

Kleptoparasitism and Host Responses in a Sandwich Tern Colony of Eastern Spain

J. IGNACIO DIES¹ AND BOSCO DIES

¹Oficina Técnica Devesa-Albufera. CV-500 km 8.5, E46012 Valencia, Spain.

Internet: jidies@hotmail.com

Abstract. – We report on the incidence of kleptoparasites and the host avoidance responses in a colony of the Sandwich Tern (*Sterna sandvicensis*) at l'Albufera de Valencia, eastern Spain, in 2004. Apart from conspecifics, five species were kleptoparasites of breeding Sandwich Terns, particularly Black-headed Gull (*Larus ridibundus*) and Slender-billed Gull (*L. genei*). Avian kleptoparasites attacked 24% of the Sandwich Terns returning to the colony with fish (N = 659) and robbed 5.3% of them. Most terns (85%) delivered their prey to a mate or chick. Fish carried by terns were mainly Clupeiformes species (96%). Prey size declined significantly as the season progressed. The probability of attack increased significantly with fish size and declined significantly as the season progressed. Most attacks were on terns as they landed to deliver their prey. Overall success rate of attacks was 12.5% and were mostly performed by single birds. The time that the terns spent flying before landing to deliver prey increased with the size of carried fish. Received 20 October 2004, accepted 28 December 2004.

Key words: Sandwich Tern, *Sterna sandvicensis*, kleptoparasitism, host response, fish size, *Larus*.

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Kleptoparasitism is a foraging method well documented in seabirds, particularly during the breeding season, owing to the large concentrations of potential hosts that represent an abundant food supply (Furness 1987). Kleptoparasitism can involve an aerial chase, or the stealing of food from adults while feeding chicks, thus becoming the most frequent type of disturbance at colonies in some species (Burger and Gochfeld 1996). Nesting Sandwich Terns (*Sterna sandvicensis*) appear to intentionally seek the proximity of gulls, from whose anti-predator behavior they benefit (Veen 1977; Oro 2002). However, some nearby breeding gulls become specialized kleptoparasites, which may have a detrimental effect on productivity of the host (Furness 1987; Ratcliffe *et al.* 1997; Stienen *et al.* 2001). Terns have developed defensive-avoidance strategies against kleptoparasites (Cavanagh and Griffin 1993; Shealer and Burger 1992; Stienen and Brenninkmeijer 1999). Effective ways to avoid robbing adopted by Sandwich Terns include luring the chicks away from the robbing gulls, masking feeding events by forming a shield with the wings, or shifting the diet to a prey less vulnerable to kleptoparasitism (Stienen *et al.* 2001).

The Sandwich Tern has two breeding locations in Spain, nesting with potential kleptoparasites at both sites (Dies and Dies

2003). Therefore, interspecific interactions with potential robbers deserve consideration since they can affect the population dynamics of the subordinate species (Martínez-Abraín *et al.* 2003). Here we report on the incidence of kleptoparasites on the Sandwich Tern colony of l'Albufera de Valencia, Spain, and on the responses developed by the terns.

METHODS

The study was carried out at the barrier island-lagoon complex of l'Albufera de Valencia (39°20' N, 00°20' W; eastern Spain). Observations were made at the Racó de l'Olla, a 64 ha saltmarsh located in the beach barrier, which supports several species of colonial nesting Charadriiformes (Dies 2000). The Sandwich Tern colonized l'Albufera de Valencia in 1993, and has since then showed an average increase of ca.160% in breeding numbers per year (Dies and Dies *in press*). The site is the extreme southwest breeding location of the species in the Western Palearctic. Observations were conducted from the onset of egg laying to the dispersal of the first fledglings (27 April to 25 June 2004) in a colony at Ponent Island (1,467 nesting pairs) which was the only colony of the species at the study site in that year.

