4 d after arrival in 2005 at a well-established, closely monitored nest. The Hyland Lake birds were a new pair at a new nest, which made this rapid egg-laying noteworthy.

Dennis (2003) reported one 2-yr-old female incubating and raising chicks in the United Kingdom in 2003. At the time, there were only two nests with laying pairs. To our knowledge, this was the first known successful breeding by a 2-yr-old female Osprey in the U.K. We have not documented successful breeding by a 2-yr-old female in the Minneapolis/St. Paul area.

Copulation Outside the Pair Bond. Poole (1989) observed that Ospreys are mostly monogamous. Our multiple observations of Ospreys copulating with more than one bird do not support this assumption in the Minneapolis/St. Paul population.

In our study, EPCs occurred within long-established pair bonds as well as with newly paired birds. Half of the observed EPCs occurred prior to the return of the previous year’s mate. They may have been a way of assessing a potential mate, if needed, as has been observed in other species (Wagner 1991).

The growing number of EPC visits in this population may have been due to the opportunity provided by an increased concentration of nests. Widen and Richardson (2000) found that EPCs were recorded only in the high density area of their study in Sweden, and concluded that the higher the density, the greater the risk of EPCs. Birkhead and Lessells (1988) reported that EPCs occurred at a low frequency with low population density. They studied a single nest in Scotland over 10 yr, with a local population of 7–24 pairs of Osprey. All but one of the 14 documented EPC visits we observed occurred between 2003 and 2005, when nests had increased in number and were clustered more tightly. EPCs were observed during normal nest monitoring; due to the large amount of time nests were unobserved, more EPC visits likely took place.

In this population, some females sought out or allowed copulation with other males more frequently when their mates were relatively old. Newton (1985) discovered a decline in breeding performance with old age among Eurasian Sparrowhawks (Accipiter nisus) in southern Scotland. Mougeot (2004) suggested that female raptors might use EPCs as a means of fertility insurance, or as a means to have their eggs fertilized by a male of higher quality than their current mate.

We suggest that fertility insurance and genetic quality (Ligon 1999) may have been motivating factors for the female at the Auburn Lake nest to engage in EPCs. She and her established mate failed to breed successfully for 4 yr prior to the female’s documented EPC visits in 2004. After her EPCs, three chicks hatched. Thus, we suggest that it was probable that the cuckolded male did not sire the chicks.

Because so few long-term studies have been conducted on Osprey populations, it is difficult to determine if copulation outside the pair bond is a common behavioral strategy occurring as colonies increase in density. To our knowledge, no Osprey-specific microsatellite markers are available that would allow us to document extra-pair fertilization.

Conclusion

Monogamy is a label employed to indicate the overall social relationship of the male and female participants. We conclude that Ospreys are primarily socially monogamous. However, the increasing number of EPC visits with the growth of this reintroduced population suggests that Ospreys may be less genetically monogamous than originally assumed. The male raising the chicks in his nest may not be the biological parent, and the paternity of chicks within a brood may differ. In addition, it is possible that Ospreys may be physiologically capable of breeding at a younger age than previously reported. Careful long-term studies and genetic analyses are needed to provide additional insight into the strategies behind these breeding behaviors.

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**LITERATURE CITED**


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