Wilson Bull., 100(2), 1988, pp. 297–302

Interspecific interactions of Spotted Sandpipers.—Interspecific interactions have been studied in a number of avian groups. While most studies have dealt with interactions stemming from competition due to niche overlap (e.g., Bock 1969, Kalinoski 1975, Burger et al. 1979, Robinson 1981), few have investigated the effects of breeding status on interspecific interactions (e.g., Walters 1979, Stephens 1984). This study examines the effects of breeding status on interspecific interactions of Spotted Sandpipers (*Actitis macularia*), a species with a resource-defense polyandrous mating system and predominantly male parental care (Emlen and Oring 1977). An "interspecific interaction" was defined as an agonistic encounter between a Spotted Sandpiper and an individual of another species.

A population of individually marked Spotted Sandpipers was studied on Little Pelican Island (LPI), Leech Lake, Minnesota (47°07′N, 94°22′W) from 1973 to 1987. Data on interspecific interactions were collected in 1976, 1977, 1979, and 1985. Observations began in early May and terminated in late July or early August when the birds left the island. See Oring and Knudson 1972, Oring and Maxson 1978, Maxson and Oring 1980, Oring and Lank 1982, 1986, and Oring et al. 1983 for further details on this population. The sandpipers were observed each day, weather permitting, from 3 m towers for an average of 6 h per day; 3 h beginning at sunrise and 3 h prior to sunset. The birds were most active during these time periods (Maxson and Oring 1980). Sandpipers were categorized by breeding status. Nonbreeding birds were not included in the analysis because individuals that failed to establish themselves as breeders never remained on LPI. "Unpaired" were all unpaired birds on LPI (prior to their breeding, exclusive of postbreeding birds). "Pre-laying" defined birds from the time of initial pairing to the laying of the first egg of a clutch. "Laying" is the time between laying of the first and last egg of a clutch; and "incubating" is the time between laying the last egg of a clutch and either hatch or destruction date of that clutch. "Brooding" is the time between hatching and fledging or loss of a brood, and "post-breeding" is any time spent on LPI after breeding activities ceased. Interspecific interaction rates for each bird in each breeding status were determined by dividing the number of interactions by the number of days spent in that status. We analyzed only interspecific interactions of adults of locally breeding species in order to minimize biases due to fluctuating migrant populations. Fluctuations in the population levels of resident species were negligible within seasons. Data from different years, however, were not combined due to possible variations in population numbers of resident species. Seasonal effects on interspecific interactions were minimal due to high predation and renesting rates (Oring et al. 1983).

Spotted Sandpipers interacted with a total of 20 species. Five species, Red-winged Blackbird (*Agelaius phoeniceus*), Killdeer (*Charadrius vociferus*), Common Grackle (*Quiscalus quiscula*), Song Sparrow (*Melospiza melodia*), and Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), accounted for 82% of male and 90% of female interspecific interactions (Table 1).

Rates of interspecific interactions of male Spotted Sandpipers were significantly related to breeding status in 1976, 1977, and 1979 (Kruskal-Wallis: 1976, adj H = 14.011, df = 5, $P < 0.025$; 1977, adj H = 28.936, df = 5, $P < 0.001$; 1979, adj H = 19.164, df = 5, $P < 0.005$). In all three years, the average interspecific interaction rate increased dramatically during brooding (Fig. 1). In 1985, interaction rates were high during brooding but moderately high rates during pre-laying eliminated significance (Fig. 1). For females, on the other hand, interspecific interaction rates were only related to breeding status in 1976 (Kruskal-Wallis, adj H = 90.792, df = 5, $P < 0.001$). In 1976, clutch loss was high, and few females engaged in either incubating or brooding activities (Maxson and Oring 1980). Therefore in 1976,

