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Wilson Bull., 104(1), 1992, pp. 142–148

Habitat use by foraging Cattle Egrets in the Mexicali Valley, Baja California.—Most studies of habitat use and foraging behavior of Cattle Egrets (*Bubulcus ibis*) have focused on investigating whether egrets benefit more by foraging in association with cattle or by foraging alone (Heatwole 1965, Dinsmore 1973, Grubb 1976, Scott 1984). The association with cattle may be sufficiently important to confine breeding to areas near cattle (Telfair 1983:48). Besides foraging in areas with cattle, Cattle Egrets have shown preferences for short vegetation sites and irrigated meadows and have exploited a variety of foods (Siegfried 1971, Fogarty and Hetrick 1973). However, only a few studies have noted the importance of field conditions (e.g., amount of moisture, whether irrigated) on habitat use by Cattle Egrets (Dusi and Dusi 1968, Platter 1976:81, Siegfried 1978, Vermeulen and Spaans 1987), but the effect of field conditions on Cattle Egret foraging-habitat selection is not well known.

In arid agricultural ecosystems dependent on frequent surface irrigation, for example, habitat preferences of foraging Cattle Egrets may be affected by the frequency and type of irrigated fields. Here, I examine (1) habitat use by foraging Cattle Egrets during the breeding season at the Mexicali Valley, Mexico, and (2) the foraging success of Cattle Egrets in alfalfa fields.

Study area and methods.—The Mexicali Valley in Baja California forms part of Water District No. 14 (30°53′ to 32°43′N, 113°50′ to 115°52′W), a subsidiary of the Colorado River (CAEMEXI 1984:9). Most of the agricultural land at the Mexicali Valley is irrigated by surface (gravity) irrigation. I studied egrets at the southern end of the valley near a mixed heronry of Cattle Egrets, Snowy Egrets (*Egretta thula*), and Great Egrets (*Casmerodius albus*). Observations on the reproductive success of egrets breeding at this heronry are reported in Mora (1991).

To assess habitat preferences, I recorded Cattle Egrets foraging in approximately 10-ha fields over an area of approximately 300 km^2 surrounding the heronry. I assumed that adult Cattle Egrets observed within this area were breeding at the heronry. I observed egrets from 06:00 to 12:00 h at different periods during the breeding seasons of 1987, 1988, and 1989, with most observations obtained in 1988. The surveys were conducted along three main routes that included most of the area. Using binoculars, Cattle Egrets were easy to see, even from long distances, from the top of a vehicle. Feeding groups were sometimes located by following flying birds. I recorded the agricultural habitat used, conditions of the habitat (e.g., whether irrigated, behind tractors, etc.), size of the feeding group, associations with other species, direction and distance from the heronry, geographic location, and time of day. Flocks were easy to observe from short distances. Egrets were considered associated with a group if they foraged within approximately 20 m or less from another egret.

To test the hypothesis that the foraging success of Cattle Egrets was greater when they foraged under irrigated conditions than when they foraged behind tractors, I observed flocks of egrets feeding in alfalfa fields along gravity-induced running-water boundaries and behind tractors in the Mexicali Valley during July 1989. A spotting scope was used to observe foraging individuals during early morning hours (06:30–11:00). For an interval of 5 min, or until the birds moved away or stopped feeding, I observed adult and juvenile Cattle Egrets actively feeding. During this interval, I counted the number of strikes followed by a swallow and the number of strikes not followed by a swallow. Individual egrets were selected from different positions in the flock or from different patches to avoid sampling the same individuals more than once.

Data were log transformed to achieve normality to meet the assumptions of linear methods (Neter et al. 1985). I therefore used geometric means and 95% confidence intervals. Analysis of variance (ANOVA) was used to determine mean differences in habitat use among and within several agricultural habitat types, as well as among field conditions. The Scheffe method of multiple comparisons was used to detect differences between means. Chi-square procedures were used to compare frequencies of flocks observed in different agricultural habitats and in different field conditions. Two-sample t-tests were used to compare feeding success between adults and juveniles, between irrigated fields and behind tractors or cutting machines, and between irrigation days (first and second) within fields. In all cases, statistical significance was set at $P < 0.05$.

