

Some comparative aspects of the breeding biology of Black-headed Gull (*Larus ridibundus*), Common Tern (*Sterna hirundo*) and Little Tern (*Sterna albifrons*) in the Lagoon of Venice, NE Italy

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Abstract - During the years 1989-1992 three species of Laridae and Sternidae breeding in the lagoon of Venice were studied. The breeding population of *L. ridibundus* increased steadily through the period of study, whereas *S. hirundo* was stable and *S. albifrons* decreased. Almost all of the colonies were closely clustered in the southern lagoon, where human disturbance is less heavy. Colonies were located on a few of the apparently favourable sites. Colony size was significantly higher in *S. hirundo* (90.8 ± 80.1 , $n=45$) than in *S. albifrons* (51.9 ± 72.3 , $n=12$) and in *L. ridibundus* (26.3 ± 42.5 , $n=20$). *S. hirundo* was significantly associated with *L. ridibundus*, whereas *S. albifrons* avoided the occurrence of the latter species. Site tenacity did not differ among species, with the majority of sites being occupied only for one or two years. Suggestions for the protection of the colonies are proposed.

Introduction

The status, distribution and breeding biology of gulls and terns in the Lagoon of Venice, the largest coastal lagoon of Italy and one of the most important in the whole Mediterranean, are poorly known. Only in 1984 data were systematically gathered (Fasola 1986) and showed that four species were breeding; Black-headed Gull (*Larus ridibundus*), Yellow-legged Gull (*Larus cachinnans*), Common Tern (*Sterna hirundo*) and Little Tern (*Sterna albifrons*). In more recent publications dealing with seabirds breeding in Mediterranean wetlands no new data were presented for the Lagoon of Venice (Fasola et al. 1989).

In 1989 we began a comprehensive survey of the colonies of Black-headed Gull, Common Tern and Little Tern occurring in the Lagoon of Venice, aimed to:

- follow the populations trend over the years;
- analyse differences on some aspects of the breeding biology (colony size, site occupancy, species association) among the three species;
- propose measures for conservation and management of the colonies.

This note presents the results for the 1989-1992 period.

Methods

The Lagoon of Venice is a coastal lagoon between the mouths of the rivers Brenta and Piave ($45^{\circ}11' - 45^{\circ}34' N$, $12^{\circ}18' - 12^{\circ}38' E$), along the Adriatic Sea in northeastern Italy. Its surface is some 550 km² wide; the lagoon is bordered by two barrier islands and it exchanges water with the sea through three entrance channels.

There is an extensive, central waterbody (about 400 km²) with bottoms that are partly covered with *Ulva laetevirens* and *Zostera marina*, tidal mudflats (mostly bare and exposed at low tide) and hundreds of muddy islets covered with halophilous vegetation (mainly *Limonium serotinum*, *Salicornia* sp. pl., *Halimione portulacoides* and *Spartina stricta*) that are usually flooded at high tide. Peripheral small waterbodies, with low salinities, are used for fish farming and hunting and totalize about 130 km², the remaining area (about 20 km²) being occupied by the town of Venice and surrounding islands. Only a very small part of the Lagoon is protected, while the remaining part is threatened by pollution, disturbance by tourism and hunting.

Field data for the Black-headed Gull, Common Tern and Little Tern were gathered during direct censuses of the whole central waterbody which were carried out from 1989 through 1992. Besides the three species

mentioned above, only the Yellow-legged Gull (*Larus cachinnans*) nests in the lagoon, with two monospecific colonies (780 nests in 1989; S. Amato, pers.comm.). A colony was defined (Goutner 1990) as any aggregation of two or more nests situated more than 200 m from another group of nests; nine single nests of Common Tern were excluded by all the computations. Site, or colony site, refers to a place where a group of birds breeds, whereas colony size is the number of breeding pairs (=nests found, in our study) in a colony (Burger and Gochfeld 1991).

Each colony was mapped on maps at 1:10,000 scale and visited at least twice from May to July. The figures presented refer to the highest number of nests that were found per each species during the breeding season.

