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BREEDING BIOLOGY AND COLONY SIZE OF SANDWICH TERN AT L'ALBUFERA DE VALENCIA (WESTERN MEDITERRANEAN)

BIOLOGÍA REPRODUCTIVA Y TAMAÑO DE COLONIA DEL CHARRÁN PATINEGRO EN LA ALBUFERA DE VALENCIA

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The Sandwich Tern *Sterna sandvicensis* started breeding in the Mediterranean basin after the 1950s, by colonisation of La Camargue (France) in 1956, Ebro Delta (Spain) in 1971, Valli di Comacchio (Italy) in 1979 and Evros delta (Greece) in 1981 (Ferrer & Martínez-Vilalta, 1993; Del Hoyo *et al*., 1996). The colony at the Ebro delta maintained over 1000 breeding pairs during the early 1990s and the species started breeding at l'Albufera de Valencia in 1993 (Martínez-Vilalta, 1997; Dies & Dies, 2003). This note gives the first information on the breeding of Sandwich Tern at this new site, which has become the extreme Southwest nesting location for the nominate subspecies.

Breeding by Sandwich Tern in the l'Albufera de Valencia (East Spain; 39°20'N - 0°20'W) occurs in the Racó de l'Olla reserve. This reserve is a 60 ha salt marsh of a barrier island where habitat management and limited access has led to the regular breeding of up to 26 waterbird species (Dies, 2000). Observations from permanent hides were made during eleven breeding seasons (1993 to 2003) and an average of 107 days, corresponding to 321 hours of observation, was spent each year from March to September. Fieldwork methods and observers were consistent over the study period and biases are assumed to be similar throughout. Data on breeding phenology was obtained for the first adult entering the reserve (arrival), onset of egg laying, first hatching and fledged juvenile and last record of adult or juvenile into the reserve (departure). The total period of presence in the reserve was obtained by subtracting arrival from departure dates.

Colonies were entered once each year, about 24 days after the onset of egg laying, to ensure that most clutches were already completed and hatching had not yet started, since incubation averages 25 days (Del Hoyo *et al*., 1996). Breeders nesting on separate islands were regarded as forming subcolonies. The number of nests and eggs was counted at each subcolony separately as estimators of subcolony size and clutch size, respectively. Owing to synchronous laying, both values obtained are considered good estimators, although these may be slightly underestimated, in particularly because of incomplete clutches. Two cases of isolated single nests were not considered in the subcolony size calculation. Annual counts timed with peak nest numbers have been found consistent enough to result in >90% probability of detecting annual changes of ± 3% or greater in nesting seabirds (Johnson & Krohn, 2001). In 1998, eggs of a random sample of clutches were measured (length and width) to the nearest 0.1 mm using a Vernier calliper. In 1994, 1996, 1997 and 1998, censuses of chicks at a single subcolony were performed *ca*. 35 days after hatching and used to estimate the breeding success as the number of chicks per breeding pair. An index of breeding success was calculated as the number of chicks fledged as a percentage of eggs laid estimated from the mean clutch size. Whereas the number of chicks was probably underestimated, the breeding success is considered a minimal value.

Phenology was expressed on the basis of days counted from 1 January and the trend of phenology values (on log-transformed data)

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was tested using the Pearson correlation coefficient (r) at the 0.05 level of significance. The annual growth rates ($\lambda = N_{t+l}/N_t$) of the colonies between year t and $t+l$ was calculated, as well as the mean annual population growth rate ($(N_{2003}/N_{1993})*\exp^{1/10}$) over the study period (Oro, 2002). *G*-test was carried out to compare clutch size frequencies among years. The few three-egg clutches were not considered to avoid the violation of minimum expected frequencies of contingency tables and their applied *G*-test. Egg size was estimated by internal egg volume (cm^3) as determined by Oro (2002).

During the study period, the colony passed from 4 pairs in 1993 to 1422 in 2003, peaking at 1591 in 2002. Mean colony growth in pairs was 1.80 showing an average 158.6 % increase in breeding numbers per year (Table 1). From 1993 to 1995 all breeders nested in a single colony while two to four subcolonies were formed each year from 1996 onwards. Subcolonies varied in size (median = 264 nests; range = 42-1030; *SD* = 319; *n* = 21 subcolonies) and location over the study period, using up to six different islands within the reserve (Table 1).

