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BREEDING ECOLOGY OF AMERICAN AVOCETS (*RECURVIROSTRA AMERICANA*) IN NORTH-CENTRAL OKLAHOMA

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INTRODUCTION

During the breeding season, American Avocets (*Recurvirostra americana*) range throughout the western United States (Robinson et al. 1997) and form loose colonies during nesting in isolated wetland areas (Gibson 1971). Their noisy, showy, and even comical behaviors during courtship and communal defense of nests are well known (Wolfe 1931, Sutton 1967, Robinson et al. 1997). In Oklahoma, avocets are considered transients and summer residents, regularly nesting at Salt Plains National Wildlife Refuge (NWR) in the north-central part of the state (Sutton 1967).

We monitored nesting success and microhabitat use of avocets at Salt Plains NWR in 1995 and 1996 and compared our data with earlier observations at the refuge. Avocets have been studied during 10 of the past 20 years on the 5,095-ha alkaline flat at Salt Plains NWR (Grover and Grover 1982, Grover and Knopf 1982, Hill 1985, Utych 1993, Koenen 1995, Winton 1997). Avocets have nested traditionally in association with endangered Interior Least Terns (*Sterna antillarum*) and Snowy Plovers (*Charadrius alexandrinus*) on the alkaline flat. Beginning in 1993, Black-necked Stilts (*Himantopus mexicanus*) also were observed nesting at Salt Plains NWR (Koenen et al. 1994).

METHODS

Nests of American Avocets were followed from 5 June to 24 July 1995 and 17 May to 23 July 1996 at Salt Plains NWR in Alfalfa County, Oklahoma. Avocet nests were located during systematic searches of the alkaline flat and monitored with the aid of an all-terrain vehicle, binoculars, nest markers (dowels), and a microcassette recorder. Avocet nests were visited every 1-6 days (mean 2.65) until outcome was determined. Microhabitat types $\leq$ 5 cm from avocet nests on the alkaline flat were

recorded and included: 1) driftwood debris; 2) other debris (i.e., dead vegetation and hay); 3) open soil/sand; 4) elevated human-made habitat improvements (i.e., plowed ridges and gravel mounds; Koenen et al 1996a); and 5) live vegetation.

Nesting success was calculated with the Mayfield (1961, 1975) method by dividing failed nests from all causes by total days that all nests were observed. Avocet nests that were lost before the first post-discovery visit could not be included in Mayfield calculations. Because the statistical properties of Mayfield estimates are unclear, we followed Johnson's (1979) recommendation and used lack of overlap of the 95% confidence intervals of estimates to establish significant differences between years.

We tabulated the number of avocet nests from both years by microhabitat type and used chi-square analysis (Schefler 1969) to determine if the observed distribution of nests in microhabitats differed from a uniform distribution. We used apparent nesting success (number of hatched nests divided by the total number of nests) to compare microhabitats. This was done because small samples lead to large confidence intervals for Mayfield estimates (Johnson 1979), making these estimates unsuitable for detecting any differences in nesting success among microhabitats. We also evaluated success of avocet nests inside electrically fenced predator exclosures (Koenen et al. 1996a) designed to enhance recovery objectives for Interior Least Terns.

RESULTS AND DISCUSSION

Twenty-one avocet nests were located in 1995 and 26 in 1996. Mean ($\pm$SD) clutch size of avocets was 3.93 eggs ($\pm$1.74), and modal clutch size was 4 eggs. These values were similar to those of Hill (1985) who also studied avocets at Salt Plains.

Exposure times were known for 15 of 21 nests in 1995 and 17 of 26 nests in 1996, and these 32 were used to calculate nesting success. Overall nesting success of avocets using the Mayfield method was 58% in 1995 and 50% in 1996 (Table 1). Nesting success of avocets at Salt Plains NWR was higher in our 1995-96 study than in 1982 (8.4%), 1983 (17.1%), 1992 (7%), and 1993 (3.1%) and similar to that in 1991 (49%) (Hill 1985, Utych 1993, Koenen 1995). Avocets at Salt Plains NWR experienced greater nesting success than in our study only in 1977 (83%) (Grover and Knopf 1982).

