EFFEKTENE AV MENNESKELIG AKTIVITET PÅ ATFERD, REPRODUKSJON OG REIRPLASSERING HOS STORJO (CATHARACTA SKUA) PÅ RUNDE, NORGE

EFFECTS OF HUMAN ACTIVITY ON THE BEHAVIOUR, REPRODUCTION AND NEST DISTRIBUTION OF THE GREAT SKUA (CATHARACTA SKUA) ON RUNDE, NORWAY

SIV MIDTLIEN

UNIVERSITETET FOR MILJØ- OG BIOVITENSKAP
INSTITUTT FOR NATURFORVALTNING

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Preface

I would like to thank my supervisor Associate Professor Svein Dale for great supervision during the process of field work and writing. Are K. Pilskog have been essential with all his help in the field and in the writing process.

I am grateful for permission to work on Runde granted from the County Governor of Møre and Romsdal, and for the financial support assigned from the Directorate for Nature Management. Also, I would like to thank Alv Ottar Folkestad for great expertise in the field, and Drew Rodgers for useful comments on the script.

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Siv Midtlien

Abstract

Understanding how human activity affects animal life is vital to ensure conservation of biodiversity. We studied the effects of human activity on Great Skua on Runde Island, Norway. We looked at disturbance effects at several levels; direct behaviour, cumulative effects (reproduction) and nest distribution. We did not detect any effect of human activity on breeding behaviour and reproduction, but this might be due to a still small population size. There were few intrusive people during observation periods, and an increase in direct disturbances by humans may show a clearer negative effect on reproduction. When analysing the distribution, we found that breeding skuas avoided nesting close to frequently used tracks. An experiment indicated, however, that birds in areas with high human activity had become partly habituated to human activity, showing less response to humans. Nevertheless, as the Great Skuas on Runde avoided areas with high human activity, we suggest that the population size and distribution of the species will be limited by the numbers of tracks and people using these tracks. Similar results may be found in a range of other species with similar habitats and should be taken into account for future conservation. The results also stress the importance of not only looking at behaviour and reproduction, but also on the distribution of the species, when analysing disturbance effects.

Introduction

Natural habitats are becoming more and more reduced in area due to human activity, and loss of habitat is considered one of the greatest threats to earth's biological diversity (Collinge 1996). Degradation of habitat has become a well studied topic, and evidence of negative effects on species is abundant and widespread (Owens and Bennett 2000, Sanderson et al. 2002). For instance, habitat loss such as building of roads (Forman and Alexander 1998) and deforestation (Turner 1996) constitute major threats to animals. Fewer studies have looked at human activity in more intact areas, and the effects this may have on animal life. In theory, human activity constitutes a disturbance for a species in an area if the human activity results in reduced reproduction or area abandonment by the species.

The areas on the Norwegian coast are today in change from work related use to that of recreational activity. How does this affect seabirds? In Norway few studies have looked at seabirds and human activity. However, one study looked at the effects of human disturbance on the breeding success of Herring Gulls (*Larus argentatus*) and found no clear negative effects (Godal 1998).

How a species reacts towards human activity may be studied at several levels. First, one may analyse the direct behaviour or level of stress of a species towards intruding humans. Secondly, one may look at cumulative factors, which for instance may affect reproduction. Finally, one may analyse the distribution of a species compared to human activity to see if the species avoids areas with high human activity.

We studied the Great Skua (*Catharacta skua*) on Runde Island. Unlike most seabirds on Runde, the Great Skua breeds on the top of the plateau, the same area where arranged for tourists with tracks leading to the different bird localities. We ask whether this may result in a conflict between the breeding skuas and tourist activity. In parks or nature reserves where birds are protected, like Runde, they often become habituated to human activities (Burger and Gochfeld 1983, 1991). Nevertheless, even with frequent exposure to humans who do not harm them, birds may still be disturbed by human presence (Burger and Gochfeld 1991), and disturbance may cause birds to abandon habitat (Burger 1986).

Different bird species have been shown to respond differently to disturbance (Naturvårdsverket 2004). In addition, seabirds have been shown to be a vulnerable group to human activity (Anderson and Keith 1980, Safina and Burger 1983, Flemming et al. 1988, Blackmer et al. 2004, Muñoz Del Viejo et al. 2004, Naturvårdsverket 2004). Studies on Piping Plovers (*Charadrius melodus*) indicate that reproductive success is lower in areas with high human disturbance because of reduced foraging efficiency and the depletion of fat reserves (Burger 1986, 1991). A study looking at disturbance sources of nine different seabird species found that human activity was that source which caused most breeding failures (Muñoz Del Viejo et al. 2004).

At first glance an aggressive bird like the Great Skua might seem to be resilient to human activity. However, as far as we know, the response of the bird to human activity has never been studied. Could it be that the species is indeed suffering from human presence? Or may they become habituated to human activity? Is there a threshold of how close the Great Skua and humans can interfere with each other? Because the Great Skua is a relatively new species on Runde, the population is still increasing. But is it possible that the human activity will limit the maximum number of pairs that can breed on the island?

In this study we looked at disturbance effects on several levels; breeding behaviour, reproduction and nest distribution of the Great Skua on Runde in relation to human activity. In addition, an experiment was executed to see if skuas in areas with high human activity have become habituated, showing less response to humans.

Methods

Study area and study species

The fieldwork was done at the plateau of Runde, a bird island on the west coast of Norway (N 69°25'-69°23', E 32°24'-32°48'). There are around 150 residents on Runde, divided into two villages, Runde and Goksøyr (Fig. 1). Thousands of tourists visit Runde every summer to see the seabirds that breed in the cliffs on the southwest side of the island. Runde is the only bird cliff in Southern Norway. The most common species are Northern Gannet (*Morus bassanus*), Atlantic Puffin (*Fratercula arctica*), European Shag (*Phalacrocorax aristotelis*), Black-legged Kittiwake (*Rissa tridactyla*) and Northern Fulmar (*Fulmarus glacialis*). There are several protected areas where humans are not allowed to walk, but these protected areas do not include the plateau were the Great Skua breeds. However, it is forbidden to disturb any breeding birds. The plateau has been arranged for tourists, with several tracks leading to the different bird localities, and the plateau consists of marsh/moorland vegetation.

Figure 1. An areal photograph of Runde Island, a) the plateau were the study was centred, b) Runde village, c) Goksøyr and d) a part of Nerlandsøy.

A total of 18 tracks were observed in this study (Fig. 2). A track was limited by intersections with other tracks. This included tracks that were marked on tourist maps, as well as some few tracks used mostly by local people that were not marked on tourist maps. Some of the most frequently used tracks were several meters wide, and the main track (track no. 2) was at some points divided into several smaller tracks, resulting in a total width of 84 m at the widest point (Fig. 2). To our knowledge there has not been any earlier estimation of the amount of human activity in different areas on Runde.

Great Skuas are long-lived seabirds with annual adult survival 91-93% (Furness 1978). The species normally lays two eggs that hatch asynchronously (Furness 1983). Their diet shows a great variation, consisting mainly of fish, eggs, predation on other seabirds and carrion (Furness 1979). They employ a number of feeding techniques, including kleptoparasitism and specialization of individual feeding habits (Furness 1979). Kleptoparasitism of Northern Gannet was observed to be quite common on Runde. The Great Skua was recorded breeding for the first time in Norway in 1975. On Runde the first breeding pair was observed in 1980, and from that time on it has been increasing in numbers. In Shetland, which hosts the largest Great Skua colonies, there are colonies of a few, to several thousand pairs (Furness 1983). On Runde there are around 20-30 breeding pairs. The Great Skua is known to be aggressive to people that come too close to their nests, and to attack people physically to scare them away. The female Great Skuas are usually larger than the males, but from a distance it can be difficult to recognise the sex. Thus, sex differences in breeding behaviour was not recorded.

Data collection

On Runde we observed a total of 24 pairs of Great Skuas during incubation and chick period. Observations were made from 28 May 2005 to 2 August 2005. We divided the observation effort for each pair into six observation periods of 1 h each. Four of six observation periods were executed during week days, while the last two periods were executed during the weekends (Saturday/Sunday). Furthermore, the six observation periods took place at different times during the day; two periods during morning (0800 h – 1200 h), two periods during midday (1300 h – 1700 h) and two periods during evening (1800 h – 2200 h). Finally, the six periods were evenly distributed during the total observation period; three of the periods evenly distributed during incubation and three periods evenly distributed during the chick period. However, due to the fact that two pairs lost their eggs, and that one nest was placed in terrain where it was impossible to watch the chicks without disturbing them, only 21 pairs of Great Skuas were observed during the chick period. During one observation period we observed one, two or three pairs at the same time, depending on the closeness between pairs and ease of observation. This gave us a total of 67 observation hours on Runde. The observations were executed by using a binocular and a telescope to avoid disturbing the breeding pairs, as recommended by Safina & Burger (1983).