Since the frequency distribution of several parameters did not appear normally distributed, we used non-parametrical tests. All statistical tests were performed with the SPSS statistical package. The significance of the association between two species in the same colonies was tested pairwise using chi-square test; the strength of the association was studied using the index of association (Krebs 1972 in Goutner 1990). This coefficient varies from +1 (complete association) to -1 (complete avoidance), and is 0 for random occurrence (Fasola and Canova 1992). Colony turnover rates (T) between two years were calculated as in Erwin *et al.* (1981): $T = 1/2(S1/N1 + S2/N2)$, where S1=number of sites occupied only on the first census, N1=total number of sites during first census, S2=number of sites occupied only on second census, and N2=total number of sites on the second census.

Results

Black-headed Gull *Larus ridibundus*

In 1984, only one colony with 70 nests (Barbieri 1986) was found. This was also the first breeding record for the species in the Lagoon of Venice. During our census the number of nests increased at a regular rate (Table 1); 20 colonies were found on 15 different sites (Table 2). In Table 3 the distribution of sites number according to the years of occupancy is shown. None of the sites was occupied for all the four years, whereas most of the sites were abandoned after only one year. The turnover rate (0.61) was the highest among the species studied; nevertheless, no significant difference on site occupancy was found among *L. ridibundus*, *S. hirundo* and *S. albifrons* (chi-square=2.73; d.f.=6, P>0.05). Moreover, the size of colonies did not differ significantly among sites occupied in different years (Kruskal-Wallis test, chi-square=3.64, d.f.=3, P=0.16).

In all four years, most of the pairs gathered in only one colony, but a few other pairs were scattered in several small colonies. There were no statistical differences in colony size among different years (Kruskal-Wallis test, chi-square=1.20, d.f.=3, P=0.75). A comparison of the colony size among the three species studied showed statistically significant differences (Kruskal-Wallis test, chi-square=17.49, d.f.=2, P<0.001); *S. hirundo* nested in the largest colonies, and *L. ridibundus* in the smallest.

All the colonies, except one in 1991, were in the southern lagoon. Sixteen (80%) were mixed, all with Common Tern whereas Little Tern was observed only in three (15%).

The association with *S. hirundo* was significantly positive (index of association: +0.19, chi-square=6.95, d.f.=1, P<0.01). At the opposite, *L. ridibundus* is significantly non-associated with *S. albifrons* (index of association: -0.33, chi-square=10.25, P<0.01).

Monospecific colonies of *L. ridibundus* did not differ significantly in size from those with either one or both the other species (Kruskal-Wallis test, chi-square=5.70, d.f.=2, P=0.05).

Among other species of Charadriiformes nesting in the same sites, Redshank (*Tringa totanus*) was recorded in all the colonies, with Black-winged Stilt (*Himantopus himantopus*) observed in only one colony.

Common Tern *Sterna hirundo*

In 1984, 29 colonies were recorded, with a total of 982 nests, accounting for the 21.3% of the Italian breeding population (Bogliani 1986).

Throughout the period of our study, the number of nests regularly increased until 1991, with a slight decrease in the following year (Table 1). Apart from one, all the colonies were located in the southern Lagoon, in an area of some 30 km² which supports almost all the colonies of breeding gulls and terns found in the study. Common Terns breed here along with Little Terns, Black-headed Gulls and Redshanks. This area is unprotected, but human presence is restricted to professional fishermen.

Common Tern was the most common breeding species, being recorded in 45 out of the 55 colonies found in the 1989-1992 period (Table 2). It nested in 27 different sites; only three sites (11.1%) have been occupied without interruption during the study period and gathered the 39.5% of the pairs, over the four years. Turn over rate of the colonies was lower (but not statistically significant) than in *L. ridibundus*, and similar to that of *S. albifrons* (Table 2). Size of colonies among sites occupied for different years did not differ significantly (Kruskal-Wallis test, chi-square=4.58, d.f.=3, P=0.20).

Table 1. Number of nests and of colonies (in brackets) in the Lagoon of Venice.

Species	1989		1990		1991		1992	
<i>L. ridibundus</i>	101	(4)	111	(6)	154	(6)	160	(4)
<i>S. hirundo</i>	832	(12)	1037	(17)	1209	(10)	1008	(6)
<i>S. albifrons</i>	258	(3)	200	(1)	78	(6)	89	(2)

Table 2. Characteristics of the colonies in the lagoon of Venice: years 1989-1992 (T=mean turnover rate of the colonies).