Results.—There were no significant differences in habitat use patterns among years; thus I combined all the habitat use data for the statistical analysis. Cattle Egrets were generally observed foraging in flocks from two to 1600 individuals. Single foraging birds were observed occasionally (6.7% of all observations), mostly along canals or by field edges. The agricultural crops in the study area were comprised of approximately: 8% alfalfa, 3% asparagus, 2% cantaloupe, 40% cotton, 40% fallow (including recently harvested wheat fields), 5% pastures, and 2% miscellaneous (SARH, pers. comm.). On average, 15% of the fields were irrigated,

TABLE 1

AGRICULTURAL HABITATS USED BY FORAGING CATTLE EGRETS IN THE MEXICALI VALLEY, BAJA CALIFORNIA

Agricultural habitat[a]	Number of flocks	Flock size[b]	Scheffe ranking		
Alfalfa	147	39.1 (28–54)	A		
Asparagus	16	24.6 (9–66)	A	B	C
Cantaloupe	43	21.9 (12–40)	A	B	C
Fallow field	156	20.3 (15–28)		B	
Pasture	102	16.3 (11–24)		B	C
Cotton	35	8.3 (4–16)		B	C
Canals, drainages	31	6 (4–10)			C

[a] Miscellaneous fields (N = 5) are not included in the analysis.
[b] Geometric means and 95% confidence intervals. Comparisons by one-way ANOVA; means not sharing the same letter are significantly different ($P < 0.001$).

10% had operating tractors, and 75% were non-irrigated and without tractors. Most flocks (79%) were observed within a 15 km radius from the heronry. I sometimes observed individuals taking off in the direction of the heronry from as far as 35 km; thus, Cattle Egrets may have flown that far to feed. Custer and Osborn (1978) observed Cattle Egrets feed as far as 20 km from the heronry, and Telfair (1983) noted that Cattle Egrets in Texas may visit feeding areas as far as 26–32 km from the heronry.

In general, Cattle Egrets were observed foraging more frequently in irrigated than in non-irrigated fields or behind tractors (chi-square = 560, 2 df, $P < 0.001$). This preference for irrigated fields was also consistent among all the agricultural habitats (Kendall's tau, $P < 0.05$). Cattle Egrets foraged more frequently in alfalfa, pastures, and cantaloupe fields than in cotton, fallow, and asparagus fields in irrigated ($\chi^2 = 482$, 5 df, $P < 0.001$) and non-irrigated conditions ($\chi^2 = 316$, 4 df, $P < 0.001$). Cattle Egrets were seen behind tractors only when they were operating in alfalfa and fallow fields, although tractors often operated in other agricultural habitats.

The total number of flocks observed and the mean flock size of foraging Cattle Egrets in various agricultural habitats are given in Table 1. Overall, the mean number of individuals per group foraging in alfalfa fields was significantly higher ($P < 0.001$) than the mean number in flocks foraging in pastures, fallow fields, cotton, and canals but not significantly different from the mean observed in asparagus and cantaloupe fields (Table 1.) Asparagus fields were visited only while the fields were being irrigated, whereas alfalfa and cantaloupe fields were visited during various times.

When field condition was considered, the mean size of foraging flocks in irrigated fields was significantly greater ($P < 0.001$) than the mean flock size behind tractors or in non-irrigated fields (Table 2). Under irrigated conditions, egrets foraged in larger groups in alfalfa

TABLE 2

FIELD CONDITIONS OF HABITATS USED BY FORAGING CATTLE EGRETS IN THE MEXICALI VALLEY, BAJA CALIFORNIA

Field condition	Number of flocks[a]	Flock size[b]	Scheffe ranking
Irrigated	260	49.2 (41–58)	A
Behind tractors	66	15.6 (11-22)	B
Non-irrigated	178	8 (6–10)	C

[a] 6.7% of all "groups" consisted of a single individual.
[b] Geometric means and 95% confidence intervals. Comparisons by one-way ANOVA; means not sharing the same letter are significantly different ($P < 0.001$).

