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# Brief report

# Host selection by Arctic Skuas *Stercorarius parasiticus* in the North-western Mediterranean during spring migration

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## 1. Introduction

The Arctic Skua *Stercorarius parasiticus* relies nearly exclusively on kleptoparasitism to obtain its food, both when breeding in coastal areas and away from the breeding grounds (reviewed in Furness 1987a). Many studies on this species have focused on this feeding behaviour, mainly dealing with the factors affecting the outcome of kleptoparasitic chases. However, host selection has received little attention (cf. Bélisle & Giroux 1995).

According to Bélisle (1998), Arctic Skuas seem to maximise the probability of obtaining a fish when chasing terns, although other fitness currencies (i.e. gross and net energy intake, efficiency) can not be excluded. Thus, skuas should prefer to chase the most vulnerable host species, which would drop food most readily and provide the highest success rate. However, host availability should also play an important role in host selection. When a skua is faced with a potential host, the decision of whether or not to chase it will be a result of the balance between the suitability of the host and the probability of finding a more fitting host in a given search time (cf. Stephens & Krebs 1986). So far, a few studies have suggested a relationship between the success rate and the tendency of skuas to chase a given host species. Indeed, Furness (1978) found that Arctic and Great Skuas *Catharacta skua* in Shetland differed in the host species they chased, in accordance with the success with which they kleptoparasitised them. At migration stopover sites, Taylor (1979) found that Arctic skuas tended to chase Sandwich *Sterna sandvicensis* over Common Terns *Sterna hirundo*, and chases on the former were more successful. Bélisle and Giroux (1995) also found a clear preference to chase terns rather than larger species of gulls, with the former providing a higher success rate.

One would expect kleptoparasites to select small host species, since they are expected to be more vulnerable. However, the generally greater manoeuvrability of these species and the small amount of food potentially dropped could make these hosts less suitable, and no clear relationship between host body mass and tendency to be chased has been shown in seabirds (Furness 1987b). Feeding behaviour has also been reported to influence the suitability of a host (Duffy 1980), with diving species (that can feed on prey inaccessible to surface feeders) being chased preferentially. Finally, host diet seems an important determinant of host suitability, with species feeding on discrete items such as fish being preferred (Brockman & Barnard 1979, Furness 1987b).

In this study, host selection by spring migratory Arctic Skuas in a Mediterranean seabird community was investigated. The following questions were specifically addressed: (1) are host species selected solely according to their availability in the area?; (2) if not, are those hosts that provide a higher success rate (more vulnerable) preferentially selected?; and (3) does body mass influence host selection (vulnerability)?.

## 2. Material and methods

Field-work was conducted in North-east Spain (41°23'N, 2°21'E; Barcelona province), during the spring migration period (March-May), in 1991-1993 and 1995. Data were collected from a coastal vantage point on 129 days (44 in 1991, 37 in 1992, 30 in 1993, and 18 in 1995). The observation time per day varied between 20 and 150 min (mean ± SD = 70 ± 28 min).

A chase was defined as any pursuit of a specific individual or flock of potential hosts by one or more skuas. The sea was scanned from the observation point with the aid of 8×30 binoculars. When a skua was detected, it was followed with a 20–60× telescope and, if it performed a chase, the following details were recorded: (1) age class (immature or adult) and number of skuas involved, (2) host species, (3) duration (≤ 15 s or > 15 s, counted from the moment that the skua started to accelerate), and (4) chase outcome (a chase was considered successful when the host dropped its food). The success rate (SR) for each host species was calculated from chases conducted only by single adult birds, in order to avoid potential biases due to the age class and the number of skuas involved in a chase. To increase sample size, some chases recorded opportunistically on days when no seabird censuses were conducted (thus not considered for the estimation of host preferences, see below) were also considered. Skuas passing the observation point were usually on active migration and, in the rare cases that a skua performed more than one chase, only the first one was considered in order to ensure independence of data.