Terns entering the colony with fish were observed from an elevated hide, using 10 × 40 binoculars. Observations were approximately one hour in duration, were evenly distributed between 07.30 h and 19.30 h, and resulted in 30 hours of observation. Focal terns were watched to determine whether they delivered the fish, were attacked by kleptoparasites or ate their prey (see Ratcliffe *et al.* (1997) for similar procedures).

A stopwatch was used to time the interval between entry to the colony and prey delivery of each focal tern. Only the time-score of terns that were not attacked by kleptoparasites was considered in the analy-

ses. For all attacks on focal terns, the type of attack (assault or aerial pursuit), the species and number of individuals involved, the length of aerial pursuit attacks (in seconds) and the outcomes of attacks (successful or unsuccessful) were recorded. Assaults were sudden attempts to seize the host prey, when the adult was on the ground.

The fish prey was identified by comparison with dropped specimens collected in the colony site. The length of each fish was compared to the culmen length of adult Sandwich Terns and classified into three broad size classes (1: <1 bill length, 2: 1-2 bill lengths, 3: >2 bill lengths). Small sized Clupeidae and Engraulidae species were difficult to separate and species of both families were grouped into the Order Clupeiformes. Less than 1% were unidentified fish. To assess possible seasonal changes in prey size and attack rates, the prey brought to the colony were examined in three stages. Fish captured before hatching were grouped into the "courtship period" of 27 April to 20 May (N = 147 observations). Fish taken during chick feeding were separated in the "early stage" from 25 May to 9 June (N = 240) and the "late stage" from 10 June to 25 June (N = 247). Only Clupeiformes, which formed 96% of fish carried, were considered in this study.

Logistic regression analysis was performed to model the relationship between the variables studied on the probability of an attack taking place and the G statistic to determine the overall significance for the model. Fish size and date were defined as independent variables. Contingency tables were used together with the chi-square statistic to analyse frequencies.

RESULTS

Kleptoparasites attacked 24% of all observed Sandwich Terns returning to the colony with fish (N = 659). Most terns succeeded in delivering their prey to a mate or chick (85%). Kleptoparasites robbed 5.3% of studied terns. Terns seldom ate the prey they were carrying (1.1%) and the fate of 8.3% was unknown because the terns were lost from sight while still carrying the fish.

The fish species carried by terns were mostly Clupeiformes, including Anchovy (*Engraulis encrasicolus*), Sardine (*Sardina pilchardus*) and Gilt Sardine (*Sardinella aurita*). Other prey amounted to less than 4% (including Gadidae, Soleidae, Mugilidae, Sparidae and Belontiidae species). Relative frequencies of fish size classes fed to mate or chicks by the terns are shown in Table 1. Prey size declined significantly with season ($\chi^2_4 = 64.9$, $P < 0.001$). During courtship, large (Size 3) fish were the most frequently carried by terns (47%) during early chick feeding, medium (Size 2) fish dominated (47%) and during late chick feeding, 48% of fish were small (Size 1; Table 1). In only seven of 634 occasions were terns recorded carrying two small or medium sized fish.

The probability of attack increased significantly with fish size (logistic regression, $G^2_1 = 533$, $P < 0.001$). Thus, terns carrying Size 1 fish resulted in a 0.04 probability of being attacked by robbers, but this probability increased to 0.21 for terns carrying Size 2 fish and to 0.69 for those carrying Size 3 fish. The probability of attack declined significantly as the season progressed (logistic regression, $G^2_1 = 714$, $P < 0.001$). During the courtship period, the probability of attack was 0.38, while during the early and late stages of chick feeding period it was 0.19 and 0.18, respectively. Attack rates for particular fish size classes decreased significantly with season in the case of Size 1 and Size 2 classes ($\chi^2_2 = 11.9$ and $\chi^2_2 = 11.2$, $P < 0.01$ respectively) but remained similar through time for Size 3 ($\chi^2_2 = 2.7$, n.s.). Terns carrying Size 3 fish resulted in the greatest risk of attack in each time period (0.6, 0.73 and 0.79, respectively).

