Mueller is of course correct that there are small age-dependent size differences between HY and PHY birds. Including such age difference would split each of the peaks in the unaged distribution shown in Fig. 1 into two peaks, but consistent data were not available to us at the time of writing. We have been acquiring such data ourselves, and have measured 2588 birds to date. Our statistical analysis (unpubl.) yields mean wing chords of 131.8 ± 3.6 mm for HY males, 133.1 ± 3.3 mm for PHY males, 139.3 ± 3.6 mm for HY females, and 140.8 ± 3.3 mm for PHY females. Clearly, the age-dependent differences of 1.3 mm for males and 1.5 mm for females are much smaller than the sex-dependent differences of 7.4 mm for HY birds and 7.7 mm for PHY birds.—MARTIN H. EDWARDS, *Dept. Physics*, RON D. WEIR, *Dept. Chemistry and Chemical Engineering, Royal Military College of Canada, Kingston, Ontario K7L 2W3, Canada*, AND ROBERT B. STEWART, *Dept. Microbiology, Queen's Univ., Kingston, Ontario K7L 3N6, Canada.* *Accepted 27 July 1982.*

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Use of two habitats related to changes in prey availability in a population of Ospreys in northeastern Nova Scotia.—Reproductive success of altricial birds may depend largely on the ability of adults to find and bring sufficient food from foraging sites to their nestlings. In particular, large raptorial birds that forage for seasonally fluctuating and patchily distributed prey may encounter problems in obtaining enough food for both themselves and the rearing of their young. Presumably the feeding and nesting strategies developed by a species reflect the abundance, distribution, and availability of prey for the predator.

Time budget studies of nest-site activities of Ospreys (*Pandion haliaetus*) have been limited (Green, Ibis 118:475–490, 1976; Stinson, Oecologia 36:127–139, 1978; Levenson, M.S. thesis, Humboldt State Univ., Arcata, California, 1976). Even today relatively little is known about details of Osprey nesting activity, especially relative differences in time budgets between adults of a pair.

Ospreys in Antigonish County, Nova Scotia, use two different habitats: nesting within 3.5 km of estuaries and capturing winter flounder (*Pseudopleuronectes americanus*) in the estuaries; and nesting inland, usually beside lakes and/or streams and feeding primarily on white sucker (*Catostomus commersonei*), alewife (*Alosa pseudoharengus*), and blueback herring (*A. aestivalis*). Prévost (M.Sc. thesis, MacDonald College, McGill Univ., Montreal, Quebec, 1977) suggested that inland nesters feed on the latter two species in that portion of the nestling period coinciding with the spawning migration of these fish. He also noted these birds might have to shift foraging locations from lakes and/or streams to estuaries in years that the herring migration ceases before their young fledge.

In our study we attempt to identify major breeding activities of inland and coastal nesting pairs and to determine the extent of changes in relative time devoted to hunting by males throughout stages of the breeding cycle.

Use of the two anadromous herring species by inland nesters and the possible significance of a shift in foraging locations during the nestling period are assessed. Also, we have hypothesized that the length of time of hunting by coastal birds would be less variable than that of inland birds since flounders in the two estuaries used by the study population are available to Ospreys throughout the breeding season (Prévost 1977).

Study site and methods.—This study was conducted within the watersheds of Antigonish and Pomquet estuaries in northeastern Nova Scotia (Fig. 1). The West and South rivers are the two major watershed systems emptying into Antigonish Estuary and water from shallow, eutrophic Gaspereaux Lake meets the West River about 11 km from Antigonish estuary.