Host abundance was estimated from censuses of all seabirds passing the observation point on each day throughout the observation period. The expected number of chases of each host species was then calculated as follows:

$$E_i = \sum_{i-1}^{129} P_{ij} \times N_j \qquad (1)$$

where $E_i$ = expected number of chases of the host species $i$, $P_{ij}$ = proportion of the host species $i$ on the day $j$, and $N_j$ = total number of chases observed throughout the day $j$.

In order to assess if all host species were chased in accordance with their availability, I first performed a Chi-square goodness-of-fit test. Since this hypothesis was rejected, Bonferroni confidence intervals (Neu et al. 1974) were used to determine the probability that these differences in observed and expected proportions might have occurred by chance on each particular case. Differences between the observed and the expected number of chases for each host species were also shown through an Ivlev's electivity index (see Krebs 1989):

$$EI_i = \frac{O_i - E_i}{O_i + E_i} \qquad (2)$$

where $EI_i$ = Ivlev's electivity measure for species $i$, $O_i$ = number of observed chases of species $i$, and $E_i$ = number of expected chases of species $i$. Species with expected number of chases less than two were not considered, nor were intraspecific chases. Furthermore, since the Neu et al. (1974) method is quite sensitive to the number of categories considered (Alldredge & Ratti 1986), species that were never chased (namely the Northern Gannet *Sula bassana* and the Lesser Black-backed Gull *Larus fuscus*) were also excluded. The removal of these species was also justified by their relative scarcity in the area (less than four expected chases in each case) and, in the case of the Northern Gannet, by its large size that makes it an unlikely potential host for Arctic Skuas (only one chase known by the author, Paterson 1986).

A logistic regression analysis was performed to assess the relationship between success rate (dependent variable) and body mass (independent, continuous variable). The inferential test was based on the Wald statistic, and the analysis was performed with the statistical package SPSS 9.0.

Spearman correlations were employed when assessing the relationship between the electivity index and the success rate, as well as the electivity index and body mass.

## 3. Results

A total of 80 interspecific chases were recorded during the study period. Differences in the selection of the potential host species were observed ($\chi^2_5 = 41.9$, $P < 0.0001$; see Table 1). Electivity Indices showed that Sandwich Terns, Little *Larus minutus*, Mediterranean *L. melanocephalus* and Audouin's Gulls *L. audouinii* were chased more than expected according to their relative abundance in the area, while Yellow-legged *L. cachinnans* and especially Black-headed Gulls *L. ridibundus* were chased less than expected (Table 1). However, only Mediterranean, Black-headed, and Yellow-legged Gulls received a number of chases that differed significantly from expectation.

The overall success rate for chases conducted by single adult skuas was 32.6% (n = 95), ranging from 8.3% for Yellow-legged Gulls to 44.1% for Mediterranean Gulls (Table 1). Species with high Electivity Indices tended to be kleptoparasitised with greater success by skuas ($r_s = 0.77$, n = 6, P = 0.07). The logistic regression analysis showed a significant effect of the host body mass on the probability of a chase being successful, with the smallest species dropping food most readily ($\chi^2_1 = 7.04$, n = 95, $\beta \pm SE = -0.0020 \pm 0.0008$, P = 0.008). In general, smaller species also seemed to be chased preferentially, although there was no clear correlation between body mass and the Electivity Index ($r_s = -0.60$, n = 6, P = 0.21). The Black-headed Gull was the only important exception to this trend, with a very low Electivity Index in spite of being a small species. When this species was excluded, the previous correlation improved and became significant ($r_s = -0.90$, n = 5, P = 0.037).

