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Timothy Brush
Marycrest College

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Effects of Competition and Predation on Prothonotary Warblers and House Wrens Nesting in Eastern Iowa

TIMOTHY BRUSH[1]

Biology Department, Marycrest College, 1607 West 12th Street, Davenport, IA 52804; and Department of Biology, University of Texas-Pan American, 1201 West University Drive, Edinburg, TX 78539

In a fragmented midwestern floodplain forest, a small Prothonotary Warbler (*Protonotaria citrea*) population experienced high competition with House Wrens (*Troglodytes aedon*) and mammalian nest predation in 1988-89. Despite the provision of 3 types of nest boxes and higher water levels, Prothonotary Warblers did not nest successfully and decreased in the fragmented forest in 1990-91. House Wrens used >90% of the nest boxes in both years. Wren territories doubled within the nestbox area, while remaining constant on an unmanipulated area. In contrast, a larger warbler population had high nesting success during 1990-91 in a relatively unfragmented, wetter forest tract. Such forests, which have lower wren densities and less predation pressure, may be crucial for Prothonotary Warbler populations in the Midwest.

INDEX DESCRIPTORS: avian ecology, House Wren, Prothonotary Warbler, floodplain forest

Recently, studies of neotropical migratory birds have shown that habitat fragmentation, leading to increased nest predation and cowbird parasitism, has seriously impacted upland-nesting neotropical migrants in the United States (Robinson, 1990). Increased competition for food or nest sites from residents or short-distance migrants has been suggested as another cause of declines of neotropical migrants but has been demonstrated less thoroughly (Ambuel and Temple, 1983).

Effects of fragmentation on neotropical migrants in floodplain forests are uncertain, because of less research, natural fragmentation and short-rerm effects of flooding (Emlen et al, 1986; Mossman, 1988). Much floodplain habitat, which supports many neotropical migrants, has been lost (Swift, 1984) or has deteriorated due to changes in flooding regimes (Grubaugh and Anderson, 1988).

The Prothonotary Warbler (*Protonotaria citrea*), a cavity-nesting neotropical migrant of wet floodplain forests, has declined in the Midwest (Graber and Graber, 1983). House Wrens (*Troglodytes aedon*), which have increased due to fragmentation (Droege and Sauer, 1990), may have contributed to the decline in Prothonotary Warbler populations by outcompeting them for nest sites. In the Southeast and Lower Midwest, which lack House Wrens in floodplain forests, warbler nesting success is much higher (Walkinshaw, 1941; Kleen, 1973; Petit et al., 1987). Predation by mammals and lack of suitable nest sites also lower warbler nesting success in some areas (Graber et al., 1983; Petit, 1991).

The goal of this study was to determine the effect of fragmentation on breeding numbers and success of Prothonotary Warblers along the upper Mississippi River in eastern Iowa. My focus was to determine the effects of competition for nest sites with House Wrens and nest predation on Prothonotary Warblers, by comparing nesting densities and success in a highly fragmented forest and in a relatively unfragmented forest, and by using nest boxes to possibly alleviate nest-site competition. Possible nest-box preferences were explored by using 3 types of nest boxes, including the milk carton box preferred by Prothonotary Warblers in Tennessee (Petit et al., 1987).

STUDY AREAS

The main study area was in floodplain forest at Big Sand Mound Nature Preserve (BSM), in extreme northeastern Louisa Co. and extreme southeastern Muscatine Co., Iowa, on the Mississippi River. Dominant trees are silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*), and black willow (*Salix nigra*). The 42-ha forested study plot was narrow and highly fragmented artificially by old fields and the Mississippi River levee and naturally by ponds and meadows. No location in the forest was more than 200 m from an edge, and most were within 40 m of the nearest edge. Point counts during the 1980's revealed a small population of Prothonotary Warblers and a relatively large population of House Wrens (P.C. Petersen, unpublished report to Iowa-Illinois Gas and Electric Co., 1982). A small number of wooden nest boxes (5-10/year) were available to wrens and warblers during 1983-1987, and resulted in a small increase in the number of nesting warblers (P.C. Petersen, unpublished reports to Iowa-Illinois Gas and Electric Co., 1983, 1984, 1987). The area was divided into a 23-ha experimental area, to receive nest boxes, and a control 19-ha area.