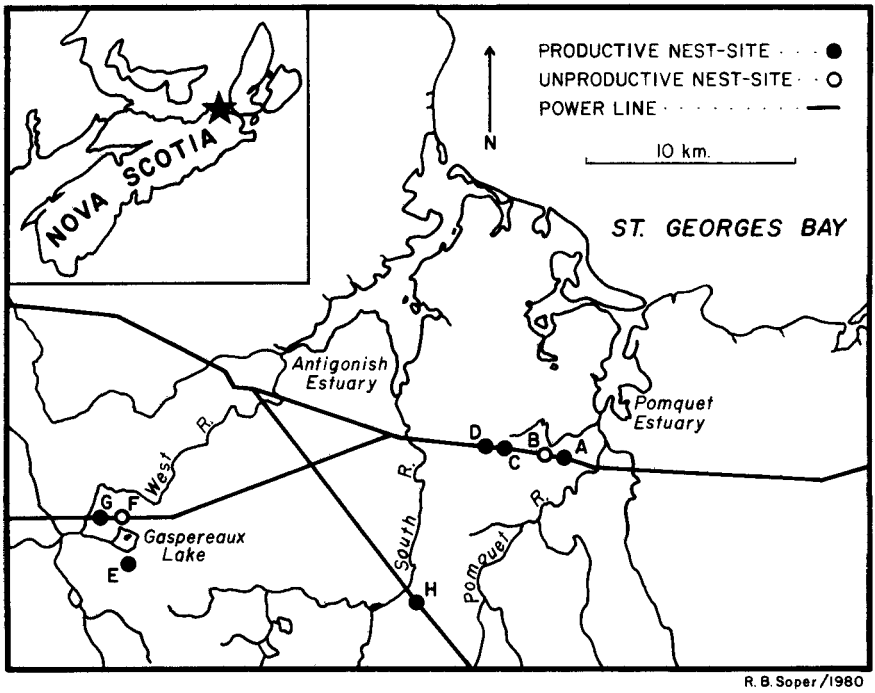

FIG. 1. Locations of Osprey nest-sites studied in Antigonish County, Nova Scotia, in 1978. The star in the insert shows the location of the study area in Nova Scotia.

Ospreys fished almost exclusively in these two estuaries, the two rivers, and Gaspereaux Lake.

Most Ospreys that fished primarily in the estuaries nested on Nova Scotia Power Corporation power poles about 3 km south of and approximately midway between the two estuary systems (Fig. 1). Adults at four nests, 0.25–1.2 km apart, were intensively observed.

Inland nest-sites were no closer to each other than 0.25 km and both trees and power line poles were used as nest-sites. Two intensively observed nests were on power line poles between Gaspereaux Lake and the West River, approximately 10.8 km from Antigonish estuary, 0.8 km from Gaspereaux Lake, and 0.5 km from the West River. A third inland nest was located in a live white spruce (*Picea glauca*) 0.6 km from Gaspereaux Lake, and 12 km from Antigonish estuary. A fourth inland nest was situated on a hilltop power pole 2.4 km from the South River and 9.0 km from Antigonish estuary (Fig. 1).

The timing and duration of spawning migration of the two herring species are variable but both species usually begin by mid-May and end early in July. The alewives are in the river from approximately 15 May until 15 June and the blueback herring from 15 June until 15 July, although there are few fish left after mid-July. Blueback herring spawn in rivers and lakes but alewives usually spawn in lakes.

Nests were initially located and periodically surveyed by helicopter. Elevated blinds were erected within 100–300 m of each nest, allowing unobstructed surveillance of nests and nearby trees in which birds perched. Breeding activities from egg-laying through fledging were

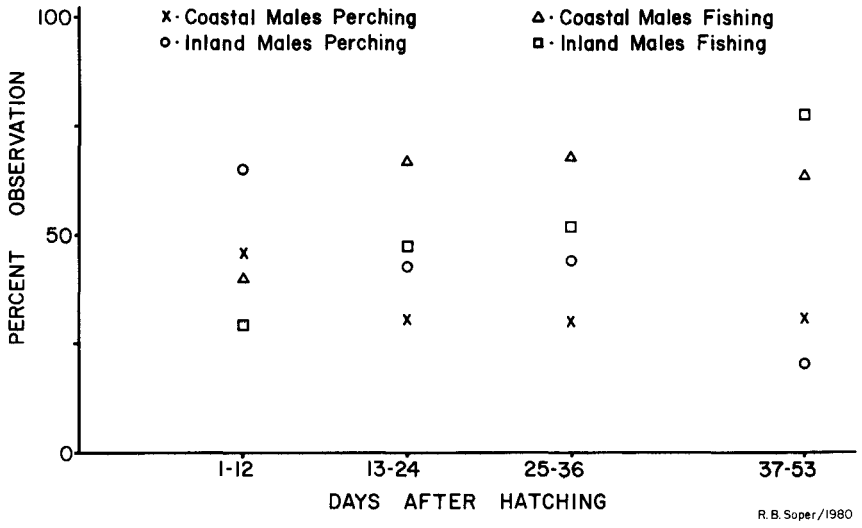

FIG. 2. Percentage of time spent by inland and coastal males fishing and perching near nests during the nestling period.

observed at nest-sites from 9 May–22 August 1978, for a total of 487 h. Daily observations were made from 06:00–11:00, 11:00–16:00, and 16:00–21:00. One day the observation period included the 06:00–11:00 and 16:00–21:00 periods, and the next day the 11:00–16:00 period. A different nest was watched during each observation period and each nest was usually observed at least once every 4 days.