Like Least Terns and Snowy Plovers (Winton 1997), the first avocet nests were located earlier in 1996 (17 May) than in 1995 (5 June). Rainfall

totals at the nearby Salt Plains Reservoir Dam from 1 May to 31 July were greater in 1995 (50.6 cm) than in 1996 (28.5 cm), resulting in more frequent sheet flooding of the alkaline flats in 1995. We suspect the 1995 nesting season was delayed by flooding and are certain that the nesting season ended due to inundation of nesting habitat (32.8 cm of rain occurred from 31 July through 7 August 1995). However, avocets in 1995 experienced higher apparent nesting success than in 1996.

Avocet nests were found in clumped distributions at nine locations on the alkaline flat in 1995 and at 11 sites in 1996. Nests were most concentrated north of the selenite crystal digging area near Cottonwood Creek in the central part of the alkaline flat. This area is subjected to the most severe sheet flooding after rainfall (Koenen 1995, Winton 1997). In the wet year of 1995, fewer avocets nested along Cottonwood Creek (35%

Table 1. American Avocet nesting success (Mayfield method), approximate 95% confidence intervals, and losses for nests inside and outside predator exclosures, at Salt Plains National Wildlife Refuge, Oklahoma.

Year	Inside	Outside	Cumulative
1995			
n	3	12	15
Success	0.77	0.50	0.58
95% C.I.	0.45-1.00	0.26-0.92	0.49-1.00
Losses to predation	0	2	2
Losses to flooding	0	3	3
Losses to other[a]	1	0	1
1996			
n	0	17	17
Success	-	0.50	0.50
95% C.I.	-	0.30-0.81	0.30-0.81
Losses to predation	-	5	5
Losses to flooding	-	3	3
Losses to other[a]	-	0	0
Both years			
n	3	29	32
Success	0.77	0.50	0.53
95% C.I.	0.45-1.00	0.33-0.73	0.38-0.75
Losses to predation	0	7	7
Losses to flooding	0	6	6
Losses to other[a]	1	0	1

[a]Nests lost from abandonment, storms, or unknown causes

of all nests) compared with 1996 (73%); however, apparent nesting success was higher in that area in 1995 (88%) than in 1996 (26%).

In 1995, five avocet nests (24%) were found inside two electrically fenced predator exclosures in the northern region of the alkaline flat (Koenen et al. 1996a); these nests had 60% apparent nesting success. In 1996, no avocet nests were located inside predator exclosures. No significant differences in avocet nesting success were observed between nests inside predator exclosures versus nests found outside exclosures in 1995 using Mayfield estimates (Table 1).

Occurrence of avocet nests in the five microhabitats over both years was not uniform ($\chi^2_4 = 12.54$, $P < 0.025$). Fifteen (36.5%) of the 41 nests were associated with non-driftwood debris, and 12 (29.2%) were associated with human-made habitat improvements (Table 2). Elevated habitat improvements implemented on the alkaline flat since 1990 have included plowed ridges (Boyd 1990) and gravel mounds (Koenen et al. 1996a). Avocets used elevated habitat improvements most frequently in 1995 (47%; n = 9) with 33% apparent nesting success, but three avocet nests on elevated habitat improvements in 1996 had the highest apparent nesting success (67%; Table 2). Use of elevated structures by avocets is not unknown; Wolfe (1931) noted an avocet nest on a post just above the water in an alkaline pond.

Fluctuating levels of the Great Salt Plains Reservoir continually deposit and rearrange driftwood and other debris on the alkaline flat, creating nesting microhabitats for avocets and other shorebirds. Hay represented a new microhabitat type for avocets in 1996 as a result of a flood in early August 1995 that washed away bales of hay from Ralston Island, redepositing the hay along the high water line on the alkaline flat. Hay originally was used by the refuge to discourage island erosion in the early 1990's. Avocet nests near live vegetation, driftwood, and other debris experienced $\geq$ 50% apparent nesting success in 1995, and nests on elevated habitat improvements and driftwood debris resulted in $\geq$ 50% apparent nesting success in 1996 (Table 2). Avocet nests were observed near hay debris most frequently in 1996 (50%; n = 11), probably due to the increased availability of hay, with 45% apparent success for hay-associated nests.

Avocets that nested in open soil/sand experienced the lowest overall apparent nesting success: 0% in 1995 and 25% in 1996 (Table 2). Reduced success for avocet nests in open soil/sand may be partially due to this species' large egg size or the behavior of adult avocets, both of which could attract predators (Simmons and Crowe 1951).