Arrival of breeders to the reserve was observed between mid March and mid April (median 29 March, range 17 March-19 April; *n* = 10 years). Terrestrial courtship and copulation was recorded immediately after arrival. Egg laying started 30 days later on average (median = 28 April, range = 20 April-23 May). Groups engaged in courtship behaviour where observed far from the breeding area, particularly at coastal beaches, but occurred mostly in places that were subsequently used as nesting sites. Hatching was rather synchronous and started from late May on average (median 19 May). Juveniles were fledged by late June (earliest fledged juvenile observed on 16 June). Departures were observed shortly after chicks fledged and the reserve was fully deserted by late August (median = 26 August, range = 10 August-12 September). Median presence of the species in the reserve was 146 days (range = 139-169 days). Both arrival and departure dates advanced significantly during the study period (r_{10} = -0.758, $P < 0.05$; r_{10} = –0.817, $P < 0.05$, respectively), while laying date and total days of presence showed no significant change during the same period (r_{10} = –0.595, n.s. ; r_{10} = -0.106, n.s., respectively).

All the nests were placed on islands. Islands used for breeding were sandbanks of variable size (average surface 2,200 m^2) and low height (less than 0.7 m); all surrounded by shallow brackish water and covered in sparse low vegetation mainly composed of *Salicornia herbacea* and *Suaeda maritima*. Eggs were laid in shallow scrapes on the ground, the nests forming dense clusters. Modal clutch was two eggs for most years, being, on average, 56.1% of total sampled clutches (Table 2). Clutch size was significantly different among years (G_{12} = 1068, $P < 0.01$), it ranged 1-3 eggs and average

TABLE 1

Numbers of breeding pairs of Sandwich Terns at l'Albufera de Valencia during the study period with the composition of each subcolony. λ is the population growth rate.
[Número de parejas de Charrán Patinegro en l'Albufera de Valencia durante el estudio, con la composición de cada subnúcleo colonial. λ es la tasa de crecimiento de población.]

Year *[Año]*	Llevant	Tramuntana	Mestral	Bocana	Eixaloch	Ponent	Total	λ
1993	4						4	
1994	44						44	11,00
1995	160						160	3,64
1996	264	207					471	2,94
1997	158	105	111	178			552	1,17
1998			671	52			723	1,31
1999		42	717	73			832	1,15
2000		259	431	122	407		1219	1,47
2001		1003	351			1	1355	1,11
2002					787	804	1591	1,17
2003			1		391	1030	1422	0,89

clutch size was 1.54 eggs per nest. In 1998, average clutch volume obtained was 31.20 cm^3 (*SD* = 3.71, range = 24.0-37.6, *n* = 28), mean egg length was 52.16 ± 2.44 mm (range = 46.5-58.5, *n* = 28) and egg width 35.06 ± 1.92 mm (range = 31.4-37.8, *n* = 28).

The average number of chicks fledged per breeding pair was 0.85 (*SD* = 0.24, range = 0.61-1.14, *n* = 4 subcolonies) and the average breeding success was 52.7% (range = 39.8-68.0%, *n* = 4 subcolonies). In 1993, rats (*Rattus* sp.) predated all nests. Two other cases of chick predation by Red Foxes *Vulpes vulpes* and feral dogs *Canis canis* were recorded in June 1996 and in July 1999, respectively. The presence of the dog caused an «alarmed crèche» (Smith, 1975), the chicks coming together into two tightly packed moving masses. No other predation of eggs and chicks was recorded. Egg losses due to nest flooding after heavy rain storms during egg laying period were also recorded.

The terns always nested accompanied by other colonial Charadriiformes, particularly Common Tern *Sterna hirundo* and Black-headed Gull *Larus ridibundus*, and to a lesser degree by Avocet *Recurvirostra avosetta*, Black-winged Stilt *Himantopus himantopus*, Slender-billed Gull *L. genei* and Gull-billed Tern *S. nilotica*. Other Charadriiformes breeding in the reserve, such as Yellow-legged Gull *L. michaellis*, Collared Pratincole *Glareola pratincola* and Little Ringed Plover *Charadrius dubius*, were never found nesting with the Sandwich Terns. Seven cases of hybridisation with Lesser Crested Tern *S. bengalensis* were recorded from 1994 to 1998 (Dies & Dies, 1998).

Breeding phenology at l'Albufera de Valencia was similar to that given for northern European colonies (Smith, 1975). The advance of the arrival date over the study period is probably explained by the same returning individuals with increased familiarity with the new breeding site, regarding that egg laying did not started significantly earlier during the same period. Breeding was successful overall and no remarkable failure, desertion or predation was noted. The lack of records of predation by Yellow-legged Gulls is noteworthy, since the species predate heavily upon nests and chicks of other Charadriiformes (Del Hoyo *et al*., 1996) and it is probably explained by the Yellow-legged Gull being a scarce breeder (0-5 nests) in the area during the study. Black-headed Gull and Slender-billed Gull became occasional kleptoparasites of Sandwich Terns, as recorded elsewhere (Stienen *et al*., 2001; Oro, 2002).