Initially, three inland nests were watched. However, one nest was destroyed by wind early in the season and, to retain sample size, we shifted observations to another nest on the South River watershed. Three coastal pairs were also studied but young from one nest (site B) disappeared and we shifted observations to another nest (site A).

Initially sex of the birds was determined by their relative positions during copulation. Later it was noted that each female of the eight pairs watched had a darker breast patch than her mate. Similar results were found by MacNamara (U.S. Natl. Parks Serv. Trans. Proc. Series 2:43–45, 1977), although he looked at males and females in general and not pairs.

We subdivided the breeding season as follows: (1) pre-incubation (before egg-laying), (2) incubation (from the onset of egg-laying to hatching of the first egg), and (3) nestling (from the first appearance of young until the first young fledged). Pre-incubation was relatively short and data were collected from only three nests. Fishing time spanned the period from departure from the nest-site until a bird returned with a fish. Although we could not be sure that males hunted during this entire period, males usually fish continuously while in these two estuaries (Seymour, unpubl.), and in this study, always returned to their nests from the direction of the estuaries. Since males sometimes ate part of fish before returning to their nests (see also Prévost 1977), fishing duration included the time males spent eating. However, eating time for females was precisely recorded and encompassed the time females spent feeding themselves and their young.

Identification of fish species was relatively easy because they differ markedly in form and

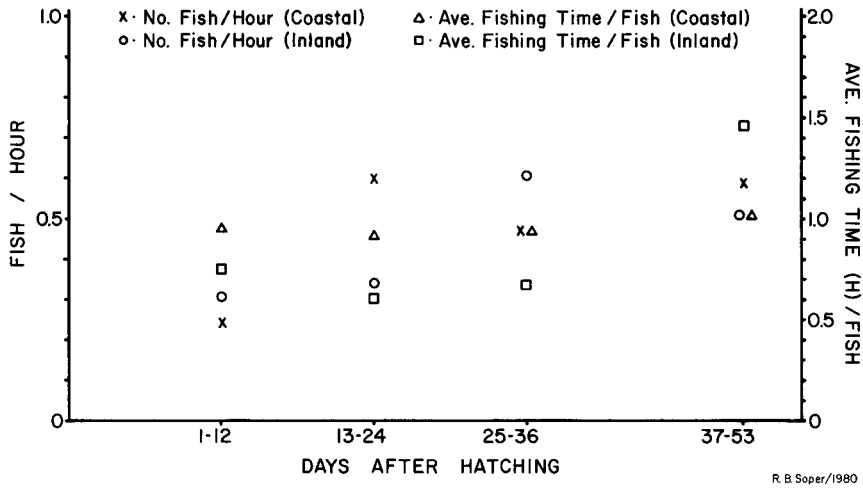

FIG. 3. Average duration of fishing and number of fish brought back to nests (per hour of observation) by inland and coastal nesting male Ospreys during the nestling period.

color. However, size of fish was so difficult to estimate accurately that we did not attempt to do so. A concurrent study of the chronology of the migration of the two herring species in the West and South rivers allowed us to determine the relationship between shifts in foraging locations of Ospreys and changes in the distribution or abundance of these fish.

Time budget analysis.—During pre-incubation females mostly sat beside or on the rim of their nests. Males gathered nesting materials, nest-built or perched near nests. Females rarely fished and males averaged only one hunt per 5-h observation period with a mean yield of 0.18 fish/h (five fish in 28.2 h).