Marking of Great Skua chicks has been effectuated almost every year by a local ornithologist since 1980. Together with this person we visited 24 pairs to ring the chicks on 17 July. As two of the 24 pairs had lost their eggs, we ringed a total of 32 chicks from 22 pairs.

All statistical tests in this paper are two-tailed, and we employed either parametric or nonparametric tests, depending on the distribution of data for each variable.

Use of tracks and nest locations

Tracks were mapped by recording a GPS-position each time a track curved (a total of 200 GPS-positions for all the tracks; Fig. 2). We counted the people using the different tracks, and this was done concurrent with the observation periods of the different skua pairs. Thus, use of track refers to number of people using a certain track divided by the duration of the period observation for this track. The use of the different tracks varied widely from 0-1 persons/h observed to 15-24 persons/h observed (Fig. 2). Nest locations were also mapped by recording GPS-positions (Fig. 2). To avoid unnecessary disturbance, this was done at the same time the chicks were marked. The distance between each nest position and the closest point at the closest track was calculated using GPS positions and are referred to as nest-track distance in this paper.

Figure 2. A map of the Great Skuas breeding area, and the 18 different tracks observed. ■ 22 nests where eggs hatched. ■ One pair we observed only during incubation because of the inaccessible location in the terrain. ■ Two nests where the eggs did not hatch. Colour lines indicate tracks, whereas the different colours indicate the level of use of tracks. ▬ 0-1 persons/h, ▬ 1-2 persons/h, ▬ 4-9 persons/h, ▬ 15-24 persons/h. (#) Track number, ▬ intersection with other track(s), ⟶ Sheep made track (short cut), with arrow indicating that people walked straight through three skua territories, the three that were most disturbed and which raised only one chick each. Tracks 12 and 16-18 are not marked on tourist maps. The use of track no. 13 may be underestimated (see discussion).

Breeding behaviour

For each observation period during incubation, we recorded the time each pair used on incubation, time only one parent or both parents were present, and the amount of disturbance by humans (number of disturbances and time disturbed) or White-tailed Eagles *(Haliaeetus albicilla)* (time disturbed by White-tailed Eagles). We also recorded disturbances by other Great Skuas, but the amounts of these disturbances were too few to analyse. Time disturbed refers to the time from the incubating skua left its nest to defend it and until it returned and started incubating again.

During the chick period we recorded the date of hatching and the number of eggs that hatched. Hatching date refers to the date we saw either the chicks the first time, or behaviour of the parents that indicated hatching (for instance not incubating). Since we did not observe every nest every day, the hatching date may contain an error of one or two days. We also recorded the number of chicks two weeks after hatching date. Furthermore, we recorded the time both parents (mate present) or only one parent were present, the time parents used on feeding their chicks (feeding time), and the time used on defending their chicks against humans (number of disturbances and time disturbed) or White-tailed Eagles (time disturbed by White-tailed Eagles). During the chick period, time disturbed refers to the time the Great Skuas respond to the disturbance by circling above their territory, attacking the disturber, or standing on the ground between the disturber and the chicks.

Experiment

An experiment was designed to measure the aggressiveness of the different pairs towards approaching humans. One person approached, with walking speed, an incubating skua from the nearest point at the nearest track. Another person observed from distance the response of the bird. The experiment was executed for all the 24 nests on Runde during incubation independently of whether the mate was present or not. We estimated the distance from the person to the nest at the time the bird left the nest (nest leaving distance). At this point the person turned and went straight back towards the track, and kept walking in the same direction. As the bird returned and started incubating again, the distance from the person to the skua was estimated again (nest returning distance). The time from when the skua left the nest until it returned and started incubating again was noted (time in air). The cumulative responses refers to the sum of the ranked values of nest leaving distance, nest returning distance and time in air.

Nerlandsøy

Nerlandsøy is an island southwest of Runde, and Great Skuas also breed on top of the plateau on this island. As the island has no other seabird colonies, except a small Lesser Black-backed Gull *(Larus fuscus)* colony, few tourists visit this island. Some local people hike on the mountain, but human activity is low compared with Runde. Due to this low human activity, Nerlandsøy was planned to be used as a control area. However, the reproduction of the skuas this year at Nerlandsøy was very low. Whereas nine pairs were observed incubating, only two pairs managed to raise one chick each. Because of this low reproduction we could not use

Nerlandsøy as a control. However, we did experiments on six of these incubating pairs, using the same methods as we did on Runde. Nest locations were mapped by plotting GPS positions, and we also did a rough estimation of human activity.

Results

Use of tracks and nest locations

The use of a certain track had an effect on the number of nests within a 100 m distance from that track (Spearman rank correlation; $r_s = -0.52$, n = 18 different tracks, P = 0.027; Fig. 3). This effect became less clear as we increased the radius to 150 m around the tracks ($r_s = -0.43$, n = 18, P = 0.076). As use of a nests nearest track increased, the distance between nests and tracks also increased ($r_s = 0.78$, n = 24, P < 0.001; Fig. 4). When we exclude those pairs where eggs did not hatch, this trend seems to be even clearer (Fig. 4).

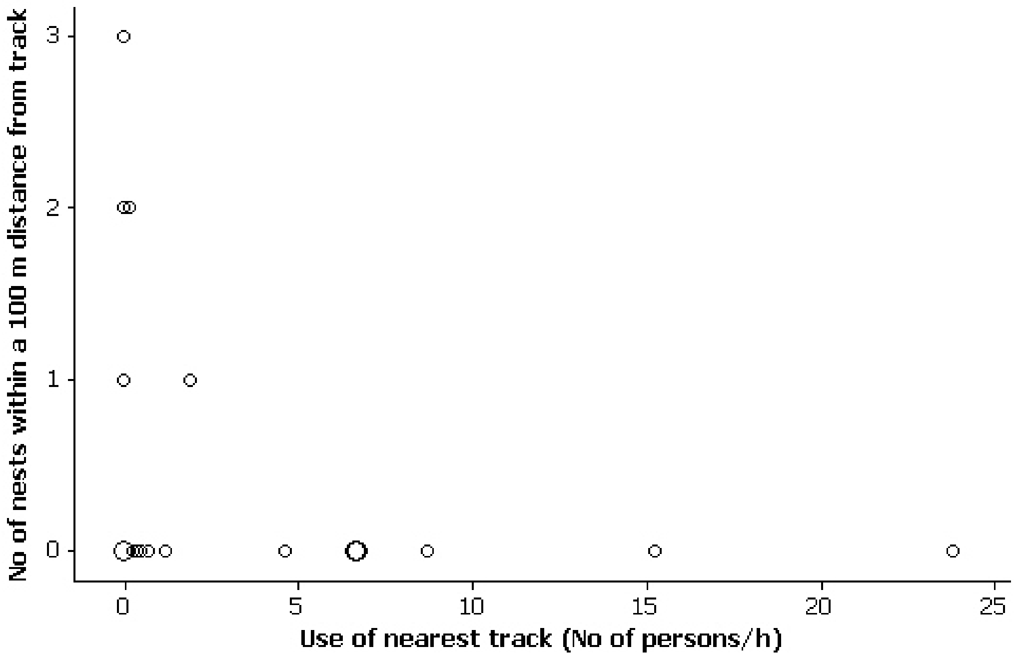

Figure 3. Use of tracks (n = 18) in relation to number of nests within a 100 m distance from each track. Larger circles indicate two overlapping data points.

