

Diet of Nesting Gull-billed Terns in Eastern Spain

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Abstract.—The prey displayed to mates and delivered to chicks by nesting Gull-billed Tern (*Sterna nilotica*) was studied in a colony on a coastal lagoon in eastern Spain during 2003. During 31 hours of observations, 1,091 prey items were observed. The trophic resources exploited by the species and seasonal differences in prey composition within the same breeding season were examined. Red Swamp Crayfish (*Procambarus clarkii*) was the main prey species (64% of prey items), followed by insects (17%) and fish (6%). The proportion of terrestrial prey taken was low. Proportionately more aquatic prey was brought to the colony during courtship-period and chicks were fed proportionately more aquatic prey earlier in the season. The proportion of vertebrate and invertebrate prey did not change significantly during the season. The prey observed in the study suggests that the Gull-billed Terns foraged mostly in rice fields. Received 24 June 2004, accepted 12 August 2004.

Key words.—Diet, Gull-billed Tern, *Sterna nilotica*, breeding, *Procambarus clarkii*, rice fields.

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The diet of the Gull-billed Tern (*Sterna nilotica*) in the western Palearctic during the breeding season has been reported (Boroludina 1960; Møller 1977; Bogliani *et al.* 1990; Goutner 1991; Biber 1993), and particularly in Spain (Vargas *et al.* 1978; Costa 1984; Sánchez *et al.* 1991; Sánchez *et al.* 1993) where the largest numbers in Europe occur (Tucker and Heath 1993; Sánchez 2003). Nevertheless, published quantitative data are scarce and studies in Spain only report the diet in southern colonies. Biber (1994) indicates that there is considerable geographical and seasonal variation in the diet of Gull-billed Tern, the species foraging over both wet and dry terrain and showing variation in the use of feeding sites at different times within the breeding season.

A Gull-billed Tern colony has recently (1994) been established in eastern Spain and has rapidly increased in numbers (Dies 2000) where this study was made. This species is unusual among terns in its abilities to exploit both aquatic and terrestrial prey, although the composition of the prey fed to young depends on the habitats surrounding the colonies and on the seasonal changes in the ecosystem (Sánchez *et al.* 1993; Erwing *et al.* 1998). Such dietary changes are likely in the unstable Mediterranean environment (Sánchez *et al.* 1993; Estrada 1996). Here we report on the prey presented to mates and delivered to chicks by nesting Gull-billed Terns in a western Mediterranean wetland. We describe the diet of the species and eval-

uate seasonal differences in prey composition within the same breeding season.

METHODS

Fieldwork was carried out in the barrier island-lagoon complex of l'Albufera de Valencia (39°20' N, 00°20' W; E Spain), from 2 May to 25 June 2003. A total of 31 hours of observations were completed. L'Albufera de Valencia has 21,120 ha of protected wetland habitats, comprising a 30 km long barrier beach, a freshwater lagoon (2,850 ha) with 350 ha of reedbed islands and fringe. The formerly extensive, shallow marshes (*ca.* 14,000 ha) have been entirely transformed into rice fields through drainage and impoundment.

The colony at the Racó de l'Olla saltmarsh, is located on a barrier beach. Breeding birds bringing prey back to the colony were observed from a permanent hide. When terns brought prey to the colony, they were identified as bird, fish, frog, reptile, crustacean, insect or other invertebrate. Some prey remained unidentified, particularly the smaller or fragmented ones. When possible, prey were identified to family, genus or species level (see Erwing *et al.* (1998) and Ramos (2000), for similar procedures). To assess seasonal changes in prey composition, we divided the prey brought to the colony into three time periods. Observations of prey used to display to mates (before hatching) were separated in the "courtship period" of 2-15 May (202 minutes, N = 80 observations). Observations of prey delivered to chicks were separated in both the "early period" of 21 May to 9 June (842 minutes, N = 489) and the "late period" of 10-25 June (856 minutes, N = 522). Contingency tables together with the chi-square statistic were used for data analysis. Prey items were divided into aquatic and terrestrial, and also into vertebrates and invertebrates. Unidentified prey (N = 77; 7%) were not included in the data set.

RESULTS

Prey organisms brought to the colony by nesting Gull-billed Tern are shown in the Table 1. Results showed that Red Swamp Cray-

Table 1. List of prey items brought to the colony by nesting Gull-billed Terns at l'Albufera de Valencia (East Spain) in 2003, during Courtship (2-15 May) and chick feeding (Early: 21 May-9 June; Late: 10-25 June) time periods.