Most chases were performed by single skuas (n = 95, SR = 32.6%), but chases performed by two (n = 19, SR = 26.3%) and three skuas (n = 3, SR = 66.7%) were also observed. Irrespective of host species, the success rate did not differ significantly with the number of skuas involved in a chase (single chases versus group chases, $\chi^2_1 = 0.01$, P = 0.9). However, Yellow-legged Gulls appeared to be chased more successfully by groups of skuas (SR = 33.3%, n = 9) than by single individuals (SR = 8.3%, n = 24), although there were no statistical differences (Fisher's exact test, P = 0.09), and skuas usually chased this species in groups (27.8% of the chases, n = 36). Furthermore, most chases of Yellow-legged Gulls were short (≤ 15 s) and unsuccessful (*n* = 25 short chases, SR = 4.0%), and the few long chases (> 15 s) presented a higher probability of success (n = 7 long chases, SR = 42.8%) (Fisher's exact test, P = 0.047). Conversely, the Mediterranean Gull (as a representa-

Table 1. Observed (Obs.) and expected (Exp.) number of chases over the different species of hosts considered, and the respective values of Ivlev's electivity index (EI); the asterisks indicate statistical significance according to Bonferroni intervals of confidence (* *P* < 0.05, ** P < 0.01). Data on success rate (SR) of single skuas are presented for each host species along with the number of chases observed in each case (n). Mean body mass of the different host species is also provided, and was calculated from data obtained in del Hoyo et al. (1996).

| Species | Obs. | Exp. | EI | SR | (n) | Body mass (g) |
|---|---|---|---|---|---|---|
| Little Gull | 5 | 2.2 | + 0.38 | 37.5 | (8) | 125.0 |
| Mediterranean G. | 28 | 15.8 | + 0.28 (*) | 44.1 | (34) | 282.5 |
| Black-headed Gull | 2 | 14.9 | - 0.76 (**) | 16.7 | (6) | 260.0 |
| Audouin's Gull | 8 | 5.5 | + 0.19 | 28.6 | (7) | 675.0 |
| Yellow-legged G. | 26 | 37.8 | - 0.18 (*) | 8.3 | (24) | 1150.0 |
| Sandwich Tern | 11 | 3.9 | + 0.48 | 43.8 | (16) | 207.5 |
| Total | 80 | 80.0 | | 32.6 | (95) | |

tive of smaller and preferentially selected species) was rarely chased by a group of skuas (6.4% of the chases, n = 47), and did not present differences in the success rate in relation to chase duration (13 short chases, 46.1% successful, and 20 long chases, 35.0% successful; Fisher's exact test, P = 0.4).

## 4. Discussion

Host availability was not the only factor influencing host selection by Arctic Skuas. Indeed, some species were chased significantly more (Mediterranean Gulls) or less (Yellow-legged and Black-headed Gulls) than expected according to their availability in the study area. These differences appear to be related to host vulnerability, since host selection (EI) was positively correlated with the success rate achieved by skuas when chasing hosts. This trend had been previously suggested by Furness (1978), Taylor (1979) and Bélisle and Giroux (1995), and is in accordance with the idea that Arctic Skuas maximise the probability of obtaining food from a host (Bélisle 1998).

In his review, Furness (1987b) did not find a clear relationship between the size of a host and its probability of being chased by a kleptoparasite, and suggested that kleptoparasites might do best by chasing those species that carry the largest food items but can still be robbed. In the present study body mass appeared to be an important factor influencing host species selection, smaller species being chased more often than larger species. This was probably due to the higher vulnerability of smaller species, as suggested by the negative correlation between body mass and success rate. Indeed, chases of the largest host species, the Yellow-legged Gull, were rarely successful except when a group of skuas was involved, and most chases were short and unsuccessful, suggesting that these were mere exploratory chases directed to a generally unprofitable host (see Osorno et al. 1992). The consideration by Furness (1987b) of a large number of species with different diving abilities and different ways of carrying food, both being important factors determining host suitability (Duffy 1980, Furness 1987b), could have hidden the effect of host size. In this study this problem was partially avoided since all host species considered have a very limited diving ability, and most of them have roughly similar feeding strategies.