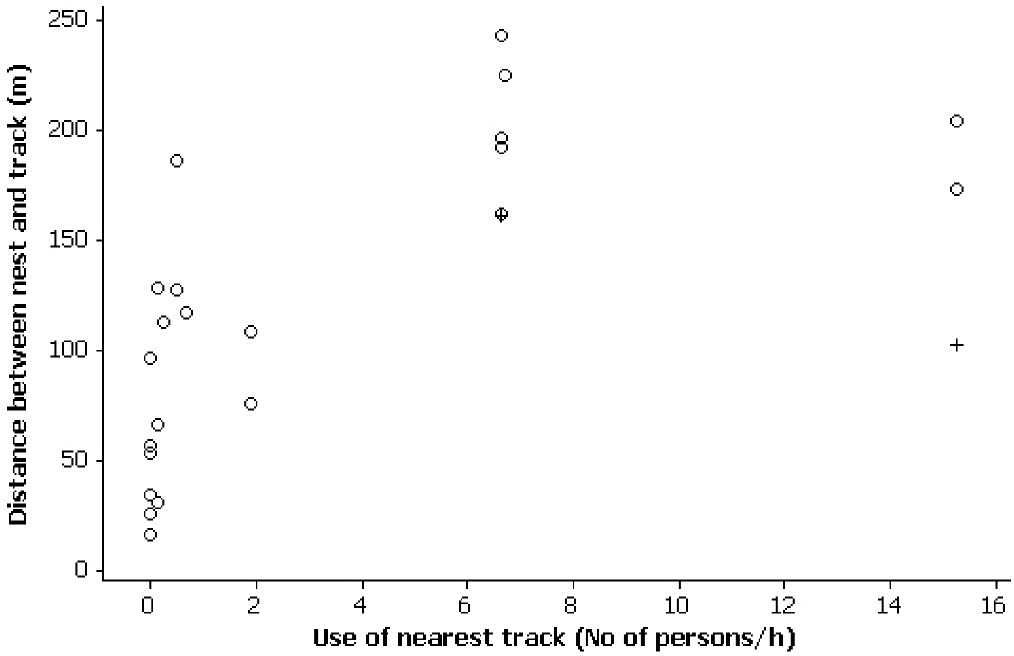

Figure 4. Distance from nest to nearest track in relation to use of a nest's nearest track. The + symbols refers to nests where eggs did not hatch.

Looking at the distances between nests, the distance from a nest to its nearest nest decreased as use of the nearest track increased (r_s = -0.60, n = 24, P = 0.0019; Fig. 5). Similarly, the distance between nests decreased as distance from nest to nearest track increased (r_s = -0.70, n = 24, P< 0.001; Fig. 6). Thus, in areas with high human activity, nests were placed further from tracks and were more clumped.

The degree of human activity was highest during midday (Fig. 7), and on Mondays and Fridays (Fig. 8).

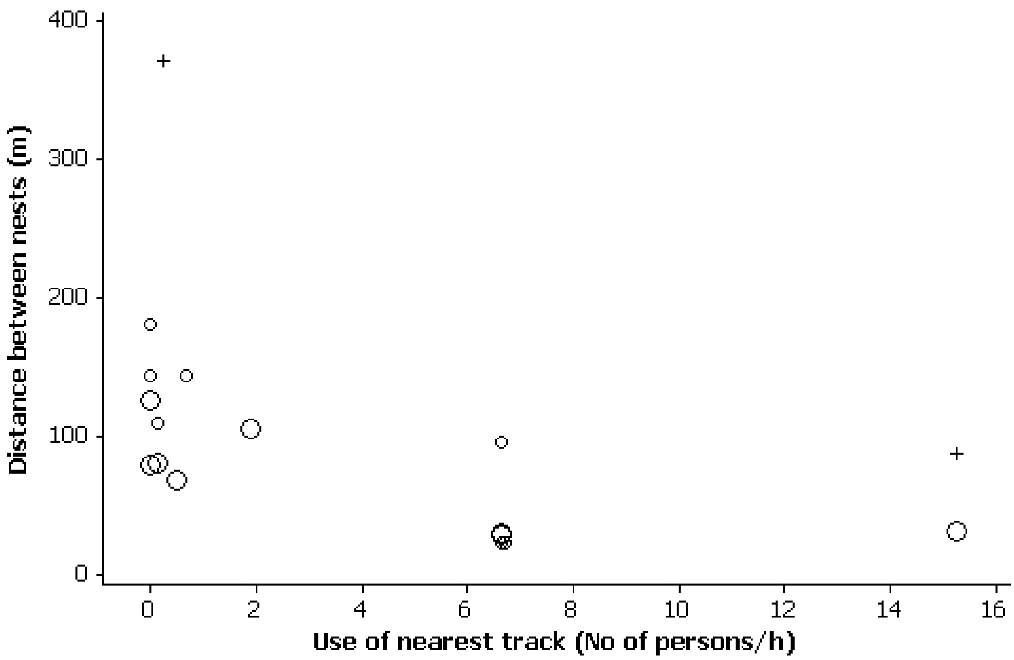

Figure 5. Distance to closest neighbour (internest distance) in relation to use of a nest's nearest track. Larger circles indicate two overlapping data points. (+) Nests where eggs did not hatch.

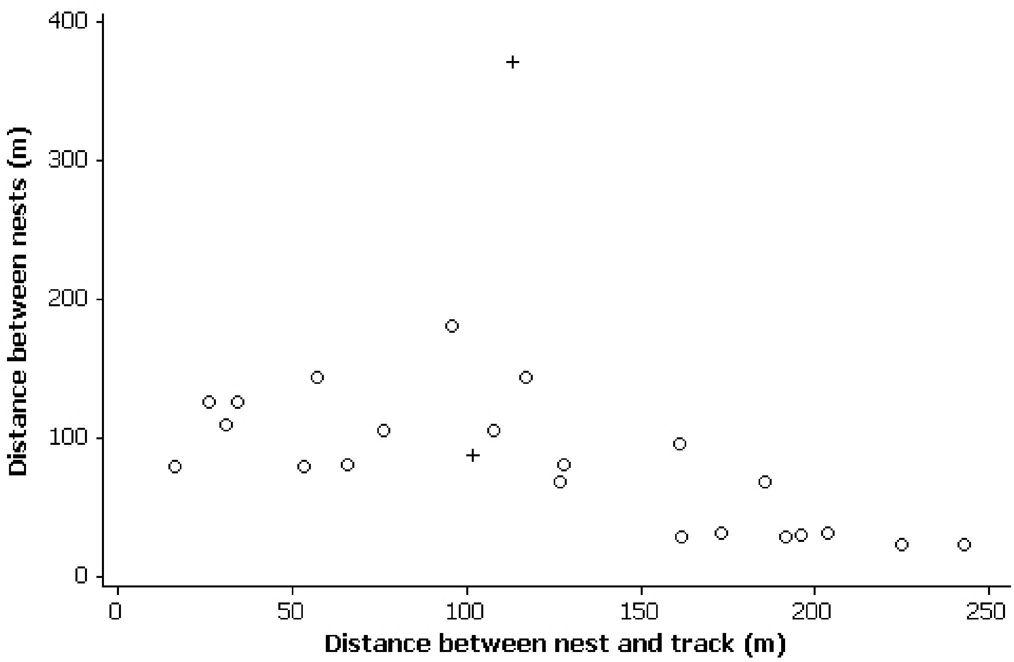

Figure 6. Distance to closest neighbour (internest distance) in relation to distance from nest to nearest track. (+) Nests where eggs did not hatch.

