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The effect of human disturbance on nest predation rate of ground-nesting birds

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ABSTRACT

A number of studies have shown that human disturbance can have a strong negative impact on the successful reproduction in birds. Ground-nesting birds are especially vulnerable to nest mortality due to trampling of nests, predation by loose dogs, or that parents abandon the nest because of extensive disturbance. However, nest mortality might also be the result of nest predation that occurs after the disturbance has seized. Predators are likely to eavesdrop human presence using visual, auditory or olfactory cues to home in on the location of nests. In this study I investigated if human disturbance would negatively affect the nest predation rate in ground-nesting birds. I predicted that a higher visitation rate would increase nest predation risk. To measure the response I used a total of 280 artificial nests that contained eggs from the Common Quail (*Coturnix coturnix*). The study was divided into two periods, and for each period two different habitats were used (forest and clear-cut). Visitation rates were divided into three groups: 1) nests visited every day, 2) nests visited every third day, and 3) nests never visited. A separate area (clear-cut) was also used to see if wildlife cameras had an effect on nest predation rate. I found that visitation rate had a significant effect on nest predation rate, with nests visited every day having almost twice the number of nests predated upon than nests that were never visited. Wildlife cameras did not seem to affect nest predation rate. The predation rate was highest for the forested area in the second period for all of the three visitation categories. The reasons for this could be distance to human settlements and agricultural landscape, and observation of both mammalian and avian predators at the study site. Previous studies have shown that nests placed on the ground close to human settlement have higher predation rate than nest placed in larger forest area, further away from human disturbance and settlements, and corvids are the most common predator of ground-nests, which could explain my results. There are no temporal trends and predation happens random through out the study period. This study illustrates that predation on ground-nests is strongly affected by daily human visits, in areas close to human settlement. Caution should be taken when visiting ground-nesting birds, avoiding damaging area close to the nest and also not walking the same path to each nest upon visits and most important have as few visits as possible.

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I want to dedicate this thesis to my parents for the strength they have shown me and to my close friends for the motivation and constant happy thoughts throughout this period.

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INTRODUCTION

Human activities can result in habitat loss and alterations causing changes in nest predation risk for ground-nesting birds (Beale and Monaghan 2004; Seibold *etal*. 2013; Ibáñez-Álamo *etal*. 2015). These changes are likely to create urbanized areas fragmenting existing wildlife areas, creating corridors and enhance the edge effect, which all can lead to reproductive failure for ground-nesting birds compared to pristine and larger areas with less human interference (Wilcove 1985; Small and Hunter 1988; Haegen and DeGraaf 1996; Keyser *etal*. 1998; Zanette and Jenkins 2000; Eriksson 2001; Lahti 2001; Thorington and Bowman 2003; Evans 2004; Coppedge *etal*. 2007; Gill 2007; Ludwig *etal*. 2012; Schneider *etal*. 2012). Generalist predators are common in open and agricultural landscapes, while visual predators such as birds are more common in forested areas (Wilcove 1985; Angelstam 1986; Andrèn 1992; Eriksson 2001). Human activities such as feeding stations, and the introduction of alien species, can also affect predation risk on ground-nesting birds (Ibáñez-Álamo *etal*. 2015).