Eggs were rarely left unattended during the incubation period. Bent (U.S. Natl. Mus. Bull. 167, 1937) and Ames (J. Appl. Ecol. Suppl. 3:87–97, 1966) said that only females incubated eggs. However, females in the present study incubated during approximately 66% of the daylight hours and males incubated the rest of the time. Similar results for males were reported by Garber and Koplin (Condor 74:201–202, 1972) and Levenson (1976). Green (1976) reported that female Ospreys incubated during the night and this appeared to be the case in our study. When not incubating, females usually perched within 200–300 m of the nest. Females never hunted during the incubation period and duration of fishing bouts by males and their yields of 0.18 fish/h (38 fish in 215 h) did not differ from bouts and yields of the pre-incubation period.

Only females brooded and fed nestlings. Intensive brooding lasted only until nestlings were 5–6 weeks old. Females continued to feed the young until they were approximately 7–8 weeks old. Nestlings of this age fed without assistance from females on only 5 of the 115 fish we saw them consume; they ate all of thse fish entirely by themselves.

Male fishing time increased dramatically, becoming the dominant activity during the nestling period. Accordingly, yields increased 2.5 times to 0.44 fish/h (108 fish in 243.5 h). Females began fishing when nestlings older than 7–8 weeks started feeding themselves, although they only contributed 7 of 115 fish brought back to nests.

Differences in activities of coastal and inland nesters.—There was no significant difference between inland and coastal males in the percentage of daylight hours spent fishing during

TABLE 1

COMPARISON OF TIME SPENT AT MAJOR ACTIVITIES BY COASTAL AND INLAND NESTING OSPREY PAIRS BEFORE AND AFTER INLAND BIRDS SHIFTED FORAGING LOCATIONS

	Duration of observation (h)	Male fishing (%)	Male perching near nest (%)	Female feeding young (%)	Fish consumed/h	Fishing time (h) $\bar{x} \pm SD$
Inland nesters						
Before shift	83.5	35.4	56.7	9.8	0.42 (N = 35)	0.6 ± 0.4 (N = 31)
After shift	55.2	74.0	23.6	11.5	0.53 (N = 29)	1.4 ± 0.6 (N = 21)
Coastal nesters	104.8	60.3	35.2	12.0	0.49 (N = 64)	1.0 ± 0.5 (N = 40)

the incubation ($\chi^2 = 1.15$, df = 1, $P > 0.25$) and nestling ($\chi^2 = 2.04$, df = 1, $P > 0.10$) periods. Similarly, there was no difference in female eating time for the two periods ($\chi^2 = 0.04$, 0.15; df = 1; $P > 0.90$, 0.50). Since females fed their young in one continuous bout as soon as their mates deposited fish at their nests, female eating time reflects the amount of fish provided by males.

The percentage of time spent fishing by coastal males remained relatively stable throughout the breeding period (Fig. 2). However the duration of fishing by inland nesters increased markedly during the nestling period, at the expense of time spent near nest-site. The increase in the duration of fishing resulted from a shift in foraging locations, from inland lakes and streams to estuaries. Inland birds travelled an average of 23.0 km to forage after the shift, compared to 2.3 km before the shift.

The shift in foraging sites reflected a change in prey availability. Inland nesters presumably nest near lakes and/or streams to take advantage of the spawning migration of anadromous alewives and blueback herrings. The alewife run occurred between 15 May and 7 June (Dill, unpubl.). Thus this run predates the Osprey nestling period when the demand for food was greatest. However, alewives traditionally spawn in Gaspereaux Lake which is connected to the West River. In some years, some fish were stranded in the lake by lowered water levels and available to Ospreys after the migratory run in the streams was over. The blueback herring migration is traditionally later in the season than that of the alewife and Dill (unpubl.) reported this herring in the West River between 13 June and 15 July 1978. The blueback spawned in rivers and lakes and were available to Ospreys until approximately mid-way through the nestling period. Consequently, blueback herring were the main prey of most inland nesters during the nestling period. When numbers of this fish dwindled, male Ospreys were seemingly forced to shift to estuaries to fish for flounders. Once the shift to flounders occurred, herring were no longer brought to nests. Birds followed rivers on their way to estuaries and still caught suckers after the shift, although the availability of these fish decreased toward the end of the spawning season when they moved to deeper water.