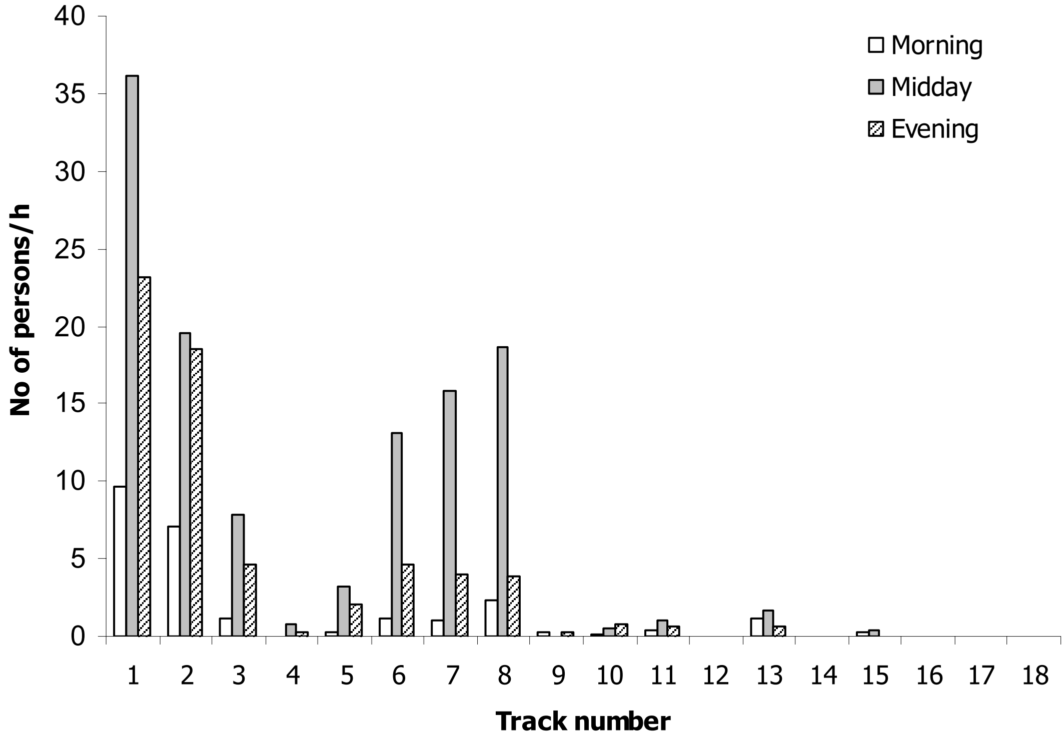

Figure 7. Use of track in relation to time of day and track number. (See Fig. 2 for track number references).

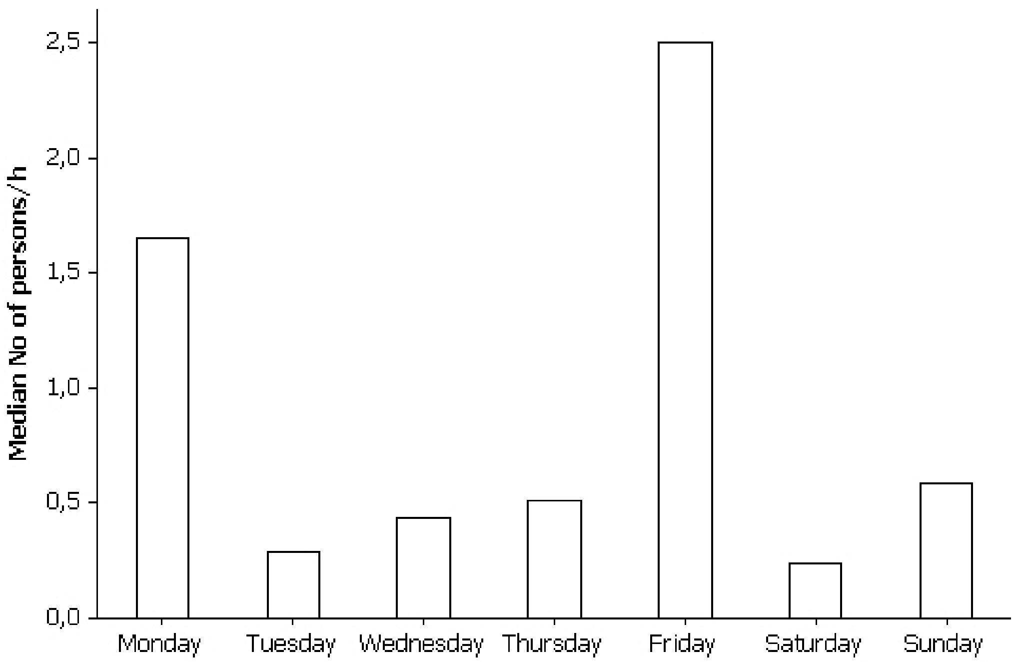

Figure 8. Median use of track in relation to day of week.

Use of tracks, breeding behaviour and reproduction

There were no correlations between use of the nearest track and reproduction (Table 1). We did, however, find that increased use of nearest track was related to decreased total time disturbed by White-tailed Eagles during the chick period (Table 2, Fig. 9). Other breeding behaviour variables showed no correlation with use of nearest track (Table 2).

Table 1. Effect of use of nearest track on reproduction.

Response	G[a]	df	P
Number of chicks observed	0.17	1	0.68
Number of chicks marked	0.47	1	0.49
Number of chicks two weeks after hatching	0.71	1	0.40

[a]Logistic regression

Table 2. Effect of use of nearest track on breeding behaviour and eagle disturbance.

Response	N	Rs	P
Eagle disturbance incubation period	24	0.02	0.91
Eagle disturbance chick period	21	-0.57	**0.0071**
Mate present incubation period	24	0.19	0.37
Mate present chick period	21	0.02	0.93
Feeding time	21	0.22	0.34

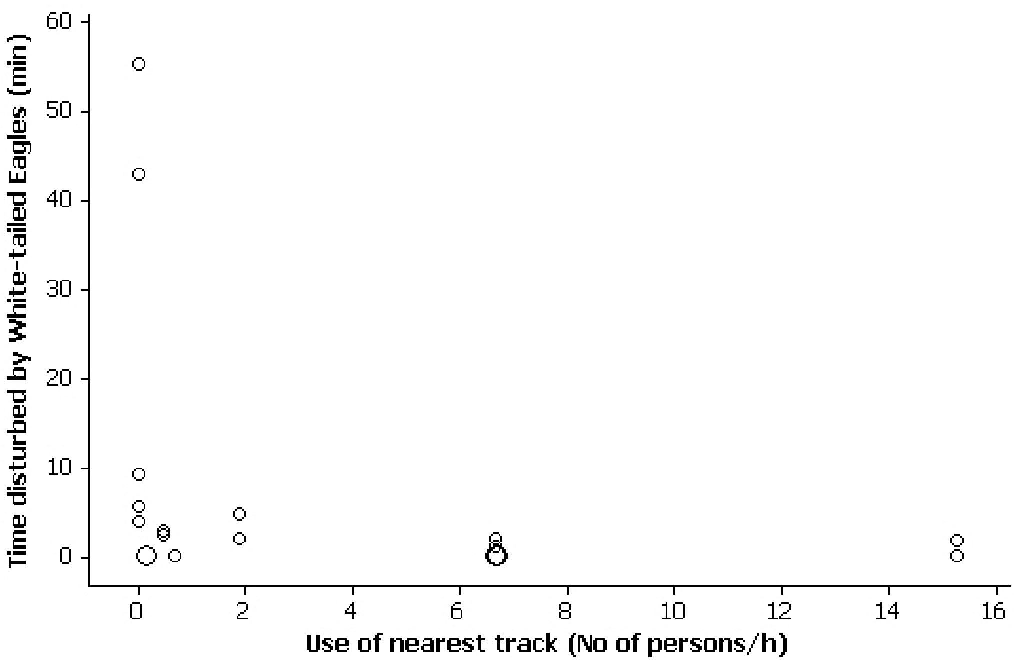

Figure 9. Time disturbed by White-tailed Eagles during the chick period in relation to use of a nest's nearest track. Larger circles indicate two overlapping data points.

Nest to track distance, breeding behaviour and reproduction

There were no relationships between distance from nest to nearest track and different reproduction parameters (Table 3). We did, however, find that as distance between nest and nearest track decreased, the total time of disturbance by White-tailed Eagle increased during the chick period (Table 4, Fig. 10). Other breeding behaviour variables showed no correlation with nest location (Table 4).

Table 3. Effect on distance between nest and nearest track, on reproduction.

Response	G[a]	df	P
Number of chicks observed	2.58	1	0.11
Number of chicks marked	0.74	1	0.39
Number of chicks two weeks after hatching	0.45	1	0.50

[a]Logistic regression

Table 4. Effect of distance between nests and nearest track, on breeding behaviour and eagle disturbance.