However, the reproductive success of birds can be more directly affected by the physical presence of humans, which can occur through researcher activities, ecotourism and recreational activities (Lenington 1979; Major 1990; Giese 1996; Carney and Sydman 1999; Bolduc and Guillemette 2003; Weston and Elgar 2007). Researcher activities are likely to be an intense form of disturbance with its handling of eggs and birds, which could lead nests and hatchlings exposed to the surroundings that is not optimal (Götmark 1992; Carney and Sydeman 1999, Gillis *etal*. 2012). Ecotourists (e.g. photographers and birdwatchers) tend to be large groups with high visitation rates, and are likely to exert high disturbance from a longer distance (Sedinger 1990; Henson and Grant 1991; Giese 1996; Bêty and Gauthier 2001; Beale and Monaghan 2004). Recreational activities (e.g. jogging, hiking, walking and biking) are not an intense form of disturbance and are not interfering in any harmful manner, except with the possibility of trampling on the nest (Carney and Sydman 1999; Miller and Hobbs 2000; Bolduc and Guillemette 2003; Ruhlen *etal*. 2003; Finney *etal*. 2005). Both ecotourism and recreational activities have higher frequencies of visits through habitat and places where ground-nesting birds are located, and an increase in human visitation rates have a higher probability of affecting their reproductive success (Major 1990; Giese 1996; Ruhlen *etal*. 2003; Finney *etal*. 2005; Madsen *etal*. 2009). Especially in the incubation period when stress can lead to a decrease in efficiency leading to a failure in the protection of nest and nestlings, feeding, and concealment, which further can cause nest abandonment and/or nest predation (Major 1990; Götmark 1992; Ruhlen *etal*. 2003; Finney *etal*. 2005).

Without human disturbance do natural nests have many cues that can attract predators, such as odours, acoustic and visual cues (Burke *etal*. 2004). For example, predators can use parental and chick begging calls, visual cues such as parental activity and conspicuousness of nests, and odours (Rangen *etal*. 2000; Ibáñez-Álamo *etal*. 2015). Predation is the number one cause for reproductive failure in ground-nesting birds (Lathi 2000; Wegge and Rolstad 2011). Moreover, human disturbance can make some predators develop a search pattern by observing humans visually or by odour to find food (Eriksson 2001). This makes artificial nests convenient since they will only attract predators as a result of human disturbance (and possible visual flaws in nest placement) (Rangen *etal*. 2000; Conover 2007; Weidinger 2008).

Artificial nests prohibit bird mortality, caused by researcher, and provide an adequate sample size that is easier to control and to localize (Rangen *etal*. 2000; Eriksson 2001; Burke *etal*. 2004; Klaus *etal*. 2009). There are differences between natural and artificial nests that can lead to differences in predation rates (Gottfried and Thompson 1978; Götmark and Åhlund 1984; Zanette 2002). But as Zanette (2002) found, that the trend for predation rate would be same for both artificial and natural nests.

Predatory eavesdropping may result in predation right after or while humans are present (Götmark and Åhlund 1984; Götmark 1992; Ruhlen *etal*. 2003; Weidinger 2008). The predators can use olfactory and visual cues left by humans that persist in the environment (Conover 2007; Weidinger 2008). Cues such as damaged vegetation or markers left to find the nest and/or equipment left to monitor the nest are more permanent (Götmark 1992; Herranz *etal*. 2002; Ruhlen *etal*, 2003; Weidinger 2008). One type of equipment left to monitor nests are wildlife cameras. Wildlife cameras can be highly conspicuous, and there has been done studies investigating the possible effect they may have on the predation rates of artificial and natural nests (Herranz *etal*. 2002; Richardson *etal*. 2009). Wildlife cameras have been shown to both reduce and increase predation rates (Herranz *etal*. 2002; Richardson *etal*. 2009).

The aim of this study was to investigate if human disturbance would negatively affect the nest predation rate in ground-nesting birds. I predicted that 1) the nest predation rate would increase with an increase in human visitation rate, and 2) the daily predation rate would increase with time during the study period.

METHODS

Experimental design

The study was conducted in Bø in Telemark municipality, Norway, between the 20th May and 30th June 2014. The study was divided into two periods, 26th May to 8th June and 16th June to 29th June, each period lasted for 14 days. The purpose for using two study periods was to increase the sample size, and also to make sure that the sample for first period weren't bias, taken the composition of different possible predators in consideration.

The experiments within each period were performed in one forested area (human visitation rate) and two clear-cut areas (human visitation rate and wildlife cameras). These locations differed between periods, so in total six areas were used. The two forest areas consisted of both coniferous and deciduous trees, and the most frequent species were pine (*Pinus sylvestris*), spruce (*Picea abies*) and birch (*Betula pubescens*). The most common low growing shrubs were common heather (*Calluna vulgaris*) and European blueberry (*Vaccinium myrtillus*). The clear-cut areas consisted of different types of grass, common heather (*C. vulgaris*), and shrubs like raspberry (*Rubus* ideaus) and European blueberry (*V. myrtillus*), with few trees such as pine (*P. sylvestris*) and birch (*B. pubescens*). The reason for two habitats was to see if fragmented landscapes, agricultural landscape and farmland, being illustrated by clear-cut area, have a higher predation rate than larger forest habitats.