Species	n. of sites	n. of colonies	Colony size	Mean \pm s.d.	Median	T
<i>L. ridibundus</i>	15	20	2-138	26.3 \pm 42.5	5	0.6
<i>S. hirundo</i>	27	45	3-256	90.8 \pm 80.1	62	0.4
<i>S. albifrons</i>	8	12	2-200	51.9 \pm 72.3	23	0.41

Table 3. Colony sites distribution (percentages; n=total n. of sites) according to the years of occupancy: years 1989-1992.

		Years occupied			
		1	2	3	4
<i>Larus ridibundus</i>	(n=15)	73.4	20	6.6	0
<i>Sterna hirundo</i>	(n=27)	62.9	18.5	7.5	11.1
<i>Sterna albifrons</i>	(n=8)	75	12.5	0	12.5

Colony size differed significantly among years (Kruskal-Wallis test, chi-square=10.8, d.f.=3, $p < 0.05$). Twenty colonies (44.4%) were mixed with the other two species; Black-headed Gull was observed in 18 colonies (40.0%) and Little Tern in 6 colonies (13.3%). The index of association with *S. albifrons* was negative (-0.12) but not statistically significant (chi-square=1.0, d.f.=1, $p > 0.05$). No differences were observed among size of monospecific colonies and that with *L. ridibundus*, *S. albifrons* or both (Kruskal-Wallis test, $p > 0.05$ in each case).

Other breeding species were Redshank (observed in all the colonies), Black-winged Stilt and Yellow-legged Gull, in one colony each.

Little Tern *Sterna albifrons*

Nine colonies were censused in 1984, and totalized 512 nests. In the same year the Italian breeding population totalized 5980 nests, i.e. the 30% of the whole Western Palearctic population (Fasola 1986). During the 1989-92 census the number of nests was well below the 1984 value (Table 1), showing an almost linear decrease through the period of study.

Over the whole period 12 colonies were settled on 8 different sites (Table 2). Only one site has been occupied for four years (Table 3), whereas the majority was abandoned after only one year. No differences were observed among the size of colonies on sites occupied for different years (Kruskal-Wallis test, chi-square=3.57, d.f.=3, $p = 0.16$), and no differences were observed among colony size in each year (Kruskal-Wallis test, chi-square=5.8, d.f.=3, $p = 0.12$). Six colonies (50.0%) were mixed; Common Tern was observed in all of them and Black-headed Gull in 2 (16.6%). Redshank was observed in 8 colonies (66.6%). There was no relationship between *S. albifrons* colony size and occurrence of *L. ridibundus*, *S. hirundo* or both (Kruskal-Wallis test, $p > 0.05$ in each case).

In the lagoon of Venice the Little Tern bred both on salt-marshes and on barrier islands. In the former case colonies were always in the southern lagoon, where breeding sites were shared with Common Terns, Black-headed Gulls and Redshanks. These colonies were always small- or medium-sized, and they were apparently smaller than those on barrier islands (but the difference was not significant: Mann-Whitney U-

test, $z=3.17$, $p=0.06$). The salt-marshes colonies were unstable; for instance, in 1990 any colony was present in this area. On the barrier islands there is only one colony site, but it has been occupied continuously since 1989; in 1989-1991 it hosted the largest colony (up to 200 nests) of Little Tern. It is protected since 1989, but it is reported to suffer from heavy predation due to feral cats. Every year very few pairs start breeding in other sites scattered on barrier islands, but these nests are invariably destroyed by tourists and vandals.

Discussion

Censuses carried out between 1989 and 1992 confirmed that only four species of Laridae and Sternidae breed in the Lagoon of Venice. The main results are the following:

- the population of Black-headed Gull has been gradually rising up, whereas the Common Tern population is stable (1000 to 1200 nests over the last three years). Little Tern population showed year-to-year variations, but should be considered as decreasing over the last four years. Almost all the colonies of gulls and terns were clumped in a small area, which should be protected; this area is of outstanding importance also for Redshank (the most important breeding site in Italy and one of the most important in the whole Mediterranean; Valle *et al.* in press).
- in the Lagoon of Venice *S. hirundo* and *L. ridibundus* are significantly associated in the breeding sites, as found by Fasola and Canova (1992) for the northern Adriatic area of Valli di Comacchio. Moreover, in this last area *S. albifrons* tends to avoid the occurrence in the same colony of *L. ridibundus*, as it happens in our colonies. The non-significant association between *S. hirundo* and *S. albifrons* is in agreement with the results of Goutner (1990) for the Evros Delta (Greece) and those of Fasola and Canova (1992).
- *L. ridibundus*, *S. hirundo* and *S. albifrons* did not show significant different level of site tenacity: most of the sites were abandoned after only one year, and only 4 (12.9%) were occupied continuously over four years. These "usual" sites hosted a remarkable percentage (30.9%) of the total population. Only one of these sites (in a barrier island) is protected, but the hatching success of the Little Tern breeding there is severely limited by predation. Fencing should be adopted in order to limit terrestrial predator movements into this colony; this method has been proved successful against terrestrial predators in numerous sites for different gulls and terns species

(see Rimmer and Deblinger 1992). Moreover, since many other sites are occupied by gulls and terns only one year, at the beginning of each breeding season a preliminary survey of all the sites would be required before protecting the most important of them with specific measures of conservation (i.e. restrictions to boat passage in the surroundings, landing and walking forbidden, posting educational signs).

- despite hundreds of potential breeding sites, islets occupied at least once by terns and gulls were only 31, and the largest colonies were always mixed. These results may be interpreted as attraction between species, or common preference for specific type of sites, or both (see Gotmark 1982). Characteristics of possible breeding sites (size, distance from foraging zone, vegetation cover) play an important role in habitat selection by seabirds (Burger and Lesser 1978, Fasola and Canova 1992).

- for other species occurring in spring-summer in the Lagoon of Venice (Mediterranean Gull *Larus melanocephalus*, Sandwich Tern *Sterna sandvicensis* and Black Tern *Chlidonias niger*) no evidence of nesting was found. In comparison, nine species occur in the 110 km² coastal lagoon of Valli di Comacchio (Fasola and Canova 1991); in the Camargue, which is comparable in size to the Lagoon of Venice, eight species were breeding in 1988 (Boutin *et al.* 1991). We suggest that human impact is responsible for such scarcity of breeding species in our area. It is well known that human disturbance can affect habitat quality for seabirds (Gochfeld 1983); it is worth observing that all the species breeding in the lagoon, except Yellow-legged Gull, are either restricted to a small area of the southern part, where human presence is limited, or nest in protected sites. In contrast the northern lagoon, with its many islets apparently favourable as breeding sites, is heavily affected by human activity (mostly tourism and non-professional fishing) and supports just one colony. Other possible causal factors should be investigated for better explanations of this observation.

- a major long term threat to the occurrence of breeding gulls and terns is posed by the loss (mostly due to the natural compaction of sediments and erosion, this one being man-induced) of salt-marshes islets, the area of which has fallen from 91 km² at the beginning of this century to less than 40 km² at present (Favaro 1992). In 1989 a project of salt-marshes recreation using dredged material was launched by the Ministry of Public Works. Since in USA similar sites have been heavily used by nesting seabirds (see Parnell *et al.* 1986), a monitoring program will be performed in the Lagoon of Venice to investigate about the occurrence of colonies on these new islands.

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Riassunto - Durante gli anni 1989-1992 sono state compiute osservazioni su tre specie di Laridae e Sternidae nidificanti in laguna di Venezia. La popolazione nidificante di *L. ridibundus* è aumentata gradualmente, mentre quella di *S. hirundo* è rimasta stabile e quella di *S. albifrons* è diminuita. Le colonie studiate si concentravano nella laguna Sud, dove la presenza antropica è minore. La maggior parte (56.8%) delle colonie erano miste ed hanno occupato solo alcuni dei potenziali siti di nidificazione. Le dimensioni delle colonie erano significativamente maggiori per la Sterna comune (90.8 ± 80.1 , $n=45$) che non per il Fraticello (51.9 ± 72.3 , $n=12$) o il Gabbiano comune (26.3 ± 42.5 , $n=20$). La fedeltà ai siti riproduttivi è risultata bassa in tutte e tre le specie, senza differenze significative; la maggior parte dei siti è stata occupata soltanto per uno o due anni.

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