Response	N	Rs	P
Eagle disturbance incubation period	24	0.20	0.35
Eagle disturbance chick period	21	-0.56	**0.0090**
Mate present incubation period	24	-0.064	0.77
Mate present chick period	21	0.061	0.80
Time feeding	21	0.15	0.51

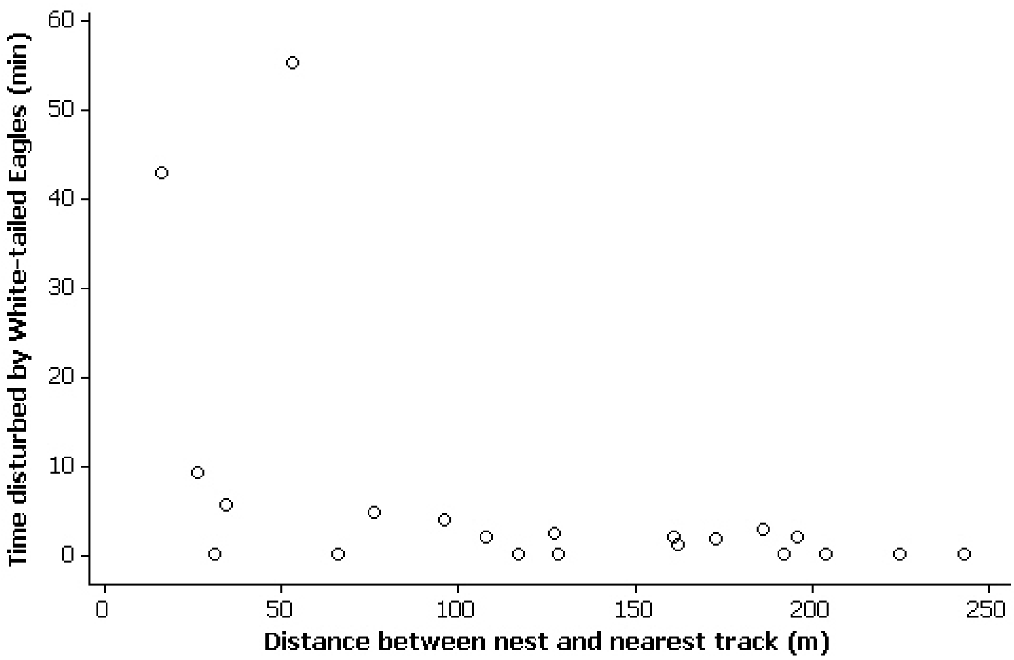

Figure 10. Time disturbed by White-tailed Eagles during the chick period in relation to distance from nest to nearest track.

Nest disturbances by humans

We observed a total of 33 nest disturbances caused by humans. 18 of these 33 nest disturbances took place during the observation hours, which resulted in 0.27 nest disturbances by humans per hour observed. Of all the 33 nest disturbances, the mean time disturbed was 4.88 min (Fig. 11). The nest disturbances were distributed among seven nests and 24 of the nest disturbances were distributed among three nests close to each other. The main reasons for human disturbances were a short cut from one particular track (from track no. 13, see short cut in Fig. 2), photographers taking pictures of the skuas, and people walking on a track that was too close to a breeding skua pair (track no. 9; Fig. 12). Photographers disturbed the skuas for a longer time than people taking short cuts and people disturbing from tracks (Kruskal-Wallis test, H = 8.45, df = 2, P = 0.015; Fig. 13).

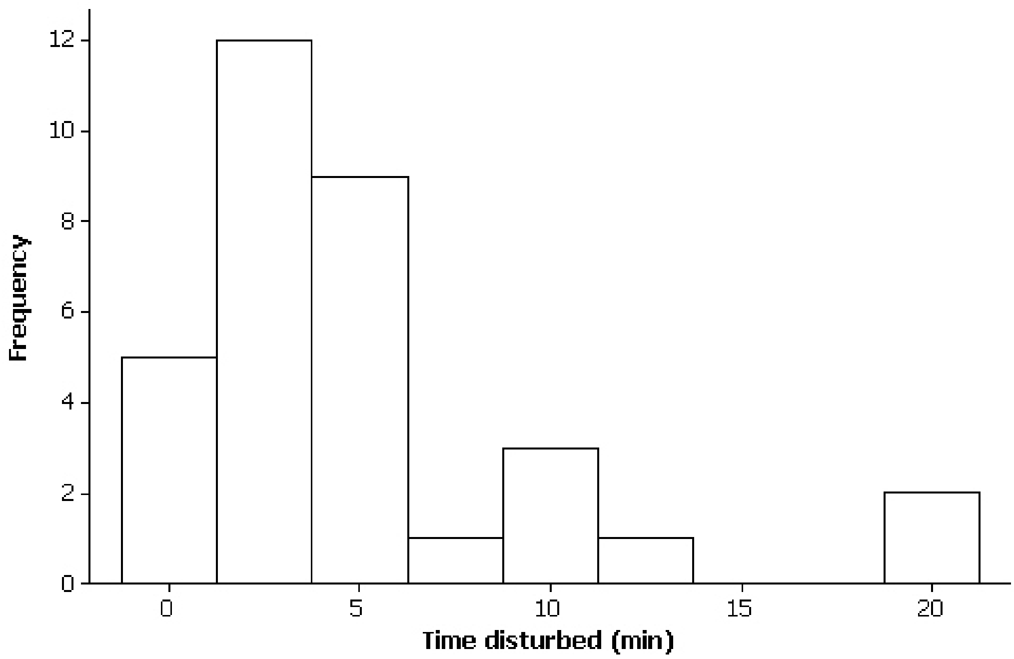

Figure 11. Frequency distribution of total time disturbed for the 33 human disturbances observed during the study period.

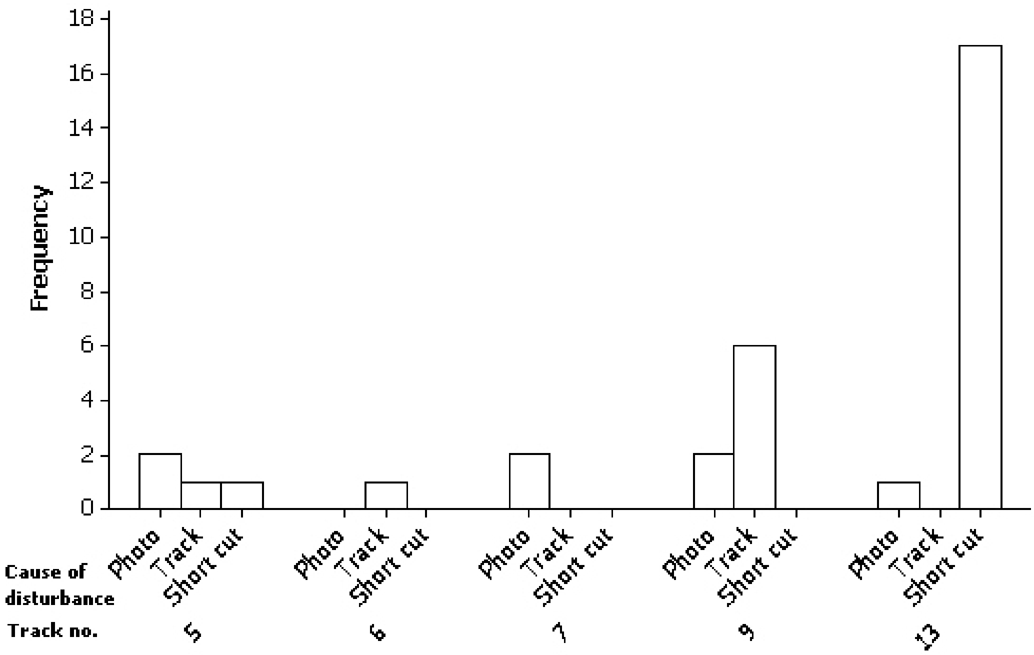

Figure 12. Frequency distribution of causes of disturbance for each track where disturbance occurred. (See Fig. 2 for track number references).