	%	Courtship N	Early N	Late N	Prey type
VERTEBRATES					
Aves (0.4%)					
<i>Cisticola juncidis</i>	0.3	0	0	3	Terrestrial
Unid. Passerine	0.1	0	0	1	Terrestrial
Pisces (6%)					
<i>Lepomis gibbosus</i>	0.9	3	1	6	Aquatic
<i>Mugil</i> sp.	0.5	0	3	2	Aquatic
<i>Gambusia holbrooki</i>	1.6	0	11	6	Aquatic
Unid. Cyprinidae	1.6	1	0	16	Aquatic
Unid. fish	1.6	2	3	12	Aquatic
Amphibia (2.9%)					
<i>Rana perezi</i>	2.9	0	24	8	Aquatic
Reptilia (2.3%)					
Unid. Gekkonidae	0.3	0	1	2	Terrestrial
Unid. Lacertidae	1.1	0	4	8	Terrestrial
<i>Acanthodactylus erythrurus</i>	0.4	0	2	2	Terrestrial
<i>Psammmodromus algirus</i>	0.5	0	5	1	Terrestrial
INVERTEBRATES					
Crustacea (64.3%)					
<i>Procambarus clarkii</i>	64.3	63	319	320	Aquatic
Insecta (16.8%)					
ORTHOPTERA					
<i>Gryllotalpa gryllotalpa</i>	2.3	6	8	11	Terrestrial
<i>Anacridium aegyptium</i>	3.2	0	5	30	Terrestrial
<i>Gryllus campestris</i>	0.1	0	1	0	Terrestrial
<i>Mantis religiosa</i>	0.1	0	0	1	Terrestrial
ODONATA (adults)	2.6	0	9	19	Terrestrial
LEPIDOPTERA	0.5	0	3	2	Terrestrial
COLEOPTERA					
<i>Hydrous pistaceus</i> (larvae)	2.7	0	11	18	Aquatic
Unid. Coleoptera	0.3	0	0	3	Terrestrial
Unid. Insect	5.1	1	29	26	Terrestrial
Annelida (0.2%)					
Unid. Annelida	0.2	0	1	1	Terrestrial
Unidentified prey (7.1%)	7.1	4	49	24	
Total		80	489	522	

fish (*Procambarus clarkii*) was the primary prey species (64% of prey items, N = 1091). Secondary prey items were insects (17%), such as grasshoppers (mainly *Anacridium aegyptiacum*), beetles (mainly larvae of *Hydrous pistaceus*), dragonflies (Odonata) or crickets (mainly *Gryllotalpa gryllotalpa*), and fish (6%).

Crayfish was the main prey in all three seasons (courtship-period = 79%, early period = 65%, late period = 61%). The propor-

tion of terrestrial prey taken was 21% (217 of 1014). Comparison of aquatic and terrestrial prey types by season showed a significant difference ($\chi^2_2 = 16.2$, $P < 0.001$), with proportionately more aquatic prey brought to the colony during courtship-period. The composition of prey delivered to chicks during early and late periods varied significantly ($\chi^2_1 = 11.7$, $P < 0.001$). Chicks were fed proportionately more aquatic prey earlier in the season. The proportions of vertebrate and inverte-

brate prey did not change significantly during the season ($\chi^2_2 = 2.4$, n.s.).

DISCUSSION

Previous studies in Spain have reported both geographical and seasonal differences in the diet of nesting Gull-billed Terns, suggesting that different diets were explained by changes in the foraging habitats. At Fuente de Piedra (southern Spain), prey fed to young were mostly insects (Orthoptera 76%) (Sánchez *et al.* 1991), whereas at the Guadalquivir marshes (SW Spain), prey were mainly crustaceans (Red Swamp Crayfish 40%) (Costa 1984). Extensive rice fields exist around the colony at the Guadalquivir marshes and the introduction of the Red Swamp Crayfish at this location in 1974 caused a shift in prey abundance (Costa 1984). The Red Swamp Crayfish also formed an appreciable part of the diet of breeding Gull-billed Terns at l'Albufera de Valencia. This crustacean was introduced to l'Albufera in 1976 and it is now widely used as prey by waterbirds in the extensive rice fields (Dies *et al.* 2003). A large dependence on a single crustacean species (Fiddler Crab, *Uca* spp.) by Gull-billed Terns feeding their young has also been reported in eastern North America (Erwing *et al.* 1998).

The prey observed in our study (particularly crayfish, fish, frog and aquatic insects; accounting for 76% of prey total) suggests that the Gull-billed Terns foraged mostly in rice fields, which were flooded during the terns' breeding season and easily accessible from the colony site. Other prey species, such as reptiles (particularly *Acanthodactylus erythrinus*) were obtained from the coastal dunes of the beach barrier. Although the primary prey was the same throughout the season, significant seasonal changes were observed in the secondary prey items. Rice grows taller and denser through the season, obstructing aerial access by foraging Gull-billed Terns, and this could explain the higher proportion of aquatic prey early in the season.

Our results are consistent with previous studies (Møller 1977; Sánchez *et al.* 1993) suggesting that Gull-billed Tern rely on spe-

cialized diets at lower latitudes, preying heavily on a small number of species, presumably the more profitable energetically.

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