FACTORS AFFECTING THE BREEDING SUCCESS OF ARCTIC TERNS *STERNA PARADISAEA* IN A COLONY AT KALDBAKSBOTNUR, FAROE ISLANDS

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Schreiber, J. & Kissling, W.D. 2005. Factors affecting the breeding success of Arctic Terns *Sterna paradisaea* in a colony at Kaldbaksbotnur, Faroe Islands. Atlantic Seabirds 7(3): 97-105. *Food shortage and predation are the main factors limiting the breeding success of many colonial seabirds. The aim of this study was to examine whether they influence breeding success of Arctic Terns* Sterna paradisaea *in a colony of 99 breeding pairs at Kaldbaksbotnur on the island of Streymoy, Faroe Islands. In 2003, we investigated clutch size, hatching success, food provisioning to chicks, kleptoparasitism, and predation, and the number of fledged chicks. Clutch size was on average 1.65 (±0.48) eggs/clutch with a hatching success of 100%. Food provisioning rates were low with 0.47 (±0.18) feeds per nest per hour. Most prey items were small (c. 32 mm long), and terns showed high rates of intraspecific kleptoparasitism. Attacks by avian predators were occasionally observed, mainly by Herring Gulls* Larus argentatus, *but were unsuccessful in all observed cases. Counts of fledged chicks indicated average breeding productivity of 0.22 chicks per pair. Our results suggest that breeding success in this colony was mainly affected by food shortage, possibly limited sandeel* Ammodytes *spp. availability. Predation appears to be less important, but could occur at a low rate. The results are consistent with recent evidence showing that seabirds that feed on sandeels currently have limited breeding success in the North Atlantic region.*

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INTRODUCTION

As a circumpolar breeding species, Arctic Terns *Sterna paradisaea* are widespread in the North Atlantic region (del Hoyo *et al.* 1996), including the Faroe Islands. In 1981, the Faroese population of Arctic Terns was estimated to be 11,800 pairs (Bengtson & Bloch 1983). In recent years, a marked decline in the population was assumed because the numbers and sizes of colonies seemed to have decreased (B. Olsen, *pers. comm.* 2003). However, since the investigations by Bengtson & Bloch (1983) no detailed studies on Arctic Terns have been conducted on the Faroe Islands, and the factors influencing Arctic

Tern breeding success and population trends at this locality are not known. Two main factors are commonly reported to influence the breeding success of colonial seabirds. Firstly, major breeding failures are often caused by food shortage (Croxall *et al.* 1999; Mavor *et al.* 2004, 2005), and this has been confirmed for Arctic Terns in particular (Monaghan *et al.* 1992; Suddaby & Ratcliffe 1997). Secondly, predation is known to be a major factor causing declines in seabird numbers including Arctic Terns (Becker 1995; Whittham & Leonard 1999, 2000; Nordström *et al.* 2004).

The aim of this study was to investigate factors influencing breeding success of Arctic Terns in one colony on the Faroe Islands. We examined whether Arctic Tern breeding success at this site is affected by predation and/or food availability. We thus determined clutch size and hatching success, observed food provisioning to chicks, kleptoparasitism, and predation attacks, and finally counted fledged chicks. The results may help to evaluating potential reasons for the decline in Faroese Arctic Tern numbers.

METHODS

Arctic Terns were studied in 2003 at one colony on the Faroe Islands - Kaldbaksbotnur (62°04' N; 6°55' W) on the main island of Streymoy, 13 km north-west of the capital Tórshavn. The study site was visited at least every two days by one or two observers. Observations on food provisioning, kleptoparasitism, and predation were made with binoculars and a spotting scope from a nearby hill about 45 m from the colony centre. During the incubation period, nests within the colony were visited every 4-5 days to determine clutch sizes, hatching success (i.e. the percentage of nests producing at least one chick), and chick numbers. To minimize disturbance, 30 intensive study nests in different parts of the colony were selected for frequent checks during the whole season. Twenty of these were marked with numbers on wooden sticks for detailed observations from outside the colony. Once hatching had started, the 30 clutches were checked every two days. No visits were made during unfavourable weather conditions. The number of eggs or chicks was registered during each visit as well as any signs of imminent hatching.