TABLE 1
FREQUENCY OF INTERSPECIFIC INTERACTIONS OF SPOTTED SANDPIPERS

Species	1976		1977		1979		1985		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Red-winged Blackbird *Agelaius phoeniceus*	30 (21)[a]	4 (22)	45 (30)	6 (38)	12 (20)	6 (60)	16 (80)	5 (42)	103 (27)	21 (38)
Killdeer *Charadrius vociferus*	83 (57)	9 (50)	27 (18)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	110 (29)	13 (23)
Common Grackle *Quiscalus quiscula*	4 (3)	3 (17)	12 (8)	3 (19)	13 (22)	1 (10)	1 (5)	3 (25)	30 (8)	10 (18)
Song Sparrow *Melospiza melodia*	10 (7)	0 (0)	38 (26)	1 (6)	0 (0)	0 (0)	1 (5)	0 (0)	49 (13)	1 (2)
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	2 (1)	1 (6)	15 (10)	1 (6)	0 (0)	0 (0)	0 (0)	3 (25)	17 (5)	5 (9)
Purple Martin *Progne subis*	2 (1)	1 (6)	1 (1)	0 (0)	26 (43)	0 (0)	0 (0)	0 (0)	29 (8)	1 (2)
Brown-headed Cowbird *Molothrus ater*	8 (6)	0 (0)	5 (3)	1 (6)	1 (2)	2 (20)	1 (5)	0 (0)	15 (4)	3 (5)
Other species[b]	7 (5)	0 (0)	6 (4)	0 (0)	8 (13)	1 (10)	1 (5)	1 (8)	22 (6)	2 (4)

[b] Other species presented in descending frequency of encounter: *Microtus* spp., Tree Swallow (*Tachycineta bicolor*), Common Tern (*Sterna hirundo*), Herring Gull (*Larus argentatus*), Sora (*Porzana carolina*), Northern Oriole (*Icterus galbula*), Yellow Warbler (*Dendroica petechia*), *Anas* spp., Ring-billed Gull (*Larus delawarensis*), Mourning Dove (*Zenaida macroura*), Eastern Kingbird (*Tyrannus tyrannus*), American Robin (*Turdus migratorius*), Painted Turtle (*Chrysemys picta*).

