How do Arctic Skuas *Stercorarius parasiticus* search for diver eggs?

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Two methods are described that might be used by Arctic Skuas *Stercorarius parasiticus* searching for nests to rob. One is to employ features of the landscape correlated with the presence of nests. The other is to memorize the location of each nest and make regular visits to it, to check whether it is unprotected. Experimental field tests indicated that both methods are used by Skuas searching for eggs of the Red-throated Diver, *Gavia stellata*. Artificial nests placed by the water's edge, the typical location of a diver nest, were plundered much more rapidly than nests placed 25 m away from a pond. Nests by the water's edge were also found and plundered more rapidly when a diver dummy had been placed there for the 24 hours immediately preceding the test.

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Introduction

Bird eggs constitute an important part of the diet of the Arctic Skua in many parts of its range (Gudmundsson 1954, Maher 1974, Martin & Barry 1978). The Red-throated Diver *Gavia stellata* is one of the species whose eggs are regularly taken by skuas (Keith 1937, Löwenskiöld 1954, Enquist, unpubl.). The comparatively large eggs of the Red-throated Diver and the limited capability of the parents to protect the nesting site are important factors contributing to such predation.

During 1978 and 1979, while studying the territorial behaviour of the Red-throated Diver in Iceland, I became interested in how skuas search for diver eggs. When disturbed by humans, incubating divers often left the nest and eggs unprotected. At such times skuas frequently found the nest and ate the eggs. I was impressed by the efficiency of the Skuas in finding nests. The eggs of the Red-throated Diver are cryptically coloured and the nest generally hard to detect for the human eye.

The purpose of this paper is to describe two methods which, when utilized by a skua searching for divers' nests, may theoretically increase the finding and predation rate. It also presents the results of an experiment made to test whether these methods appear to be used.

One way to increase the probability of finding a nest may be to restrict searching to such areas where the likelihood of finding nests is reasonably high. Some features of the landscape may be positively or negatively correlated with the presence of nests. In this area, divers' nests are never located more than 0.4 m from the water and only by certain types of pools.

Having found an incubating diver the hunting skua may store information on the exact location of the nest. As skuas were never observed to attack incubating divers to drive them off their nests, the bird frequently has to return to such places in the hope of finding the nest unprotected. An optimal strategy may be a combination of searching in restricted areas for new nests and flights over memorized nest sites to check whether a nest is unprotected. Trade-off between exploration time and exploitation time was not investigated in this study, but an experiment was made to test whether hunting skuas use environmental cues (vicinity of shore), memorized knowledge of the position of nesting divers, or both.

Methods

The experiment was conducted in 1979 in a part of Myrar, western Iceland (64°35'N, 22°15'W), where 74 pairs of Red-throated Divers bred in 1978. These pairs laid 206 eggs (including relaying). About 100 (50 %) were probably taken by skuas. The distance between the nests varied from 15 to 200 m. A smaller area (1x1 km) was chosen for the experiment. This was composed of flat marshland with more than 150 small pools. Within this area about 30 pairs of Red-throated Divers breed yearly, and within or close to it breed about 25 pairs of Arctic Skuas and 100 pairs of Great Black-backed Gulls *Larus marinus*. To eliminate the influence of earlier experience of feeding success in the skuas, ponds were selected for the experiment that had not been utilized as breeding ponds for divers in 1978 or 1979.

A Red-throated Diver dummy (made of papier mâché and painted) was placed for 24 hours on the shore of a pond (about 0.2 m from the water's edge), in a position similar to that of an incubating diver. Experimental set-ups consisting of three dummy nests, each containing one egg (Great Black-backed Gull egg painted dark brown) were then arranged as follows.

a. one nest in the position where the diver dummy had earlier been placed.
b. one nest in a location similar to a by another pond.
c. one nest in the vegetation at least 25 m from the nearest pond.

Table 1. Results from experiments on Skua predation on experimental nests. Pairwise comparison of nest types was used to determine which type was plundered first.

Nest types compared	Number of times taken first	
a (shore + dummy)	12**	P<0.006*
b (shore)	2	
a (shore + dummy)	15	P<0.001
c (inland)	0	
b (shore)	13**	P< 0.001
c (inland)	0	

* One-tailed test
** The sum does not equal 15 because it was not possible to determine the order in all cases.

The three nests in each set-up were arranged in a line and the sequence of types a, b and c regularly changed. The nests were each time placed in the same type of vegetation and the nesting material was chosen to avoid contrast with the ground. Each day three trials were conducted. The distance between two set-ups was at least 200 m. No pond was used more than twice and at least seven days were allowed between trials. In total 15 experimental set-ups were studied from 14 to 30 June 1979. The majority of the nesting Red-throated Divers in the area were incubating during that time.