Most kleptoparasitized terns (64%) experienced a single attack during each visit but others accumulated up to seven attacks in a single visit, before the prey was lost or delivered.

Table 1. Distribution of observation effort and fish sampled (only Clupeiformes), together with the relative frequency (%) of fish size classes fed to mates or chicks through the season by Sandwich Terns breeding in l'Albufera de Valencia during 2004. The calculated value of the χ^2 test statistic and the level of significance is also given for the frequencies of each size class (1: <1 bill length, 2: 1-2 bill lengths, 3: >2 bill lengths).

Dates	Courtship 27 April-20 May	Early chick feeding 25 May-9 June	Late chick feeding 10 June-25 June	χ^2_2	P
No. of hours	11.0	9.0	10.0		
No. of fish	147.0	240.0	247.0		
Size 1 (%)	14.9	36.9	48.2	26.5	<0.01
Size 2 (%)	20.4	46.8	32.7	28.1	<0.01
Size 3 (%)	47.4	19.0	33.6	14.1	<0.01

ered. Attacks ($N = 263$) consisted of assaults on terns (63%) as they landed to deliver prey or aerial pursuits (37%) around the colony site. Aerial pursuits took place during landing attempts and only lasted a few seconds (Mean = 3 ± 1.6 seconds; Range = 1-11, $N = 98$). Overall success rate of attacks was 12.5%. Assaults resulted more successful (14.5%, $N = 165$) than aerial pursuits (9.2%, $N = 98$) ($\chi^2_1 = 5.9$, $P < 0.05$; with Yates' correction). Most attacks were performed by a single robber (86%) but they could be joined by up to five robbers.

Five species were kleptoparasites of breeding Sandwich Terns. Black-headed Gull (*Larus ridibundus*) was the most frequent robber, with 67% of cases ($N = 263$ attacks) and a success rate of 13%. Slender-billed Gull (*L. genei*) was responsible for 23% of attacks and accumulated a success rate of 10%. Other species engaged in robbery were Common Tern (*S. hirundo*), Gull-billed Tern (*S. nilotica*) and Mediterranean Gull (*L. melanocephalus*), and each was involved in less than 4% of cases, with very low or no success. Intraspecific kleptoparasitism was recorded in 5% of cases, with a success rate of 29%. In 4% of cases, more than one species were involved in the same attack.

Terns returning with fish flew directly to their nest sites. To evade robbers, terns aborted landing and kept flying around the colony while still carrying the fish. In most instances, several landing attempts were observed before landing, even if no attack was recorded. Therefore, the interval between entry to the colony and fish delivery increased with the number of landing attempts. The mean time spent to deliver prey by returning terns that were not attacked was 27 seconds ($SD \pm 31$; $N = 473$). Mean time changed significantly with size class of carried fish ($\chi^2_2 = 11.3$, $P < 0.01$) (Fig. 1). Terns carrying Size 1 fish averaged 18 seconds ($SD \pm 20$; $N = 235$) to deliver their prey, terns carrying Size 2 fish averaged 34 seconds ($SD \pm 32$; $N = 205$) and terns carrying Size 3 fish averaged 45 seconds ($SD \pm 62$; $N = 33$).

DISCUSSION

Rates of kleptoparasitism in this study were lower than those reported for the same species at Griend, in The Netherlands

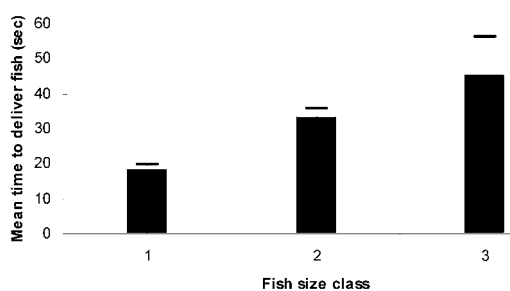


Figure 1. Distribution of the mean time in seconds ($\pm SE$) spent to deliver fish to mate or chick by adult Sandwich Terns arriving to the colony in l'Albufera de Valencia, E Spain, during 2004 ($N = 473$). Time is given by fish size classes (1: <1 bill length, 2: 1-2 bill lengths, 3: >2 bill lengths).