($\bar{x} = 107.8$, $P < 0.001$) than in pastures ($\bar{x} = 26.4$), cotton ($\bar{x} = 14.3$), cantaloupe ($\bar{x} = 31.8$), and asparagus ($\bar{x} = 24.6$). Foraging groups in irrigated alfalfa were not different in size from groups foraging in irrigated fallow fields ($\bar{x} = 78.1$). In non-irrigated fields, the mean flock size of foraging egrets varied from 7.6 to 10.3, and there were no differences among habitats, except for cotton where the number of egrets observed was lower ($\bar{x} = 2.5$, $P < 0.05$). There were no significant differences in the mean flock size of foraging egrets behind tractors in alfalfa ($\bar{x} = 17.3$) versus fallow fields ($\bar{x} = 14.1$), which were the only two crops where egrets were observed behind tractors.

Egrets foraging in flocks were mostly not associated (N = 427, 80%) with other species. When Cattle Egrets foraged with other birds (N = 53, 17%), they usually foraged in a mixed group within the same patch, mostly in irrigated fields. Under irrigated conditions, egrets also foraged closer to one another, keeping a minimum distance of 0.5 to 1 m between individuals. Cattle Egrets were seldom observed (N = 15, 3%) foraging around grazing mammals, and only in five of these occasions (0.9%) were they associated with cattle.

The foraging success of Cattle Egrets in alfalfa fields was greater ($P < 0.001$) under irrigated

TABLE 3

FORAGING SUCCESS OF CATTLE EGRETS IN ALFALFA FIELDS

Field	Day of irrigation	Individuals observed	Prey/min[a]	Scheffe ranking
1	First	19	7.2 (5.1–10.2)	A
3	First	18	7.1 (5.0–10.1)	A
	Second	30	3.5 (2.6–4.6)	B
2	First	28	5.2 (3.9–6.9)	A

[a] Geometric means. Comparisons among fields by one-way ANOVA; within fields by t-test. Means that do not share the same letter are significantly different ($P < 0.001$).

conditions (N = 95) than behind cutting machines (N = 25). Egrets foraging in surface-irrigated alfalfa fields by the edge of running water, captured prey at a mean rate of 5.2 prey/min, with approximately 95% of the strikes resulting in success. The mean capture rate behind cutting machines was 2.6 prey/min. Egrets foraging behind cutting machines moved more often and appeared to pursue their prey farther than in irrigated fields. The feeding success of Cattle Egrets was not significantly different among three irrigated alfalfa fields during the first day of irrigation (Table 3), but was higher ($P < 0.001$) during the first day than during the second day of irrigation within the same field (Table 3). No differences in feeding success were observed between adult and juvenile egrets in alfalfa fields, under irrigated conditions ($\bar{x} = 5.5$, and 4.7 prey/min, respectively), and behind cutting machines ($\bar{x} = 2.5$, and 3.4 prey/min).

Discussion.—Cattle Egrets at the Mexicali Valley foraged primarily in surface-irrigated agricultural areas that provided a patchy, highly concentrated, ephemeral source of insect prey. Siegfried (1978) pointed out that the expansion of Cattle Egrets in Africa occurred, not because of cattle, but because of the development of irrigation systems and more intensive farming. A similar situation may be occurring in some areas of northwest Mexico and the southwestern U.S. where surface irrigation systems are common. Wading birds in Italy fed intensively on irrigated rice fields during the breeding season and had higher foraging success in these fields than when foraging in non-agricultural habitats (Fasola 1986). Preference of wet rice fields by foraging Cattle Egrets has also been observed in north Sulawesi, Indonesia (Vermeulen and Spaans 1987).

In agricultural environments with a predominance of surface irrigation systems, Cattle Egrets may frequently choose foraging habitat based on the condition of that habitat (e.g., running water) because prey may be more easily available under these conditions. These high quality patches (irrigated fields) can be predicted since they may last for several days and Cattle Egrets are likely to make more than one feeding trip per day during the breeding season. A brief inspection of the water-soil interface shows increased insect activity at the edge of running water where crickets, grasshoppers, and spiders were readily available to the egrets. Alfalfa fields were probably favored because they were often irrigated and cut, activities which increased the number of insects available to egrets. Egrets were as common in pastures and cantaloupe fields as they were in alfalfa; however, the foraging preference for alfalfa fields was more manifest because the feeding flocks were larger in alfalfa than in pastures and cantaloupe fields, particularly under irrigated conditions.