To investigate food provisioning to chicks and kleptoparasitism, terns were observed at 11 of the 30 study nests. Observations were made in series within four days between 0400 hrs and 2200 hrs GMT over several hours at different times of day. However, this was often difficult because of poor weather conditions, fog and heavy rain rendering fieldwork impossible. Therefore data from incomplete observation series were used only to calculate the rate of kleptoparasitism. For calculations of the food provisioning rate only one complete observation series could be used (15-18 July) when five nests

were monitored continuously for 14 hours. Kleptoparasitism was investigated by recording attacks from other Arctic Terns, their duration, and the success or failure of the food provisioning event. Food provisioning rate was calculated as the number of prey items delivered to the chick per nest per hour (nests only contained one chick). Prey size was estimated in adult tern bill lengths whenever visible. In most cases, prey species were not identified.

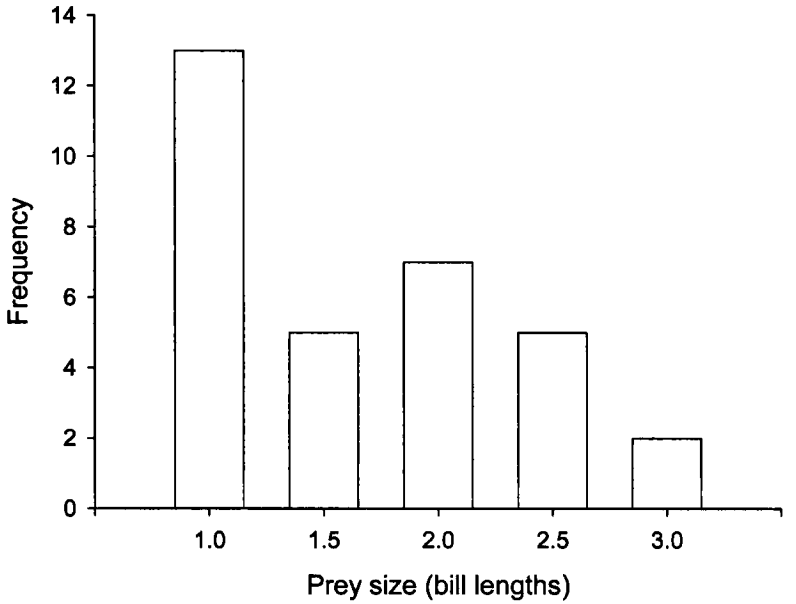
Predation was assessed at two levels. Predation attacks from flying predators were observed from outside the colony on each visit to the study site (a total of 61 observation hours). In addition, the disappearance of eggs and/or chicks from our 30 intensive study nests was taken to indicate predation by avian and/or mammalian predators. For predator observations from outside the colony, the following parameters were recorded: time of predation event, number and species of predator, reaction of the terns, and success/failure of the attack.

In order to estimate breeding productivity of this colony, seven counts of large and fledged chicks were made between 23 July and 5 August. Counts were facilitated by adults leading their chicks to a nearby stream, where they were easily visible. The maximum number of large and fledged chicks was divided by the number of breeding (i.e. egg laying) pairs, and this value was taken as an estimate of the breeding productivity per pair in this colony (see Walsh *et al.* 1995).

RESULTS

Clutch size and hatching A total of 99 breeding pairs was recorded; 64 were two-egg clutches (65%) and 35 one-egg clutches (35%). An overall, average clutch size of 1.65 (± 0.48) eggs per clutch was estimated. The 30 intensive study nests contained a total of 47 eggs, and thus the mean clutch size (1.57 ±0.5 eggs/clutch) of this sample was relatively similar to the overall estimate. Two eggs or chicks disappeared from the clutches and were thus considered to be depredated, and three eggs (6%) were given up. Thus, a total of 42 chicks hatched from these 30 clutches. All of the lost eggs were part of a two-egg clutch in which the other chick hatched. Thus, none of the clutches was lost completely during incubation resulting in hatching success of 100%. The hatching peak was reached between 4 and 7 July.