During 1990-91, an 84-ha area was studied at Princeton Marsh (PM), just south of the Wapsipinicon River mouth, in extreme northeastern Scott Co., Iowa. The area was dominated by silver maple and also contained American elm, river birch, eastern cottonwood and black willow. A levee and some agricultural fields formed part of the western border of the study area. Otherwise, this study area was not aritfically fragmented, being part of a large area of relatively mature floodplain forest at the mouth of the Wapsipinicon River (Emlen et al., 1986). However, small channels created numerous natural edges within the forest.

METHODS

Breeding numbers of Prothonotary Warblers and House Wrens were determined by the standard spot-map method (Williams, 1936) at BSM during 1988-1991, and at PM during 1990-1991. I made at least 4 visits per month in May-July to all parts of the study areas and determined territory boundaries from repeated observations of singing males in the same area.

Nests were found in cavities created by woodpeckers or by fungal rot. I recorded the date of first use and whether the nest was a start nest (built by males, with sticks only for House Wrens, leaves and moss only for Prothonotary Warblers) or an active nest (eggs or young present). The presence or absence of water and distance to the water's edge also were recorded. I recorded a nest as successful if I observed fledging, saw recently fledged young in the immediate area, or if the nest was undisturbed after the time at which fledging would normally have occurred. Predation by mammals was shown by extensive disturbance of the nesting material, presence of shell fragments, and sometimes fur or tracks on the nest box. Some snake predation could have been overlooked, since snakes may not disturb the nest material. However, I did not see partial or complete losses of eggs or young without accompanying disturbance in any box in which all eggs or young were clearly visible.

[1]Present Address: Department of Biology, University of Texas-Pan American, 1201 W. University Dr., Edinburg, TX 78539-2999

Before the arrival of warblers and wrens in 1990, 147 nest boxes were set up in a 50 X 50 m grid, in the experimental area at BSM. Three types of nest boxes were used: a wooden box based on the bluebird box in Zeleny (1976), a plastic gallon milk jug (Zeleny, 1976), and a half-gallon waxed cardboard milk carton (Fleming and Petit, 1986). The 3 types of boxes were set out alternately. Each box was painted dull brown, had a 3.8 cm (1.5 in.) nest entrance, and was attached to the nearest tree which was large enough to support it. Box entrances were about 1.5 m above the ground. The average distance of nest boxes from the nearest artifical edge was 98 m, and the average distance to the nearest edge of any kind was 21 m.

RESULTS

Big Sand Mound — 1988-1989

In the pre-manipulation years, a small warbler nesting population existed, but experienced low nesting success. In 1988, 6 pairs of Prothonotary Warblers maintained territories for at least 2 weeks and attempted nests in the BSM study area. Only 1 of the 6 pairs was successful, and none of the 3 renesting attempts were successful. Predation by mammals occurred at 2 nests, House Wrens took over 4 warbler nests, while 2 nests were unsuccessful for unknown reasons (inaccessibility of these nests made it impossible to confirm predation).

Low warbler nesting success continued in 1989. Only 1 of the 2 warbler territories with nests was successful, while the other was taken over by House Wrens. The other 3 warbler territories contained only males, who investigated cavities which were unusable due to decay or were claimed by wrens. Most of the warbler territories in both years were in the future nest-box area (Table 1).

Table 1. Density (number/40 ha) of House Wren and Prothonotary Warbler territories on control (BSMC) and experimental (BSME) subplots at Big Sand Mound, and at Princeton Marsh (PM).