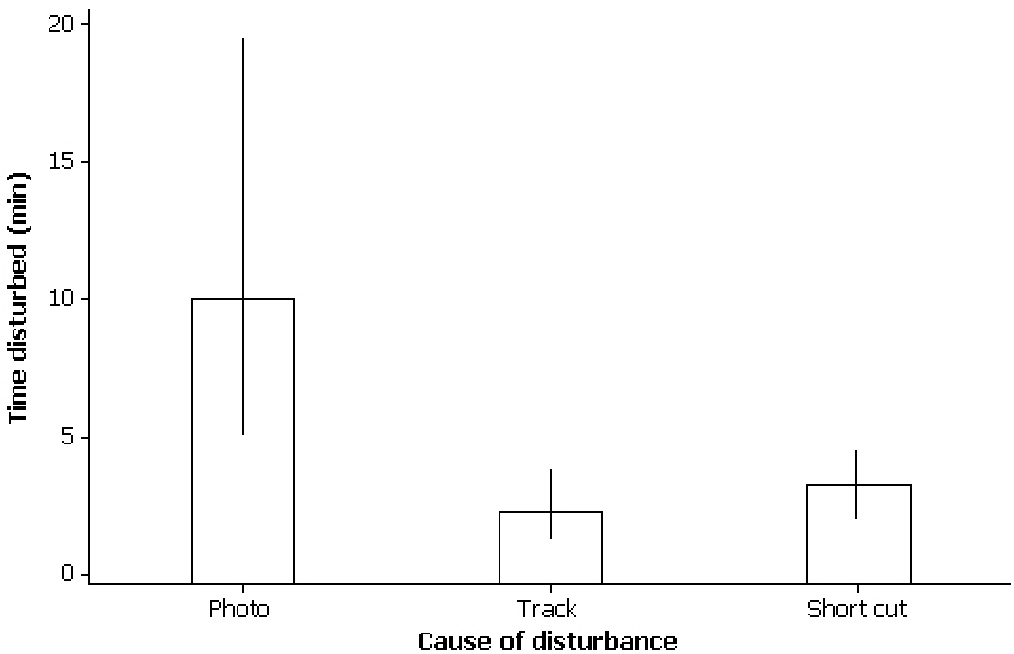

Figure 13. Median time the Great Skuas were disturbed by humans depending on if the disturbing person(s) were taking photos, walked on track or took a short cut. Bars indicate the range of observations.

We found that, as the number of persons that disturbed increased, time disturbed also increased ($r_s = 0.35$, $n = 33$, $P = 0.048$; Fig. 14). This effect became clearer if photographers were removed from the data material ($r_s = 0.53$, $n = 26$, $P = 0.0055$). The photographers actually showed an opposite correlation, but this was not significant. We also found that people leaving tracks when disturbing, disturbed the skuas for a longer time than people walking on tracks when disturbing (Mann-Whitney U-test: $U = 468.0$, $N_1 = 24$ (off-track), $N_2 = 9$ (on-track), $P = 0.016$; Fig. 14).

We did not find that the degree to which the nearest track was used and the distance from nest to nearest track had any effect on the number of times, nor the total time the skuas were disturbed by humans (Table 5). We did not find any effect of human disturbance on the reproduction of the Great Skuas, either (Table 6).

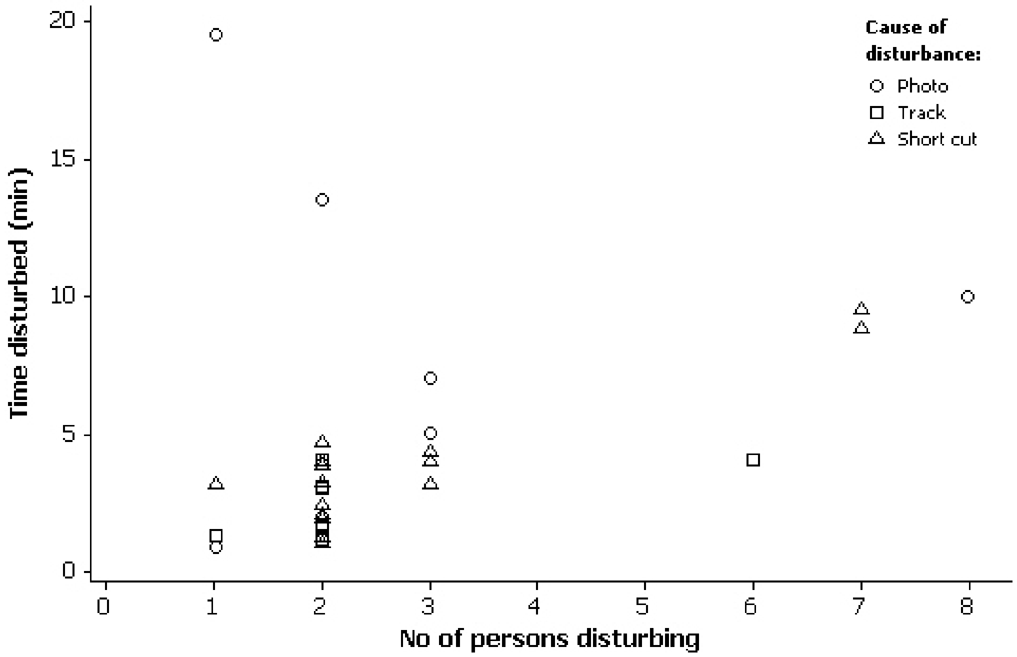

Figure 14. Effect of the number of persons on the time the Great Skuas were disturbed by humans.

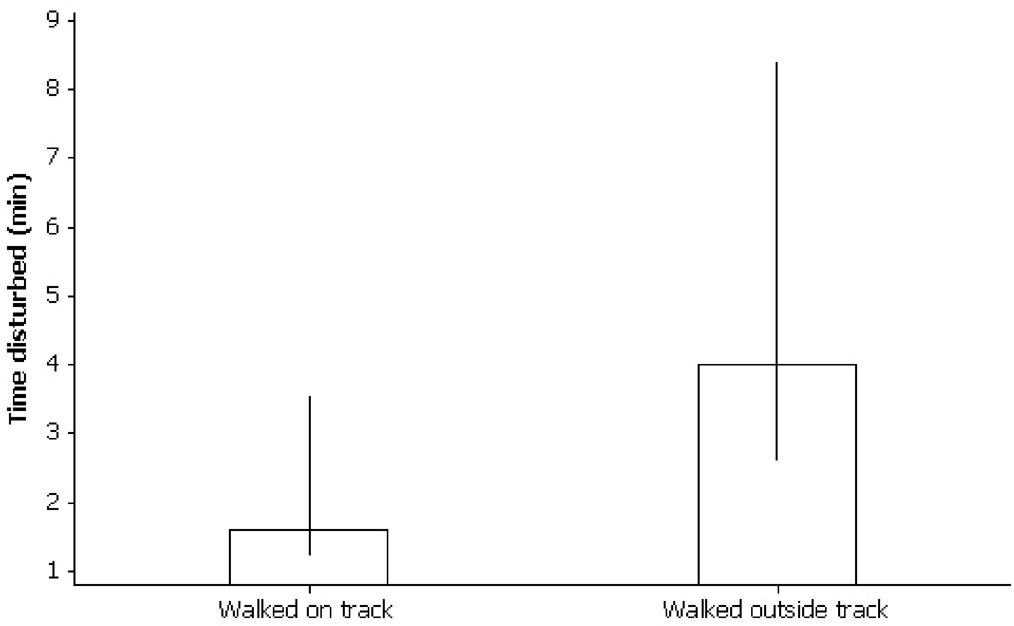

Figure 15. Median time the skuas were disturbed depending on whether the disturbing person(s) walked on a track, or walked outside a track. Bars indicate the range of observations.

Table 5. Use of nearest track and distance from nest to nearest track in relation to human disturbances.

Factor	Response	N	Rs	P
Use of nearest track	Number of disturbances	24	-0.04	0.85
Use of nearest track	Time disturbed	24	0.04	0.84
Nest-track distance	Number of disturbances	24	-0.08	0.72
Nest-track distance	Time disturbed	24	-0.00	0.98

Table 6. Effects of human disturbances on three measures of reproduction.

Factor	Response	G[a]	df	P
Number of disturbances	Number of chicks observed	0.72	1	0.40
Number of disturbances	Number of chicks marked	0.23	1	0.63
Number of disturbances	Number of chicks two weeks after hatching	0.06	1	0.80
Time disturbed	Number of chicks observed	0.02	1	0.89
Time disturbed	Number of chicks marked	0.03	1	0.85
Time disturbed	Number of chicks two weeks after hatching	0.00	1	0.97

[a]Logistic regression

Experiment

We found no correlation between distance between nest and nearest track, and responses of the Great Skuas in the experiment on Runde (Table 7). Nor did we find any correlation between use of nearest track and responses in the experiment on Runde (Table 7). However, when combining the data from Runde and Nerlandsøy, those skua nests with little use of nearest track, were the ones with largest nest returning distance (Table 8) and longest time in air (Table 8). Similarly, the cumulative responses by the skuas increased, as the use of the nearest track decreased (Table 8, Fig. 16).

Table 7. The effect of distance between nest and nearest track and use of nearest track, on the responses of the incubating Great Skuas on Runde during experiments.