In the first study period the forest area was situated approximately 1.6 km from the nearest household and farm, and 50 meter from an old clear-cut area and a small lake. The clear-cut area was close to the main road (>10 meters), and cottages (>1.5 km). The clear-cut area used for cameras were located 270 meter from the nearest farm, with free ranging domestic pigs. In the second study period the nests in the forest area was 50 – 60 meters from the nearest house, agricultural and clear-cut landscape. The clear-cut area was located 25 meter from the nearest house, cultivated landscape less than 5 meter, road (>3 meter) and rail tracks (>75 meter). The clear-cut habitat with camera disturbance was 5 meter and more from road and 40 meters from cultivated landscape.

Within each habitat 60 nests were placed along transects, except for the two clear-cut areas with wildlife cameras which had 20 nests each. The distance between transects and nests within a transect was approximately 100 meter. This distance was chosen to reflect the territory size usually found in small ground-nesting birds (Cramp and Perrin 1994).

In each artificial nest I placed three common quail (*Coturnix coturnix*) eggs to resemble the cryptically coloured eggs laid by many bird species. Each nest was made out of moss (*Sphagnum spp*.), and the moss was collected from the same place outside the study area. The nest was shaped as a small cup formed around the three eggs. When constructing the nest, the moss was carried in plastic bags, and sterile gloves were used. The artificial nests were made to look like real nests, concealed as naturally as possible.

Figure 1 The picture to the left illustrate a nest in a clear-cut area, and the picture to the right illustrates a nest in a forested area.

Cameras were used to see if they have a disturbance effect on the predation rate, if it would increase or decrease the predation rate. Twenty cameras were placed at a distance 40–300 cm from the nest, and 30-150 cm above the ground. The area between the camera and around the nest was cleared so that the camera would have a good view of the nest. This made the nests slightly more conspicuous than is usually the case under natural circumstances.

Visitation rates were categorised into three groups: 1) nests visited every day, 2) nests visited every third day, and 3) nests never visited. Nest visitations were conducted both early (07.0-13.00) and late (13.00 -21.00), and were randomly chosen between habitats (forest and clear-cut). Each visit to a nest lasted for 2 minutes, and within this period I studied the nest for predation, wrote protocol and took pictures of the nest. I followed the same path every day using a GPS with pre-plotted positions, even if a nest was predated upon. A nest was defined as predated when one or more eggs were destroyed, or removed from the nest.

Statistical analysis

I used a generalized linear model (GLM) with binomial response (not predated = 0; predated = 1) (Lewis 2004; Zuur *etal*. 2007) to study the probability of nest predation in relation to visitation rate. The explanatory variables were visitation rate (each day, each 3 day, never), habitat type (forest, clear-cut), study period (period 1, period 2), and the interaction habitat:study period.

Because visitation rate 'camera' was only available for habitat type 'clear cut', I repeated the analysis on the probability of nest predation in relation to visitation rate restricted to habitat 'clear cut' but including visitation rate 'camera'. The explanatory variables were visitation rate (each day, each 3 day, never, camera), and study period.

I used a GLM with binomial response (no nest predated = 0; at least one nest predated = 1) to evaluate a potential temporal trend in nest predation, i.e., if the probability for predation per day at a study site increased with time during the study period. The explanatory variables were visitation rate (each day, camera), habitat (clear-cut, forest), visitation day (range: 1-14), study period, and the interaction habitat:study period. I did not include visitation rate each third day into this analysis, because the number of visitation days (range 1-5) was different.

To exclude a potential habitat effect, I repeated the above analyses restricted to habitat 'clear cuts' only. The explanatory variables were visitation rate (each day, camera), visitation day (range: 1-14), and study period.