Access to surface irrigation fields may be important for Cattle Egrets especially during the breeding season when food requirements of their young are great. Differences in feeding frequency intensity between the breeding season and the winter have been observed in other egrets (Erwin 1985). The stomach contents of Cattle Egrets collected during the winter at Mexicali showed that they had fed more on mice than during the summer when they fed mostly on insects (Mora, unpubl. data). However, it is not known whether this change in diet is due to temporal variation of prey or to a seasonal shift in prey preferences by Cattle Egrets.

The association of Cattle Egrets with grazing cattle was relatively minor at the southern part of the Mexicali Valley. Egrets may be more likely to join cattle under dry conditions (Blaker 1969) or when they forage around forests rather than around pastures (Thompson et al. 1982). Cattle Egrets may have evolved in association with grazing mammals (Siegfried 1978) but may take advantage of sudden bursts in prey availability caused by surface irrigation in agricultural ecosystems.

The greater feeding success of Cattle Egrets in surface-irrigated alfalfa fields compared to success behind cutting machines or tractors and the larger flock sizes of foraging egrets in irrigated habitats indicate that flock size and feeding success are directly correlated in Cattle

Egrets. This is further supported by the smaller flock formation and the lower feeding success of egrets when they fed in the same field during the second day of irrigation. In surface-irrigated fields, flock size and feeding rates may be determined primarily by prey density. Scott (1984) found that the feeding rates of Cattle Egrets foraging near cattle were determined by prey density and that the formation of feeding groups was determined by prey size.

Under irrigated conditions, egrets fed in very dense flocks. Cattle Egrets may be able to assess patch quality based on surface irrigation and use this information as prescient (i.e., foresighted) foragers (Valone 1991). One benefit of egrets feeding in flocks may be to gain protection against predators by reducing scanning time and allocating more time to feeding (Barnard 1980, but see Scott 1984). I observed one case of a group of Cattle Egrets mobbing a coyote (*Canis latrans*) which had approached the feeding flock in an alfalfa field. While most egrets in the flock kept foraging, the mobbing continued until the coyote was chased away.

The feeding success of Cattle Egrets diminished when they fed behind cutting machines and tractors compared with their feeding success in irrigated fields, perhaps because fewer insects were flushed by these machines than were flushed by running water. The insects flushed by cutting machines may also have been more difficult to capture than those flushed by running water. Cattle Egrets had lower rates of intake and were more likely to fight over larger prey items (mice) when feeding behind tractors and cutting machines (7 piracy cases observed) than when feeding in irrigated fields (no piracy observed).

In conclusion, the distinct preference of Cattle Egrets for alfalfa and other surface-irrigated fields and the greater foraging success Cattle Egrets enjoy in these habitats demonstrate the important role that surface-irrigated systems may have played in the possible expansion of Cattle Egret populations in this arid ecosystem.

Acknowledgments.—This study was funded by UCMEXUS research and dissertation grants, a fellowship from CONACYT, Mexico, and a Jastro-Shields grant from the Univ. of California–Davis. I thank D. Anderson, D. Boellstorff, H. Ohlendorf, R. Telfair II, and an anonymous reviewer for their very useful comments on earlier drafts. I also thank D. Anderson, J. Mosqueda, M. Mount, and personnel from the Subdelegacion de Ecologia, SEDUE, in Baja California for logistical support.

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Wilson Bull., 104(1), 1992, pp. 148–155

Seasonal dynamics of bird populations in small New England wetlands.—Wetlands are widely recognized as ecosystems with diverse attributes (Office of Technology Assessment 1984), including a distinctive avifauna (Burger 1985). Avian communities of herbaceous wetlands, although not as rich as upland forest systems, are nevertheless varied (Burger 1985) and include economically important species (Bellrose 1978, Weller 1981). Despite the perceived value of wetlands for birds, basic avian community parameters such as species richness, species composition, and population density are often poorly documented even for commonly occurring types of wetlands (but for prairie marshes see Weller and Spatcher 1965, Kantrud and Stewart 1984, Brown and Dinsmore 1986). Here we characterize the seasonal dynamics of these parameters for a northeastern wetland avifauna.

Study areas and methods.—We studied avian community dynamics from spring 1988 to winter 1989–1990 in Connecticut (8 seasons). Six sites were chosen to represent the range of small, typically human-impacted wetlands present in the state. Sites differed in extent of