Food provisioning Thirty-three successful feeds were observed at the five selected nests during the 14 hours observation period, resulting in a food provisioning rate of 0.47(± 0.18) feeds per nest per hour. In most cases (39%), the terns fed small fish with only one bill-length in size; other prey sizes were less frequent (Figure 1). Given a bill-length of 32 mm (Glutz von Blotzheim &



'gure 1. Frequency distribution of prey sizes (n = 32) fed by Arctic Terns at Kaldbaksbotnur, Faroe Islands. Prey size was estimated in adult bill lengths (c. 32 mm).

'guur 1. Frequentieverdeling van prooigroottes (n = 32) waarmee Noordse Sterns hun jongen voerden in Kaldbaksbotnur, Faröer. Prooigrootte werd geschat in snavellengtes van de adulte vogel (ca 32 mm).

Bauer 1982), a mean prey size of 53 (± 21) mm (median = 48; n = 32) may be estimated. The food spectrum seemed to consist almost exclusively of fish species. Most prey was probably sandeel *Ammodytes* spp., but identification was difficult in most cases.

Kleptoparasitism A total of 96 feeds was recorded during the whole observation period, of which 47 (49%) were disrupted by intraspecific kleptoparasitism. Most kleptoparasitic attacks (47%) lasted up to 4 minutes, but some (11%) lasted more than 8 minutes (Figure 2). One tern was harassed for more than 20 minutes, having numerous attempts to feed its chick. Despite the frequent kleptoparasitic attacks, only 26% of food provisioning attempts failed.

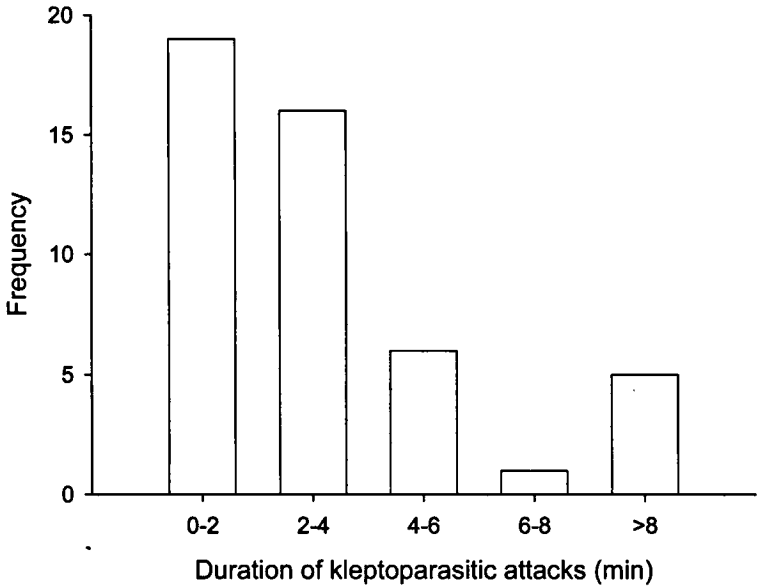


Figure 2. Frequency distribution of duration of kleptoparasitic attacks (n = 47) in a colony of Arctic Terns at Kaldbaksbotnur, Faroe Islands.
Figuur 2. Fréquentieverdeling van de duur van kleptoparasitaire aanvallen (n = 47) in een kolonie Noordse Sterns in Kaldbaksbotnur, Faröer.

The failures were due to prey being swallowed or dropped by the attacked adults or taken away by the kleptoparasites.