Hill (1985) observed 63% of 122 avocet nests near debris or short vegetation and 37% in open areas but noted near equal nesting success between microhabitat types (33-34% apparent nesting success for each type). Grover and Knopf (1982) observed that avocet nests occurred in debris lines resulting from high reservoir levels, which were frequent travel lanes of coyotes, but found little or no differences in nesting success near debris compared with other microhabitat types.

Table 2. Percent use, apparent nesting success, and losses by microhabitat type for American Avocets nesting at Salt Plains National Wildlife Refuge, Oklahoma.

	A	B	C	D	E
1995					
n	2	4	1	9	3
Percent use	11	21	5	47	16
Percent success	50	75	0	33	100
Losses to flooding	0	1	1	3	0
Losses to predation	1	0	0	2	0
Losses to other	0	0	0	1	0
1996					
n	4	11	4	3	0
Percent use	18	50	18	14	0
Percent success	50	45	25	67	0
Losses to flooding	1	3	2	0	0
Losses to predation	1	2	1	1	0
Losses to other	0	1	0	0	0
Both years					
n	6	15	5	12	3
Percent use	15	37	12	29	7
Percent success	50	53	20	42	100
Losses to flooding	1	4	3	3	0
Losses to predation	2	2	1	3	0
Losses to other	0	1	0	1	0

A - ≤ 5 cm from driftwood debris.
B - ≤ 5 cm from other debris types.
C - open soil/sand away from debris.
D - elevated man-made habitat improvement.
E - ≤ 5 cm from live vegetation.

Increased nesting success for avocets from 1985 to 1995 may have been partially due to a decline in the nesting population of avocets during that time. This could result in more food resources per nesting pair. Gibson (1971) believed that food supply was important in the establishment of nesting territories of avocets, although direct evidence of competition for food at breeding areas is lacking (Robinson et al. 1997). We assumed that food availability for avocets varied across years and was probably rainfall-dependent at Salt Plains NWR, but the direct effect of food on nesting success was unknown.

Hill (1985) found 122 avocet nests in 1982 and 1983, in contrast to our 47 nests in 1995 and 1996. The decline in relative abundance of nesting avocets at Salt Plains NWR may be the result of encroaching vegetation, especially saltcedar (*Tamarix* spp.), which is reducing availability of nesting habitat for avocets and other shorebirds and providing cover for mammalian predators (Koenen et al. 1996b). In Oregon, 79% of avocet eggs hatched in an area with predator control (Gibson 1971), compared with 60% in our study without predator control.

Long distance movements of Recurvirostridae have been documented previously (Robinson and Oring 1996) and often are influenced by local environmental conditions (Boettcher et al. 1995). Climatic differences between 1995 (a flood year) and 1996 (a drought year) and a resulting decline in abundance of aquatic invertebrates may have led to the decline in numbers of avocets and Snowy Plovers and the absence of Black-necked Stilts in 1996 (Winton 1997).

Eleven avocet nests were lost to flooding, and eight nests were lost to predators across both years. Of depredated nests, 64% were destroyed by coyotes (*Canis latrans*), and 36% were lost to Ring-billed Gulls (*Larus delawarensis*), based on observations, tracks, and yolk stains (Winton 1997). One nest inside a predator exclosure was depredated by birds in 1995. We found that nesting avocets were dispersed more widely on the alkaline flat, compared with Least Terns and Snowy Plovers, and this likely resulted in fewer nest losses for avocets during localized predation by coyotes (Winton 1997). Colony size or nest density may influence how effective avocets are at driving away predators (Robinson et al. 1997).

Despite large eggs, large body size, and showy behavior (Wolfe 1931, Sutton 1967), avocets experienced substantially higher overall nesting success than Least Terns and Snowy Plovers on the alkaline flat in 1995 and 1996 (Winton 1997). Losses of avocet nests occurred from flooding and predation in 1995 and 1996. These natural factors limit productivity of all nesting birds on the alkaline flat at Salt Plains NWR. Elevated habitat improvements at

Salt Plains NWR have increased productivity of some avocets, although the local nesting populations appears to have declined. Further studies are needed to determine if American Avocets are undergoing a long-term decline at Salt Plains NWR and to identify contributing factors.

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