Factor	Response	N	Rs	P
Nest-track distance	Nest leaving distance	24	0.09	0.69
Nest-track distance	Nest returning distance	24	-0.13	0.55
Nest-track distance	Time in air	24	-0.09	0.68
Nest-track distance	Cumulative responses	24	-0.04	0.84
Use of nearest track	Nest leaving distance	24	-0.04	0.86
Use of nearest track	Nest returning distance	24	-0.34	0.11
Use of nearest track	Time in air	24	-0.29	0.17
Use of nearest track	Cumulative responses	24	-0.30	0.15

Table 8. The effect of distance between nest and nearest track and use of nearest track, on the responses of the incubating Great Skuas at both Runde and Nerlandsøy during experiments.

Factor	Response	N	Rs	P
Nest-track distance	Nest leaving distance	30	0.23	0.23
Nest-track distance	Nest returning distance	30	0.09	0.65
Nest-track distance	Time in air	30	0.08	0.68
Nest-track distance	Cumulative responses	30	0.15	0.42
Use of nearest track	Nest leaving distance	30	-0.32	0.087
Use of nearest track	Nest returning distance	30	-0.50	**0.0051**
Use of nearest track	Time in air	30	-0.41	**0.027**
Use of nearest track	Cumulative responses	30	-0.47	**0.0086**

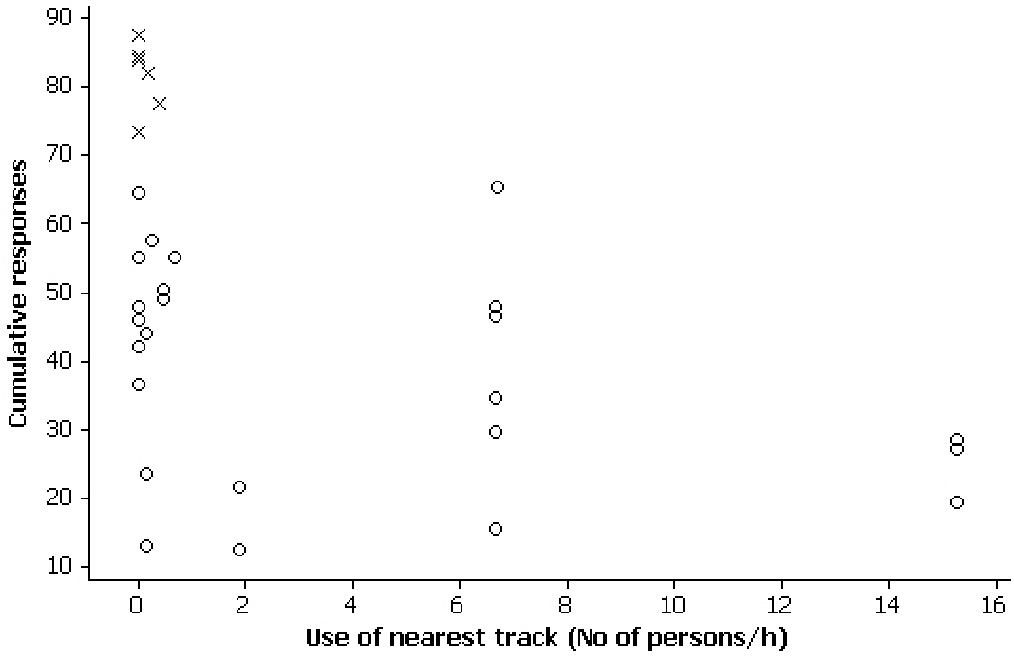

Figure 16. Cumulative responses (the sum of the ranked values of nest leaving distance, nest returning distance and time in air) in relation to use of nearest track from both Runde (o) and Nerlandsøy (×).

The mean nest leaving distance birds responded to humans on Runde and Nerlandsøy was 70m. When analysing Runde and Nerlandsøy separately, the mean nest leaving distances were 32m and 220m, respectively (Fig. 17). During the experiment we found no correlation between the responses of the skuas and reproduction on Runde (Table 9).

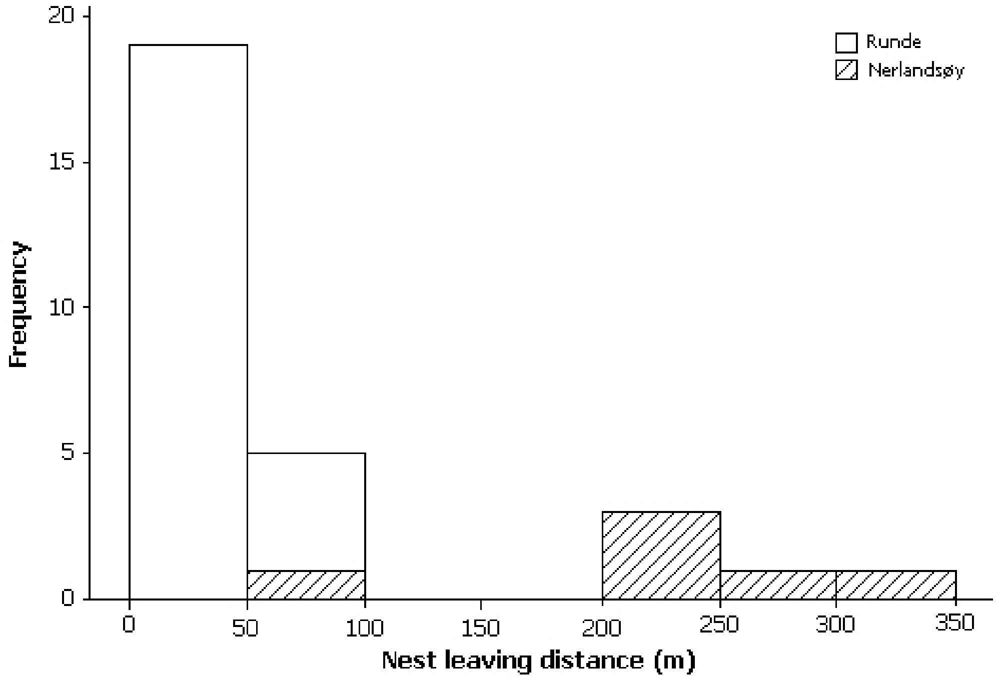

Figure 17. Frequency distribution of nest leaving distance from both Runde and Nerlandsøy.

Table 9. Relationships between the responses of the skuas during the experiment, and reproduction on Runde.

Factor	Response	G[a]	df	P
Nest leaving distance	Number of chicks observed	0.20	1	0.66
Nest returning distance	Number of chicks observed	1.67	1	0.20
Time in air	Number of chicks observed	1.24	1	0.27
Cumulative responses	Number of chicks observed	0.57	1	0.45
Nest leaving distance	Number of chicks marked	0.31	1	0.58
Nest returning distance	Number of chicks marked	3.50	1	0.062
Time in air	Number of chicks marked	3.17	1	0.075
Cumulative responses	Number of chicks marked	2.80	1	0.094
Nest leaving distance	Number of chicks two weeks after hatching	0.01	1	0.91
Nest returning distance	Number of chicks two weeks after hatching	2.78	1	0.095
Time in air	Number of chicks two weeks after hatching	3.39	1	0.065
Cumulative responses	Number of chicks two weeks after hatching	1.64	1	0.20

[a]Logistic regression

Discussion

Because the effect of human activity on animals may be studied on at least three main levels, behaviour, cumulative effects (reproduction) and distribution/avoidance, a thorough study should include all these three factors. In our study of the Great Skuas on Runde we looked at all the aspects. We did not find any effect on the species' breeding behaviour and reproduction, but when looking at the distribution, the skuas on Runde avoided nesting in areas with high human activity. Interestingly, the experiment showed that the skuas in areas with high human activity had become partly habituated to humans.

Breeding behaviour

Breeding behaviour in this study was thoroughly studied and included time incubated, time feeding chicks, time mate present, and time and number of human disturbances. We did not find any effect of human activity on the breeding behaviour of the skuas on Runde. We were surprised to see that during the chick period the birds nesting in areas with high human activity were less disturbed by White-tailed Eagles than areas with low human activity. White-tailed Eagles are known to be highly sensitive to humans. Fraser et al. (1985) found that the eagles' mean flushing distance was 500 m, and in some situations up to 1000 m. This could imply that eagles stayed away from areas with high human activity, and this could actually favour skuas nesting in areas with high human activity.