Predation During 61 hours of monitoring flying predators at the colony, only 26 events involving 29 individual predators were recorded. Most of the flying predators (58%) were Herring Gulls *Larus argentatus*. Other potential predators included Great Black-backed Gull *L. marinus* (11%), Black-headed Gull *L. ridibundus* (11%), Black-legged Kittiwake *Rissa tridactyla* (8%), Arctic Skua *Stercorarius parasiticus* (8%) and Merlin *Falco columbarius* (4%). In 65% of the cases, the terns attacked the potential predators. Even harmless species were attacked, for instance Whimbrels *Numenius phaeopus* and a White-winged Black Tern *Chlidonias leucopterus*. However, we observed only one direct attempt (4%) to rob eggs or chicks when an Arctic Skua tried to land in the colony, but this was unsuccessful due to sustained attacks by the terns. Thus, no

losses of eggs or chicks could be witnessed directly during observations and only two eggs or newly hatched chicks disappeared during our frequent clutch checks (see above).

Breeding productivity Between 2 and 4 August, a maximum number of 22 fledged chicks was counted. Based on this number, overall breeding productivity for this colony was estimated to be 0.22 chicks per pair.

DISCUSSION

The estimated breeding productivity of 0.22 chicks per pair is a relatively low value compared with other Arctic Tern colonies (Mavor *et al.* 2004). Annual productivity of Arctic Terns in the British Isles in the years 2002 and 2003 ranged from complete failure (e.g. Shetland) to 1.44 chicks per pair (Wales), with an average of approximately 0.44 chicks per pair (Mavor *et al.* 2004). Long-term mean values (1986-2002) at the same sites ranged from 0.10 chicks per pair (Scotland) to 1.09 chicks per pair (Wales), with an average value of 0.43 chicks per pair (Mavor *et al.* 2004). Our method used to estimate the reproductive success is not the most accurate as some chicks might have been overlooked in high grass. However, together with the other results of our study (see below) it suggests that breeding productivity in this colony was strongly limited. Since breeding and foraging ecology of Arctic Terns seems to vary widely in space and time we recommend more detailed and long term investigation at Faroese tern colonies aimed at assessing population trends and annual productivity.

Productivity of Arctic Terns nesting at Kaldbaksbotnur seemed to be little affected by predation since no losses of eggs or chicks could be directly assigned to avian predators during 61 hours of observation, and only two eggs or newly hatched chicks disappeared from our monitored clutches. The reason for such low avian predation pressure might be that breeding predators in the surroundings of the tern colony were largely absent. Becker (1995) studied gull predation on Common Terns *S. hirundo* in a colony adjacent to a Herring Gull colony of 10,500 pairs in the German Wadden Sea, and reported chick losses of 44 % to 94 % due to gull predation. He suggested that most of these gulls did not specialize in robbing chicks, but took them as supplementary food. Predation rates might therefore be strongly influenced by predator breeding densities adjacent to tern colonies. We did not directly investigate potential effects of mammalian predators (most likely Brown Rats *Rattus norvegicus*; B. Olsen, *pers. comm.)* on Arctic Tern productivity. However, since only two eggs or newly hatched chicks disappeared from our monitored clutches, we would expect mammalian predation at this site also to be low.

Several findings from this study suggest that the relatively low tern productivity was probably caused mainly by food shortage. The food provisioning rate of 0.47 (±0.18) feeds per nest per hour at our Faroese tern colony is clearly lower than comparable food provisioning rates of 0.71 and 1.37 trips per nest per hour in an Arctic Tern colony in Shetland (Monaghan *et al.* 1992). Most prey items delivered to chicks in our colony were small with a mean size of 53 (± 21) mm. Monaghan *et al.* (1989) reported a high proportion of very small sandeels in a colony where breeding failed completely, and concluded that intermediate sized sandeels are a prerequisite for successful reproduction. The high frequency of intraspecific kleptoparasitism also suggests that food availability was limited. Ludwigs (1998) found that high intraspecific kleptoparasitism in a colony of Common Terns in the German Wadden Sea was caused by very poor food supply. He reported attacks on 15 % of food provisioning attempts, 75 % of which ended successfully for the kleptoparasites. Our observations on the Faroe Islands differed because attacks occurred more often (49%) but were less successful (26%). This suggests high kleptoparasitism pressure due to limited food availability. Overall, evidence for food shortage limiting breeding productivity was thus indicated by low food provisioning rates, relatively small prey items, and frequent intraspecific kleptoparasitism. The average clutch size of 1.65 (±0.48) eggs per clutch is similar to that in other studies, e.g. 1.76 to 1.94 eggs per clutch in the British Isles (Monaghan *et al.* 1989, 1992), and 1.5 eggs per clutch in the German Wadden Sea (Frick & Becker 1995).