(Stienen *et al.* 2001), and were similar to those reported for several species of terns at Coquet Island, England (Ratcliffe *et al.* 1997). Approximately a quarter of the Sandwich Terns returning to the colony with fish were attacked by kleptoparasites, although success rate of attacks was low. Thus, at least 85% of terns delivered the prey to a mate or chicks in our study, whereas only 71% did so in the Dutch colony. Kleptoparasitism rates of terns by gulls vary greatly according to species or location and high values may reduce tern productivity (Ratcliffe *et al.* 1997; Furness 1987). Prey lost to kleptoparasitism in our study is unlikely to represent a threat to Sandwich Terns breeding in Spain.

Black-headed Gulls were the most frequent kleptoparasites. This could be explained by their local abundance (522 pairs in the study site, 41 of them in the studied island), although similar interspecific interactions have been reported in other European colonies (Fuchs 1977; Ratcliffe *et al.* 1997; Stienen *et al.* 2001). Slender-billed Gulls were probably involved in more attacks than expected considering the small numbers at the study site (48 pairs, nesting 350 m away from the studied island). This gull species breeds syntopically with Sandwich Tern (Dies and Dies 2000; Oro 2002), thus making interspecific behavioural adaptations feasible. No attempt at egg or chick predation was recorded, although this gull took some eggs from unattended flooded nests after an early May rainstorm.

Fish brought to the colony were mainly shoaling clupeoids, which are a resource typically exploited by terns in the Mediterranean (Oro and Ruiz 1997). The presence of epipelagic prey, such as Gadidae species, may be indicative of eventual exploitation of trawling discards by terns during our study (A. Martínez-Abraín, pers. comm.). The probability of kleptoparasitism attacks was always greater in birds carrying larger fish. The size of the fish declined as the breeding season progressed and the attack rate decreased with the season, although it maintained similarly high through time for terns carrying large sized fish. Prey size reduction could be a strategy developed by terns to reduce the chance of robbery since kleptoparasites tend to select terns with larger prey (Fuchs 1977; Ratcliffe *et al.* 2001; this study). Although larger clupeoids are more profitable in energetic terms (Palomera and Pertierra 1993), it has been suggested that robbing gulls select for prey length or visibility rather than for energy content (Ratcliffe *et al.* 2001).

The success of attacks to terns can increase with the number of gulls involved (Oro 1996), although kleptoparasitizing terns in groups can also result in an overall decline in individual success (Ratcliffe *et al.* 2001), which could explain why most attacks were performed by a single robber in this study. Some attacks consisted mostly of assaults as the tern landed, which was also the most successful technique. Attacks developed into aerial pursuit when the host aborted landing. Since terns are faster in flight, gulls may be reluctant to get involved into energy costly aerial pursuit and thus seldom perform this attack or do so for a few seconds. In fact, the most successful robbers in this study were conspecific individuals, which were more competent chasers. This agrees with Oro and Martínez-Vilalta (1994), who suggested that robbing success also depended on the flight speed and agility of the host.

The results suggest that terns delayed fish delivery in the presence of active robbers around the landing area, which could be an avoidance technique not yet fully described. Robbers placed themselves in the colony,

waiting for the arrival of terns carrying fish. When a potential host was targeted, they tried to seize the host's fish or engaged in an aerial pursuit. The time spent flying by terns before landing increased with fish size. Although terns flying around the colony with fish in their bill are exposed to kleptoparasites, they rely on a faster flight to avoid pursuers while waiting for the landing zone to become safe. The terns would finally land to deliver their prey in the absence of robbers that, at the same time, may be engaged in chasing of another host carrying a bigger, hence more attractive, fish in the bill.

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