	House Wren			Prothonotary Warbler		
Year	BSMC	BSME	PM	BSMC	BSME	P M
1988	31.5	40.0	—[1]	2.1	8.7	—
1989	35.7	38.3	—	2.1	7.0	—
1990	29.4	73.8	16.2	2.1	1.7	8.1
1991	33.6	78.3	15.7	2.1	1.7	8.6

[1] indicates area not studied that year

House wrens established many territories at BSM during 1988-1989 (pre-manipulation). Densities were slightly higher in the future nest-box area (Table 1). Many wren nests were found in old woodpecker or chickadee holes, and territories were concentrated in willow fringe and other edge habitat near the dry lakebeds. At least 2 wren territories overlapped extensively with each warbler territory. Many wren family groups were seen in June and July of both years.

Big Sand Mound — 1990-1991

During 1990-91, 147 nest boxes (6.4 boxes/ha) were potentially available to warblers in the experimental area, but warblers made little use of them and decreased in number (Tables 1, 2). Only 1 active warbler nest was found (in a nest box) in 1990, and none in 1991. Despite frequent searches, no nests or female warblers were found in the other warbler territories. All nest boxes were within House Wren territories. Only 10 boxes were claimed by warblers (contained warbler start nests), and all were apparently within 1 warbler territory in the nest-box area. One of these boxes had an active warbler nest, but a mammalian predator removed the nestlings just before fledging. Of other warbler-claimed boxes, 6 were eventually used by wrens and are included in the wren totals below. Warbler numbers remained low in the control area in 1990-1991 (Table 1).

Table 2. Percent use of nest boxes by House Wrens and other species at Big Sand Mound, 1990-1991. Active nests contained House Wren eggs or nestlings. Start nests were those defended by male House Wrens and containing numerous sticks. Others were nest boxes used only by other species for nesting or other purposes. Total = the total number of nest boxes of that type.

Year	Box type	Active	Start	Other	Total
1990	Cardboard	93.7	2.1	4.2	48
	Wooden	64.0	24.0	12.0	50
	Plastic	46.9	42.9	10.2	49
	Total	68.0	23.1	8.8	147
1991	Cardboard	83.3	14.6	2.1	48
	Wooden	58.0	30.0	12.0	50
	Plastic	49.0	46.9	4.1	49
	Total	63.2	30.6	6.1	147

In contrast, wrens used many nest boxes and increased on the experimental area in 1990, while remaining stable on the control area (Tables 1, 2). Wrens used 91% of the 147 boxes, with 68% of all boxes containing active wren nests (eggs or young), and 23% of all boxes containing wren start nests. The largest number of active wren nests were in cardboard boxes, and the fewest were in plastic boxes ($X^2=18.52$, $p<0.001$; Table 2). Likewise, eggs were laid earliest in cardboard boxes and latest in plastic boxes (Table 3). Overall wren nesting success was 52.5% in 1990.

Table 3. Date on which House Wren eggs were first detected in different types of boxes at Big Sand Mound, May-July 1990 and 1991. Kruskal-Wallis tests revealed significant variation in nest initiation date in boxes of different types in both years ($p<0.01$).

Box type	Date eggs first seen 1990 (x±SE)	n	Date eggs first seen 1991 (x±SE)	n
Cardboard	3 June ± 2.5	44	27 May ± 3.0	40
Wooden	10 June ± 4.0	34	5 June ± 3.8	29
Plastic	19 June ± 3.3	24	8 June ± 3.1	24

During 1990, 9% of the boxes were never used by wrens. In addition to Prothonotary Warblers, Eastern Bluebirds (*Sialia sialis*), *Peromyscus* mice, paper wasps, wood roaches and ants all used at least 1 box. Only 1 box was apparently never used by any species. About 3% of the nest boxes were over water during early May 1990, during territory establishment and nest construction.