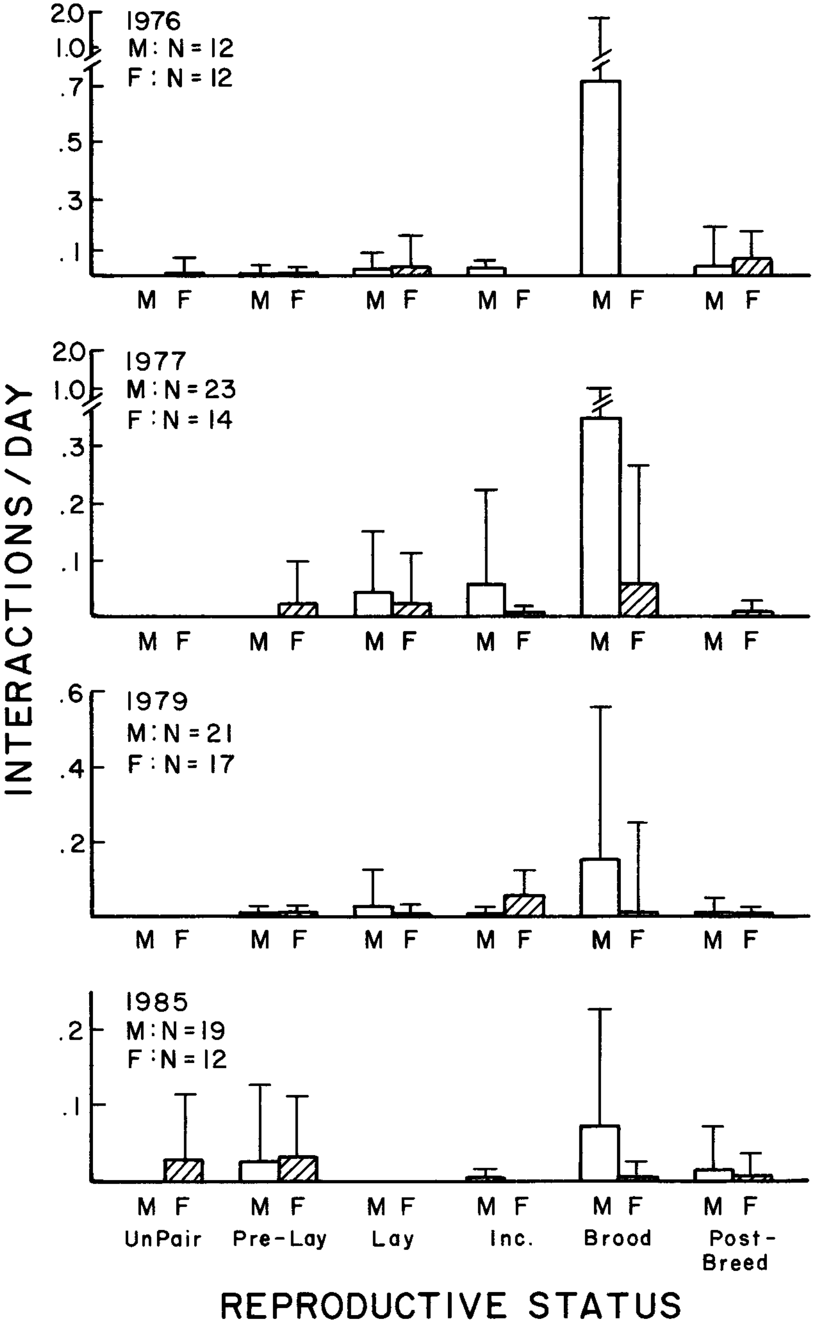

FIG. 1. Mean rates of interspecific interactions of male (M) and female (F) Spotted Sandpipers according to breeding status and year. Vertical lines show standard error of means. Unpair = Unpaired, Pre-lay = Pre-laying, Lay = Laying, Inc = Incubating, Brood = Brooding, and Post-Breed = Post-Breeding.

values for these two periods were abnormally low compared to other stages of the breeding cycle.

Within each year and reproductive status, rates of male and female interspecific interactions were compared using Wilcoxon two-sample tests. There was a significant difference between the sexes in only two cases, both during brooding (1976: $U = 120$. $P < 0.001$ and 1979: $U = 235$, $P < 0.05$).

Among years, the species composition of LPI did not change drastically, but the percent of interactions that Spotted Sandpipers spent with particular species did change. In 1976 and 1977 a pair of Killdeers bred on LPI (Oring and Maxson 1984). Since Spotted Sandpipers and Killdeers occupy similar habitats, the opportunity for contact, and hence interactions with Killdeers, was high (Table 1). Of the other primary species with which the sandpipers interacted, variation in number and percent of interactions between years was due to variation of population sizes of these species.

In three of the four years, interspecific interactions involving males increased significantly during the brooding period (Fig. 1). Stephens (1984) suggested that "greater conspicuousness of the mobile chicks" and less direct protective contact between parents and chicks than between parents and eggs could lead to increased parental protectiveness. Gochfeld (1984, p. 358) noted that, in general, "adult shorebirds are more active in protecting chicks than eggs." He provided two possible explanations for this change in parental behavior: (1) the stimulus of seeing the pipped egg or chick, and (2) a change in hormonal levels.

Increased levels of testosterone have been shown to increase aggression levels in many avian species (Trobec and Oring 1972, Searcy and Wingfield 1980). During brooding, however, male Spotted Sandpipers' plasma testosterone levels do not significantly change from incubation levels (Fivizzani and Oring 1986). Prolactin levels of brooding males also remain unchanged from incubation levels for at least three days post-hatch. It is unknown if they begin to change after this time (Oring et al. 1986). These results do not support Gochfeld's (1984) second explanation, at least for Spotted Sandpipers. While it may be true that a hatching chick provides the stimulus to alter the behavior of its parent, the mechanism by which this is regulated remains to be discovered.

We detected no effect of female Spotted Sandpiper breeding status on the rate of interspecific interactions. Although females occasionally provide parental care, such care is usually sporadic and consists of alarm calling and acting as a sentinel for the brood.