Few people went off the tracks on Runde, and it was rare that skuas were disturbed by people following tracks. Skuas were as a result seldom directly disturbed, and the data material on human disturbance is therefore small. Our material showed that most direct disturbances were due to either people taking short cuts without knowing about the skuas, or by people taking photos.

The main group of human disturbances was people taking a sheep track that seemed to be a short cut down from the mountain. Several people took this track and were obviously surprised when they were attacked by three aggressive Great Skua pairs defending their eggs or chicks. These three pairs were those most frequently disturbed by humans on Runde, and they only raised one chick each (Fig. 2). In comparison, the mean number of chicks for those other pairs with eggs that hatched (19 pairs in total) was 1.53.

Interestingly, for the people taking the short cut, time disturbed increased as the number of people increased, whereas there was an opposite tendency for the photographers, time disturbed increased as the number of photographers decreased. Photographers went off tracks and walked directly towards breeding skuas and time disturbed was sometimes rather long (up to 20 min). In a nature reserve in Florida, Klein (1993) noticed that photographers were the greatest disturbance source for birds. This may be an increasing human activity that needs to be controlled better in the future.

Cumulative effects (reproduction)

We did not detect any effect of human activity on reproduction. This could suggest that human activity does not affect the reproduction, but the result could be due to the fact that the skuas already had placed their nests away from areas with too high human activity, or that the population size was too small. Because the population of Great Skuas on Runde is quite new, the colony has probably not reached the full size the area can support. Average distances between nests were 94 m, whereas on Foula, Shetland, average distances between nests were 30 m (Furness 1987). If the skua colony size increases in the future, the human activity may have an increasing negative effect on reproduction, as it will be harder to find nesting places away from tracks, and birds will be forced to nest closer to them.

Furthermore, documenting disturbance on reproduction may be difficult as the nests normally contain two eggs, and the variation in number of offspring is small. Our data on reproduction may also be insufficient to detect negative effect on reproduction. We did not observe the number of fledged offspring, neither did we analyse the survival of the chicks until the following year or the condition and survival of the parents. In addition, this material includes only those skua pairs that laid eggs, and not those pairs that did not manage to lay eggs.

Nest distribution

The Great Skua on Runde avoided nesting close to tracks that were frequently used by humans. This implies that human activity in fact has an effect on the skuas on Runde, even though we did not detect any negative effects on breeding behaviour and reproduction. These results point out the importance of not just analysing the behaviour and reproduction, but also analysing the distribution of the species. The reason that studies not detect any effect on behaviour and reproduction may be due to individuals already having moved away from areas that could have an effect on behaviour and reproduction.

Some studies indicate that birds nesting in open areas, like the Great Skua on Runde, are more sensitive to human activity (Fernández-Juricic et al. 2002, Naturvårdsverket 2004). To our knowledge there are few seabird studies looking at distribution of birds relative to human activity in areas that have not gone through major changes. Interestingly, our result shows a similar trend as was found in breeding bird communities in Colorado, United States (Miller et al. 1998), where birds in open grassland were less likely to nest near recreational trails.

Is it possible to find a threshold of how close to tracks the skuas can exist on Runde? We found that increased human activity increased the distance between nests and track, so it is clear that the distance does depend on the degree of human activity. When looking at those tracks on Runde with the highest use (6-24 persons/h), there were no successful nests within 150 m from the tracks. For lesser used tracks (0-2 persons/h), few successful nests were within a distance of 50 m. This suggests that human activity has a negative impact up to 150 m from tracks.

A local outdoor pursuits centre as well as several local elementary schools visit the plateau in large groups in April and May. These groups used, beside the frequently used tracks, also track no. 13 (Fig. 2). As our observation period started first in late May, there are reasons to believe that the effect of the use of track no. 13 is underestimated, especially since the children's activity was centred at the time the skuas were choosing nesting areas. Interestingly, the closest breeding pair from this track was 152 m.

Experiment

As a supplement to our study of the behaviour of nesting skuas towards humans, an experiment was conducted. We found that skuas in areas with high human activity showed less response to intrusive humans than skuas in areas with less human activity. This suggests that Great Skuas may become partly habituated to high human activity, which agrees with studies done by Burger and Gochfeld (1983, 1991), where birds in areas with high human activity responded later to human activity than birds breeding in areas with less human activity. In our study this was clearly evident when combining our data from Runde and Nerlandsøy.

That birds react less to human activity, may not mean that they are not negatively affected. It may just be that birds are forced to cope with the disturbance because they already have nests or chicks in the area or because undisturbed areas are too far away (Naturvårdsverket 2004). Or it could be due to the fact that the first pairs that settled on Runde in early 1980 nested in the area where the most frequently used tracks are today. This site could be favourable for future pairs because by settling at an established site, individuals gain confidence that local conditions are favourable for breeding, even if good breeding sites may be available elsewhere (Forbes and Kaiser 1994).

The mean nest leaving distance in response to human intrusion on Runde including Nerlandsøy was 70 m. This distance may serve as a recommended minimum distance for humans to keep away of incubating Great Skuas. However, this distance seems to depend on the degree of human activity. For instance, when analysing Runde and Nerlandsøy separately, the nest leaving distances were, 32 m and 220 m, respectively. The goal should, though, be to avoid that any birds flush. On Runde, we found that keeping a distance of 90 m to the skua pairs will be enough to eliminate all flushing, whereas 60 m will be enough to eliminate flushing among 88% of the skuas. Flush distance between birds and humans seem to vary with bird species (Blumstein et al. 2003). Mean flushing distance of White-tailed Eagles was found to be 500 m from humans (Fraser et al. 1985). Erwin (1989) recommended a distance of 100 m for Least Terns (*Sterna antillarum*) and Royal Terns (*S. maxima*) and 200 m for Common Terns (*S. hirundo*) and Black Skimmers (*Rynchops niger*).

Skuas at Nerlandsøy were much less aggressive than skuas on Runde. Where Great Skuas nest at much lower densities in some other parts of Shetland, such as Yell or Shetland mainland, they also tend to be much less aggressive. Either the more aggressive individuals are the ones most likely to succeed in establishing a territory within a dense colony, and less aggressive ones are forced to move to areas where competition is less, or dive-bombing behaviour requires some social stimulation from neighbouring birds before it can develop fully (Furness 1987). One might also think that single pairs have an advantage by being discrete to avoid being detected since they would not get help from other pairs.

When executing the experiment we did not consider if the mate was present or not. One may suggest that this will interfere with the responses of the skuas, but as mates present will vary independently of area it should not matter. Some of the pairs were placed in the terrain where they did not have clear vision to the intrusive person, and this may have affected the results.

Future conservation actions

In conclusion, our study indicates that the Great Skuas on Runde have become partly habituated to humans, but avoid nesting in areas with high human activity.

Management activities such as placing signs, restricting access, and patrolling have been shown to have positive effects on shorebirds in USA (Burger et al. 2004). Better signs and more patrolling would probably reduce most of the disturbance situations observed on Runde. Situations like people becoming surprised by aggressive skuas or people using a long time on photographing skuas occurred several times and show the need for better information. Since the skuas were mostly disturbed by people using a sheep track, it would be profitable to block tracks like this in the future to avoid these being used by humans.

Restricted areas on Runde do not include the areas where the Great Skuas breed. Our results indicate, though, that in some parts of the island it would be difficult for people to depart from tracks without disturbing pairs of skuas, especially since the distance between humans and skuas should be more than 60 m to avoid most skuas to flush.

The Great Skua population on Runde is still increasing. Compared with the Great Skua colony in Shetland where the density is higher, one might think that Runde could support a larger colony than at present. Today there are areas that are not colonized by skuas, and especially the southeast side of the plateau seems to have a potential to support a far greater number of pairs in the future. As the skuas have not yet colonized this area, though, it may indicate a less suitable area, for instance due to a larger distance to food sources. In the observation area where the human activity is high, the tracks will eventually limit the colony size as breeding distances to frequently used tracks was found to be at least 150 m.

Tourism will probably increase in the region, with the nearby fjord Geiranger on the world heritage list. In this regard, it will be important to improve the track network to avoid further expansion of the track width (especially those tracks that were frequently used), as well as avoid the creation of new tracks. Simultaneously, one should be aware that increased human activity may lead to a higher disturbance effect on the Great Skua population.

Finally, we would like to point out that this study also stresses the importance of looking at disturbance on several levels. Future management should be based not only on studies of behaviour and reproduction, but also on distribution.

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