Figure 3 shows that mean foraging time was constant for coastal males throughout the nestling period. Inland males spent less time fishing than coastal males early in the nestling period but fishing time increased substantially for them later. However, the number of fish brought to nests did not reflect duration of fishing. The three inland pairs on which the results are

TABLE 2
AVERAGE TIME REQUIRED FOR FEMALES TO FEED DIFFERENT SPECIES OF FISH TO THEIR YOUNG[a]

Fish species	N	Time (h) $\bar{x} \pm$ SD (range)
Winter flounder	26	0.2 ± 0.1 (0.1–0.4)
Alewife/blueback herring	10	0.2 ± 0.1 (0.1–0.4)
White sucker	6	0.4 ± 0.2 (0.2–0.7)
White perch (*Morone americana*) and/or yellow perch	3	0.2 ± 0.1 (0.1–0.3)

[a] Refers to only whole fish that were consumed immediately, in one continuous bout.

based did not shift to estuaries to forage at the same time, and much of the period (25–36 days, 64% of observation time) included observation of birds that had not made the shift. There was a significant difference ($t = 7.5$, df = 41, $P < 0.005$) in the mean time required for Ospreys to catch herring and suckers in streams and flounders in estuaries.

To show the full impact of the shift to different foraging sites on the mean foraging time, data were analyzed on a before- and after-shift basis (Table 1). Fishing time for the three inland birds increased by 109% (perching time decreased 140%) after the shift; there was a significant ($t = 6.07$, df = 50, $P < 0.005$) increase in the mean duration of hunts/fish. Inland males fished significantly less than coastal males before ($t = 4.58$, df = 69, $P < 0.0025$) the shift. Despite differences in fishing time, inland and coastal males brought the same number of fish to their nests; inland males returned 0.46 fish/h (64 fish in 138.7 h of observation) and coastal males 0.49 fish/h (51 fish in 104.8 h).

Coastal males mainly caught flounders (39 of 40 identified fish) but inland males caught two yellow perch (*Perca flavescens*), 12 suckers, 16 herring, and 17 flounders. Although brought to nests less often than herring and flounders, suckers were larger than any other species and it took females twice as long to feed this fish to young as it did to feed them flounders ($t = 5.73$, df = 30, $P < 0.0025$) (Table 2). Suckers were usually partly consumed by males (8 of 12 fish) before being brought to nests, but flounders were almost always (45 of 51 fish) brought whole. Since there was no significant difference in time spent feeding their young by inland and coastal females, it appears that during the nestling period both inland and coastal males provided their mates and young with approximately the same amount of fish tissue.

Inland males shifted fishing sites at different times; males at sites H, G, and E shifted on approximately 12 July, 21 July, and 7 August, 25, 34, and 45 days, respectively, after their first chick hatched. This variability in time of shifting fishing sites may have resulted, in part, from differences in the timing of the herring runs in the West and South rivers (Prévost, unpubl.). However, the availability of stranded alewives in Gaspereaux Lake to males at sites G and E after the main run probably influenced timing of the shift of fishing sites. The site H male did not fish in Gaspereaux Lake. Although the male from site F continued to catch herring in the above lake, the male from site G stopped fishing there 17 days before the site E male shifted to the estuary. In general, Ospreys infrequently fished in Gaspereaux Lake and the rivers after mid-July, suggesting that fish were either unavailable or perhaps too few in number to make fishing worthwhile.

The average fishing time after the shift for males E and G increased 243% and 140%, respectively, and both caught mostly (>75%) flounders after the shift (Table 3). The average hunting time for male H increased only 56% as flounders represented less than half the fish

TABLE 3

PERCENTAGE OF TIME DURING THE NESTLING PERIOD FOR MALE FISHING AND FEMALE FEEDING, BEFORE AND AFTER A SHIFT IN FISHING AREAS BY THREE INLAND NESTING PAIRS

	Site E	Site G	Site H
Before shift	35[a]	34[a]	14.5[a]
Male fishing	24.1%	46.1%	37.4%
Mean duration of fishing bouts (h)	0.4 ± 0.3 (N = 16)	0.8 ± 0.5 (N = 11)	0.8 ± 0.1 (N = 4)
Percent flounders brought to nest	0	0	0
After shift	14.2[a]	12.4[a]	28.5[a]
Male fishing	66.7%	87.9%	71.6%
Mean duration fishing bouts (h)	1.4 ± 0.3 (N = 9)	1.9 ± 0.3 (N = 4)	1.2 ± 0.7 (N = 15)
Percent flounders brought to nest	77.8 (N = 9)	75.0 (N = 4)	46.7 (N = 15)

[a] Hours of observation.

brought to the nest. Although this male shifted to flounders earlier than the other males, he continued to catch suckers after the shift.