In 1991, 94% of the boxes were used by wrens: 63% of all boxes contained active wren nests, and 31% contained wren start nests. The remaining 6% of the boxes were used only by other species (Prothonotary Warblers, start nests in 2 boxes; *Peromyscus* mice or gray tree frogs, *Hyla spp.*, 9 boxes), or not used at all (3 boxes). Again, wrens used a greater percentage of cardboard boxes ($X^2=17.6$, $p=0.001$; Table 2) and nested earlier in cardboard (Table 3). Wrens had very low nesting success in 1991: only 16% of the 86 nests with a known outcome were successful. In early May 1991, 32% of the boxes were over water. Half of the 14 wren nests in boxes over water and >10 m from land were successful, while only 9.7% of the 72 nests <10 m from land or over land were successful ($X^2=13.95$, $p<0.001$).

Princeton Marsh — 1990-91

Similar densities of Prothonotary Warblers were seen here as in the experimental area at Big Sand Mound before nest boxes (Table 1),

but all territories at PM contained nesting pairs. The overall success rate was 82% (18 of 22 nests with known outcome) for Prothonotary Warblers during 1990-91. Permanent dry land was within 100 m of 80% of the 35 territories and >90% of the nests with known outcome. All nests were within 20 m of small channels. All nests (except 1 in 1990, the only predated nest) were separated by channels from the levee, the nearest permanent dry land, and were over water for at least 1/3 of their active period.

House Wrens were widespread but occurred in much lower densities at PM than at BSM (Table 1). Wren nests were frequently found in dead trees near narrow channels or artificial edges. Most warbler nests were within 50 m of an occupied wren territory, but only1 wren take-over occurred.

DISCUSSION

The failure of the nest-box grid to attract Prothonotary Warblers was probably due to several factors. Most importantly, use of such a high percentage of the nest boxes by House Wrens greatly reduced the number of boxes available to Prothonotary Warblers. The tendency of male House Wrens to build and defend start (dummy) nests greatly decreased the number available to Prothonotary Warblers. Prothonotaries are evidently unable to evict resident wrens (Walkinshaw, 1953; this study). Even if warblers had used the nest boxes, the high predation rates (as experienced by wrens) and the likelihood of wren take-over would probably have resulted in very low nesting success. Also, very few nest boxes were more than 10 m from land, even during flood conditions at BSM. It is possible that the Mississippi River levee delayed the onset of flooding by 1-2 weeks at BSM, although seepage did allow extensive flooding to occur.

The higher nesting success of the Princeton Marsh warbler population was probably due to lower levels of predation and competition. Wrens frequently nested over water, but their lower density probably reduced the likelihood of wren take-overs of warbler nests (Petit, 1989). Although there were many natural edges along small watercourses, the lack of artificial fragmentation may have decreased wren density. Also, since many warbler nests were on small islands or separated by a deep channel from the mainland, they were probably less accessible to predators (Picman et al., 1993).

Nest boxes in marginal habitat may actually hinder recovery of Prothonotary Warbler populations by increasing interspecific competition, since House Wrens tolerate flooding (Finch, 1991; this study) and effectively exclude other species from boxes within their territory (Finch, 1990). Furthermore, the wrens' preference for cardboard nest boxes would tend to increase competition with Prothonotary Warblers, since the warblers also prefer cardboard over other box types (Petit et al., 1987). In the southeastern USA, the absence of House Wrens from Prothonotary Warblers habitat and the greater extent of complex swamp environment may be the main factors promoting greater warbler nesting success (Walkinshaw, 1941; Small and Hunter, 1988).

Nest boxes are not recommended as a general management tool for Prothonotary Warblers in the Upper Midwest. They may be useful in some habitat restoration projects in areas with very low snag densities, but care must be taken to assure that nest boxes will not suffer intense competition by House Wrens (Finch 1990) and predation. Preservation or restoration of high-quality floodplain forest with numerous channels (Mossman, 1988) would likely be much more effective for maintenance of Prothonotary Warbler populations in the Upper Midwest.

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