The breeders split into a number of separate subcolonies after 1995 for no apparent reason;

TABLE 2

Clutch size of Sandwich Terns at l'Albufera de Valencia during the study. Percentages of clutch size are shown in parentheses.
[Tamaño de puesta de Charrán Patinegro en l'Albufera de Valencia durante el estudio. Los porcentajes del tamaño de puesta se indican entre paréntesis.]

	1 egg *[huevo]*	2 egg *[huevos]*	3 egg *[huevos]*	Mean *[Media]*	*n*
1997	179 (32,4)	371 (67,2)	2 (0,4)	1,68	552
1998	221 (33,1)	445 (66,7)	1 (0,1)	1,67	667
2000	257 (21,4)	940 (78,4)	2 (0,2)	1,79	1199
2001	1003 (75,5)	323 (24,3)	3 (0,2)	1,25	1329
2002	911 (61,6)	562 (38,0)	6 (0,4)	1,39	1479
2003	535 (37,6)	880 (61,9)	6 (0,4)	1,63	1421
Total %	3106 (46,7)	3521 (53,0)	20 (0,3)	1,54	6647

although it has been suggested that dense nesting habits of the species has necessitated the division into subcolonies as an adaptation against ground predators, disturbance and adverse weather (Smith, 1975). Islands were used in a sequence of four to six consecutive years before being abandoned. Nomadic breeding behaviour in Sandwich Tern has been described already (Del Hoyo *et al*., 1996; Gochfeld & Burger, 1996; Parnell *et al*., 1997) and seems an evolutionary selected strategy in unstable environments (Crawford, 2003; D. Oro, *in litt*.). Hence, rapid appearance of whole colonies in new sites, and disappearance from others, suggest group adherence in Sandwich Tern (McNicholls, 1975).

There was no proved breeding of the species in the study area prior to that first confirmed in 1993. The increase trend that the species has undergone in l'Albufera de Valencia has also been registered at other Mediterranean locations which were colonised previously. As suggested for the Camargue (Sadoul *et al*., 1996), immigration rather than local recruitment and local resources to accommodate new populations probably explains this increase. In the Ebro delta, protection of breeding grounds from human disturbances was an important factor for seabird population growth during the 1980s, when a strong immigration process occurred at this site (Oro, 1999). After the immigration process to the Ebro delta, large food availability, including trawler fishery discards, influenced high breeding success, high recruitment rates and rapid accession for breeding (Oro & Ruiz 1997; Oro, 1999). The long-term increases that the Sandwich Tern experienced in the Camargue and the Ebro delta made colonisation of new areas feasible. In fact, there was a breeding attempt in Salinas de Santa Pola (SE Spain) (*ca*. 311 km south of the Ebro delta) in 1993 (Ramos & Aragoneses, 1995). This illustrates that population structure of the species has to be considered at a metapopulation level (Buckley & Downer, 1992; Sadoul, 1997). Local resources appear to have favoured the establishment of the species at l'Albufera de Valencia. The nesting site is controlled under management, hence reducing the effect of some adverse factors, and the species essentially feeds at sea (Dies, 2000). Monitoring colonial waterbirds demands a long term approach (Sadoul, 1997) and further research is needed in order to assess causes of recent changes in Sandwich Terns numbers in the Western Mediterranean and to prioritise conservation strategies at a wider perspective.

RESUMEN.—*Se presentan los primeros datos sobre la biología de reproducción de Charrán Patinegro en España, obtenidos entre 1993 y 2003 en l'Albufera de Valencia. La especie nidificó en una reserva protegida y el número de pares nidificantes incrementó de 4 a 1.422 durante el estudio, alcanzando un máximo de 1.591 en 2002 (tasa media de crecimiento de la colonia de 1,80 por año). A partir de 1996 se formaron entre dos y cuatro subcolonias cuya posición cambió con los años, de forma que utilizaron hasta seis islas diferentes dentro de la reserva. Durante el estudio, las fechas de llegada y partida de los Charranes se adelantó con los años, aunque el inicio de la puesta no se adelantó en igual medida. Los Charranes siempre estuvieron acompañados por otros Charadriiformes, particularmente Charrán Común y Gaviota Reidora. El tamaño medio de la puesta fue 1,54 huevos por nido y la puesta modal fue de dos huevos. El éxito reproductor fue 0,85 pollos por nido (52,7% de los huevos puestos). Ocasionalmente se registró depredación por mamíferos terrestres y la pérdida de huevos por inundación del nido durante fuertes tormentas.*

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