Conclusions.—Flounders, although smaller and lower in calorific value than herring or suckers (Prévost, 1977), were a permanent, if patchily distributed, resource. Use of flounders means that coastal Ospreys need not shift to a new foraging site during the nestling period. Inland nesters could experience a depletion or lack of herring and suckers prior to fledging of their young. Adult male Ospreys could then shift to foraging for flounders in estuaries. In 1978, inland male Ospreys brought as many fish to their nests after the shift as before. Although not a problem in 1978 the year of our study in this habitat, where climatic factors are variable a change in conditions could influence the availability of herring and make it difficult for inland male Ospreys to provide their nestlings with adequate fish.

Nest-site location relative to the foraging site likely influences the amount of time a male can spend at the nest-site. A male Osprey frequently interacts with other Ospreys, as well as other species, perhaps protecting the nest from intruders (Jamieson, unpubl.).

Both coastal and inland habitats have been used for nesting since at least 1974 when surveys of this population were begun. There has been variation from year to year both in the number of birds using each habitat and in the relative reproductive success of pairs. However, use of both nesting habitats appears well established. Birds were on nest-sites within a few days after arrival on the study area and hostile interactions between pairs were rare when nest-sites were being established; this suggests that birds were not forced by competition to use sub-optimal habitat. Furthermore, comparison of fledging success (cf. Postupalsky, Raptor Res. Rept. 2:21–31, 1974) shows no significant difference ($t = 1.11$, $df = 20$, $P > 0.20$) between the coastal and inland nesters; five inland pairs produced 1.8 young per pair and 17 coastal pairs produced 1.2 young per pair. Choice of habitat presumably reflects the ability of a male to provide himself, his mate, and their young with food while maximizing the amount of time spent near the nest.

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Nest provisioning behavior by a male Northern Harrier on the death of his mate.—At about 10:00 on 16 May 1980, at Malheur National Wildlife Refuge, Harney Co., Oregon, Thompson observed an adult female Northern Harrier (*Circus cyaneus*) carry a small mammal to a nest. The nest, which was located in a broad-fruited burreed (*Sparganium eurycarpum*) over 30 cm of water, contained three young and a pipping egg. The young were estimated to be under 10 days old, based on comparisons to other nestlings of known age.

When we reexamined the nest on 3 June, it contained one live, 3-week-old nestling and one dead nestling of about the same age. A dead adult female harrier was found floating ventral side down 0.5 m from the nest. The nest was littered with prey carcasses. Of 36 whole prey counted on and around the nest, most were montane voles (*Microtus montanus*) or long-tailed voles (*M. longicaudus*), but a few ground squirrels (*Spermophilus* sp.) were present. Some prey were fresh, while others were in various stages of decay. Of 10 harrier nests examined from incubation to fledging in 1980, only this one contained prey remains. Watson (The Hen Harrier, T. and A. D. Poyser, Ltd., Berkhamsted, Hertfordshire, England, 1977) reported that the female harrier removes uneaten food from the nest until the chicks can feed themselves. Beske (pers. comm.) also found this to be true with his research on harriers in Wisconsin.

The nest was visited again on 12 June. The surviving nestling appeared healthy and about to fledge. Heysham (1783, cited *in* Watson 1977) reported seeing a male harrier feeding chicks and further stated that a male could rear a brood after his mate was killed. Watson (1977) could find no recent reports of male harriers feeding chicks. He stated that the nestlings would likely survive only if they were well developed and capable of tearing up prey for themselves.

We do not know if the adult male was feeding the surviving nestling or simply bringing prey to the nest. Breckenridge (Condor 37:268–276, 1935) reported that a male's visits to a nest lasted only long enough to release prey. Watson (1977) observed a male visit a nest repeatedly and remain there for a minute or more, but did not see the male feed nestlings. In our case, the nestling appeared large enough and strong enough to feed itself. After the death of a female harrier in Wisconsin, Beske (pers. comm.) recorded a similar nest history in which a male continued to provide prey to a nest containing nestlings.

The dead female was clearly visible from above. We did not remove her from the vicinity of the nest, because of the possibility that her presence may have stimulated the male to continue provisioning the nest. To the best of our knowledge, this is only the third record