Maxson and Oring (1980) observed that intraspecific interactions were highest during the pre-laying stage but also increased during brooding. We observed no comparable increase in interspecific interactions during pre-laying. Intraspecific competition for mates has little if any effect on the frequency of interspecific interactions.

Although Spotted Sandpipers have a male-biased parental care system, we only found a difference in interspecific interaction rates between the sexes in two cases, both in the brooding period. In 1977 and 1985, the two years in which there was no significant difference between the sexes during brooding, the average interaction rate of males was indeed higher than that of females (Fig. 1). Of the 20 species with which Spotted Sandpipers interacted, only two, the Common Grackle (Maxson 1978) and *Microtus* spp. (Maxson and Oring 1978), were known to prey upon Spotted Sandpiper eggs and/or chicks. Red-winged and Yellow-headed blackbirds are also suspected of preying upon Spotted Sandpiper eggs (Oring, unpubl.).

Acknowledgments.—This study was supported by National Science Foundation Grants (GB 42255 and DEB 77-11147) to L. Oring and (PCM 8315758 and DCB 8608162) to L. Oring and A. Fivizzani. We thank the University of Minnesota Forestry and Biological Station, Lake Itasca, Minnesota, R. Huddle, and Judge M. Lord for logistic assistance. P.

Sheldon, D. Bjerklie, S. Hennes, P. Dolan, R. Reese, M. Skwarok, and A. Fivizzani helped with field work. C. Gratto and M. Colwell provided helpful comments on the manuscript.

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Wilson Bull., 100(2), 1988, pp. 302–305

Adaptive perch selection as a mechanism of adoption by a replacement Bald Eagle.—Replacement of lost mates within the same nesting season has been recorded in 26 raptor species (Newton 1979). Only three species (Cooper's Hawk, *Accipiter cooperii*; Northern Goshawk, *A. gentilis*; and Peregrine Falcon, *Falco peregrinus*) have exhibited full adoption, i.e., incubation of eggs and/or rearing of young by an unrelated, replacement mate (Rohwer 1986). Neither mate replacement within the same season nor adoption has been recorded for Bald Eagles (*Haliaeetus leucocephalus*). Herrick (1932) describes two Bald Eagle mate replacements of 11 and 14 weeks' duration, but both occurred over winter (October–February), prior to nesting. Adoption may be adaptive for long-lived species, through establishment of a pairbond for future seasons, if: (a) following mate loss and nest failure, renesting within the same season is unlikely; (b) the probability of starting the next breeding season with an established pairbond is increased with adoption; and (c) experienced pairs tend to have higher breeding success than new pairs (Rohwer 1986).

In 1983, while monitoring a Bald Eagle nest in Arizona, we observed mate replacement and full adoption, which provided an opportunity to verify one aspect of adoption theory under natural circumstances. Given that habitat familiarization contributes to experience of pairs (see item c above), and that perch use is one mechanism of that familiarization process, we hypothesized that the replacement adult should perch more selectively as the season progressed, i.e., exhibit less movement between fewer perches. He should also use more perches in common with the original mate and fewer perches new to himself, if optimal or preferred perches with discriminating characteristics exist within the breeding area. In this paper, we present results of the perch analysis, along with documentation of the mate replacement and full adoption.

Study site and methods.—Observations were made at a cliff nest in central Arizona, 32 km east of Phoenix, Maricopa County. On-site surveillance of the nest was maintained 1 February–7 June 1983 as part of a USDA Forest Service volunteer nest watch program on central Arizona Bald Eagle nests (Forbis et al. 1985). The female (A1), the original male (A2), and the replacement male (A3) were differentiated by size, plumage, and behavior. A3 also had a U.S. Fish & Wildlife Service band. It was later determined to be a 4-year old at the time of replacement, fledged from an adjacent breeding area 11 km away. To analyze perching in terms of habitat and behavior, we recorded both locations (perches) and the frequency of their use (perching frequency or observations). A perch location was tallied only once per month for each eagle using it, while a perching observation was recorded each time a perch was used. We defined A3's perches used by A1 or A2 within the same or