The fact that Black-headed Gulls were almost ignored as hosts in spite of their small size suggests that other factors, such as the diet and the foraging behaviour of a species, were involved in the determination of host choice. Indeed, the Black-headed Gull mainly feeds in agricultural fields, sewage outfalls and refuse tips in the study area (pers. obs.; see Prévot-Julliard & Lebreton 1999), and is rarely seen offshore (e.g. Arcos & Albiol 1997). Conversely, the other host species considered rely more on seafish, captured either in a natural way or from trawler discards (e.g. Oro & Ruiz 1997; author, unpublished data), although the Yellow-legged Gull also makes use of refuse tips (Oro et al. 1995). Since suitable hosts should feed on large and discrete food items (e.g. fish; Brockmann & Barnard 1979, Furness 1987b), the predominance of non-discrete food items in the diet of Black-headed Gulls could explain the low electivity index of the species. A similar case was reported by Furness (1987a,b) from Foula, where Kittiwakes *Rissa tridactyla* were chased in a very small proportion, probably due to the well-digested items they drop.

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## References


Alldredge, J. R. & Ratti, J. T. 1986: Comparison of some statistical techniques for analysis of resource selection. — Journal of Wildlife Management 50: 157–165.

Arcos, J. M. & Albiol, D. 1997: Observations of seabirds in waters off Barcelona (April 1996–March 1997). — Boletin del GIAM 23: 13–16. (In Spanish with English summary).

Bélisle, M. 1998: Foraging group size: models and a test with jaegers kleptoparasitizing terns. — Ecology 79: 1922–1938.

Bélisle, M. & Giroux, J. F. 1995: Predation and kleptoparasitism by migrating Parasitic Jaegers. — Condor 97: 771–781.

Brockman, H. J. & Barnard, C. J. 1979: Kleptoparasitism in birds.
— Animal Behaviour 27: 487–514.

Del Hoyo, J., Elliott, A. & Sargatal, J. (eds.) 1996: Handbook of the birds of the world. Vol. 3: Hoatzin to Auks. — Lynx Edicions, Barcelona, Spain.

Duffy, D. C. 1980: Patterns of piracy by peruvian seabirds: a depth hypothesis. — Ibis 122: 521–525.

Furness, R. W. 1978: Kleptoparasitism by Great Skuas (Catharacta skua Brünn.) and Arctic Skuas (Stercorarius parasiticus L.) at a Shetland seabird colony. — Animal Behaviour 26: 1 167–1 177.

Furness, R. W. 1987a: The skuas. — T & AD Poyser, Calton, U.K.

Furness, R. W. 1987b: Kleptoparasitism in seabirds. — In: Croxall, J.P. (ed.), Seabirds: feeding biology and role in marine ecosistems: 77–101. Cambridge University Press, New York

Krebs, C. J. 1989: Ecological methodology. — Harper Collin publishers, New York.

Neu, C. W., Byers, C.R. & Peek, J. M. 1974: A technique for analysis of utilization-availability data. — Journal of Wildlife Management 38: 541–545.

Oro, D., Bosch, M. & Ruiz, X. 1995: Effects of a trawling moratorium on the breeding success of the yellow-legged gull Larus cachinnans. — Ibis 137: 547–549.

Oro, D. & Ruiz, X. 1997: Exploitation of trawler discards by breeding seabirds in the north-western Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. — ICES Journal of Marine Science 54: 695–707.

Osorno, J. L., Torres, R. & Macias García, C. 1992: Kleptoparasitic behavior of the Magnificent Frigatebird: sex bias and success. — Condor 94: 692–698.

Paterson, A. M. 1986: Kleptoparasitic feeding by migrating skuas in Malaga Bay, Spain. — Ringing and Migration 7: 51–55.

Prévot-Julliard, A. C. & Lebreton, J. D. 1999: Spatial organization of foraging within a Black-headed Gull Larus ridibundus colony. — Ibis 141: 144–149.

Stephens, D. W. & Krebs, J. R. 1986. Average-rate maximizing: the prey and patch models. *In* Foraging theory. Monographs in Behaviour and Ecology. — Princeton UP, Princeton, New Jersey.

Taylor, I. R. 1979: The kleptoparasitic behaviour of the Arctic Skua Stercorarius parasiticus with three species of tern. — Ibis 121: 274–282.