When the dummy nests had been placed out, each set-up was watched with the aid of binoculars from a nearby observation point, for three hours. Notes were taken on skua predation on the eggs.

Results and discussion

Studies on foraging behaviour in birds are mostly concerned with cases where each food item is very small compared with the predator (see e.g. Krebs 1978). To search for several small items or a few large ones should surely involve great differences in strategy. In this case the food item, i.e. the diver egg weighs about 16 % of an adult skua.

The results indicate that hunting skuas use both environmental cues and memorized information of the location of incubating divers to increase feeding success (Table 1). Nests close to the shore were robbed before nests located 25 m from the water's edge (P<0.001). Shore nests placed at a spot where a diver dummy had been earlier were plundered before other shore nests (P<0.006), which indicates that the skuas flying overhead had memorized the exact location of the "incubating diver". A similar picture emerges from an analysis of time elapsed before predation. Shore nests at dummy sites tended to be found earlier than other shore nests (P<0.01, Mann-Whitney U-test) and shore nests were found earlier than nests at some distance from the pools (P<0.001, Mann-Whitney U-test). Of the 15 shore nests at dummy sites, 11 were exploited within the first hour and the remaining 4 within three hours. Corresponding figures for the other shore nests are 7 nests plundered within the first hour and 6 within three hours (Table 2).

Table 2. Time taken for Skuas to find each of the three different types of nests.

Nest type	0—1 h	1—3 h	>3 h
a (shore + dummy)	11	4	0
b (shore)	7	6	2
c (inland)	0	3	12

Of the 15 nests placed in the vegetation, none was exploited during the first hour, 3 were plundered within three hours and most of the nests were still unharmed after as long as 24 hours.

A tentative explanation of the results presented in this paper is that skuas patrol divers' nesting grounds using environmental cues (shore edges) to locate incubating divers. They also seem capable of storing information about the location of incubating divers and utilizing this information to increase predation success. The expected trade-off between exploration of new areas and checking of old ones cannot be evaluated now, but could be analysed in a further study. Agreement with the theoretical optimal trade-off between exploration and exploitation has earlier been found in experiments with captive Great Tits (Krebs et al. 1978).

Utilization of environmental cues when searching for nests has earlier been observed in Carrion Crows feeding on Red Grouse eggs (Picozzi 1975). Nests marked with a small flag were significantly more likely to be robbed than unmarked ones.

The ability of the Arctic Skua to feed on the eggs of large birds such as geese, ducks and divers is already well documented (e.g., Alison 1975, Gudmundsson 1954, Martin & Barry 1978). In such cases predation is possible only when the nest is unprotected, since the skua will not be able to drive a large bird off the nest. I never saw a skua attacking an incubating diver. This suggests that a successful skua should also be sensitive to events correlated with an increased proportion of unattended nests. I noticed that the presence of humans seemed to attract skuas, and a skua searching for divers nests in the vicinity of a human will probably have a greater chance of finding an unattended nest. However, humans seldom visit these nesting areas and the majority of divers eggs were taken, when divers left their nests for other reasons.

Martin & Barry (1978) observed that skuas are attracted by disturbances within geese colonies.

Thus, the presence of large mammals, birds of prey and even territorial fights within the colony might provide opportunities to steal eggs.

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Selostus: **Miten merikihu löytää kaakkurin pesän?**

Etologinen ja/tai käyttäytymisekologinen tutkimus tarkastelee, miten "munarosvon" tulisi etsiä pesiä. Työssä tarkastellaan kahta pesienetsintämetodia. Ensinnäkin munarosvo voi käyttää etsintätyössään sellaisia vihjeitä, jotka yleensä esiintyvät pesän yhteydessä. Toiseksi munarosvo saattaa muistaa aikaisemmin havaitsemansa pesän sijainnin ja vierailee siellä säännöllisesti tarkastaakseen emon pesälläolon. Esimerkiksi merikihu ei kykene pelottamaan suurta kaakkuria pesältään, joten tarkastuskäynnit ovat menestymisen edellytys.

Tehtyjen kokeiden mukaan merikihu käyttää molempia menetelmiä (taulukko 1). Rantaviivaan asetetut tekopesät tulivat tuhotuiksi paljon nopeammin kuin 25 metrin päähän rannasta asetetut pesät (taulukko 2). Merikihut löysivät ja tuhosivat nopeammin ne tekopesät, joiden päällä oli 24 tunnin ajan ollut hautovan kaakkuriemon kuva, kuin "emottomat" pesät. Hautova emo siis helpottaa pesän löytymistä.

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