A major component of Arctic Tern diet in the North Atlantic is sandeels (Monaghan *et al.* 1989, 1992; Suddaby & Ratcliffe 1997), and adult terns generally feed their chicks on sandeels of the current year, while the adults themselves mostly feed on sandeels of the previous year (Monaghan *et al.* 1992). Several Arctic Tern populations in Shetland, west, and north-east Scotland exhibited large declines between 2002 and 2003, which were attributed to low availability of sandeels (Mavor *et al.* 2004). Low sandeel availability appears to continue to be a severe problem for many seabirds in the North Sea, and probably accounted for an almost complete breeding failure of Arctic Terns in Orkney, Shetland, and NE and SE Scotland the year following our study (Mavor *et al.* 2005). Earlier dramatic declines in breeding numbers of Arctic Terns in Shetland between 1984 and 1988 were also attributed to a decline in sandeel populations (Monaghan *et al.* 1992). The recent decrease in numbers and sizes of Arctic Tern colonies on the Faroe Islands might therefore be most likely explained by limited sandeel availability. Since no sandeel fishery exists around the Faroe Islands, other factors such as demographic or environmentally induced changes in sandeel survival and abundance might be responsible for

potentially low sandeel availability in this region (Fisheries Research Services 2003).

We conclude that breeding productivity of Arctic Terns in the Kaldbaksbotnur colony was primarily affected by food shortage (possibly limited sandeel availability). This is consistent with recent evidence showing that seabirds that feed on sandeels currently have limited breeding success in the Northern Atlantic region (Mavor *et al.* 2004, 2005). In order to achieve deeper insights into the spatial and temporal variation of Arctic Tern productivity at the Faroe Islands, it would be desirable to investigate more sites, and to monitor colonies over a longer time period.

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FACTOREN DIE HET BROEDSUCCES BEPALEN VAN NOORDSE STERNS *STERNA PARADISAEA* IN KALDBAKSBOTNUR, FARÖER

Voedselgebrek en predatie zijn de belangrijkste factoren die het broedsucces van vele kolonie-broedende zeevogels beperken. Het doel van dit onderzoek was te onderzoeken of deze factoren invloed hebben op het broedsucces van Noordse Sterns Sterna paradisaea *in een kolonie van 99 broedpaar in Kaldbaksbotnur op het eiland Streymoy, Faröer. In 2003 onderzochten we legselgrootte, uitkomstsucces, voederen van de kuikens, kleptoparasitisme, predatie en het aantal uitgevlogen jongen. De legselgrootte bedroeg gemiddeld 1.65 (±0.48) ei/legsel met een uitkomstsucces van 100%. Voederfrequenties waren laag met 0.47 (±0.18) voederbeurten per nest per uur. De meeste prooien waren klein (ca 32 mm lang). De sterns ondervonden een hoog aandeel van intraspecifiek kleptoparasitisme. Aanvallen door vogels werden soms waargenomen, met name door Zilvermeeuwen* Larus argentatus, *maar deze waren in alle waargenomen gevallen niet succesvol. Tellingen van uitgevloegen jongen wezen op een gemiddeld broedsucces van 0.22 kuiken per paar. Onze resultaten suggereren dat het broedsucces in deze kolonie grotendeels wordt beïnvloed door voedselgebrek, mogelijk door een beperkend aanbod zandspiering* Ammodytes *spp.. Predatie lijkt minder belangrijk, maar kan in een lage frequentie optreden. De resultaten zijn consistent met recente bevindingen dat zeevogels die op zandspiering foerageren, in de Noord-Atlantische regionen tegenwoordig een laag broedsucces hebben.*

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