All of the above models were also run as generalized linear mixed models (Zuur et al. 2007), including study site id as a random factor. However, the results were almost identical with the GLM analyses, therefore I only present the GLM results. We selected the best model in a backward elimination procedure, choosing predictor variables according to their p-values; an α level of 0.05 was considered statistically significant, and an α level < 0.1 was considered statistically suggestive. All analyses were carried out in R. 3.1.2. (R Core Team 2014).

RESULTS

General results and observations

A total of 280 artificial nests were established, 120 nests in forest habitats (60 in the first period and 60 in the second period), and 120 nests in clear-cut habitats (60 in the first period and 60 in the second period). A total of 7 nests were removed from the analysis, because they were either predated before the disturbance period had started (1 nest), not found after the 14-day period (4 nests), or because of camera malfunction (2 nest). This resulted in a total of N=273 nests used for statistical analysis.

A total of six potential nest predators were visually observed by chance during the study periods. In the first period study site clear-cut, four dogs (*Canis familiaris*) were observed twice; according to their owner these dogs walk through this study area on a daily basis. In the second study period study site forest, a pair of common raven (*Corvus corax)* were observed on every visit, and a red fox (*Vulpes vulpes*) was observed the day the nests were established. In the second period study site clear-cut, a red fox family (1 mother with 4 pups) was observed once.

Two predators were observed at nests disturbed by camera (Figure 2); a common crane (*Grus grus*) predated 1 nest in the second period, and a badger (*Meles meles*) predated 3 nests in the first period.

Figure 2 Picture to the left illustrate a crane predating nest in the second period, picture to the right illustrate a badger predating a nest in the first period.

A visual comparison of the different visitation rates and camera disturbance in relation to number of predated nests in total, demonstrating a trend of predated nests following the increase of visits (Figure 3).

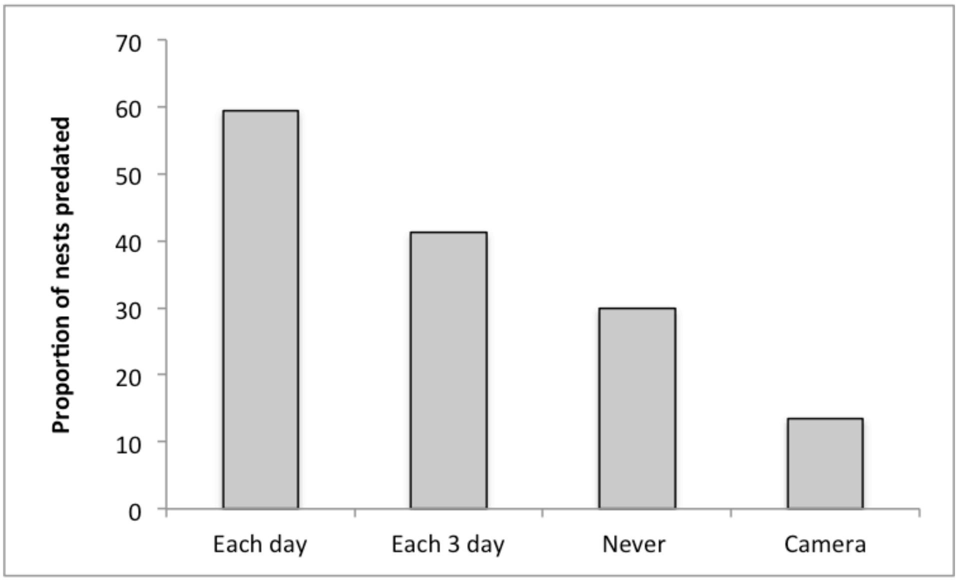

Figure 3 The total number of predated artificial nests (in percent), in relation to visitation rate by an observer and camera in Bø, Telemark, Norway, 2014.

A visual comparison of number of predated nests in relation to visitation rate indicates a trend towards increasing predation rate with increasing visitation rate, in each study site (Figure 4).

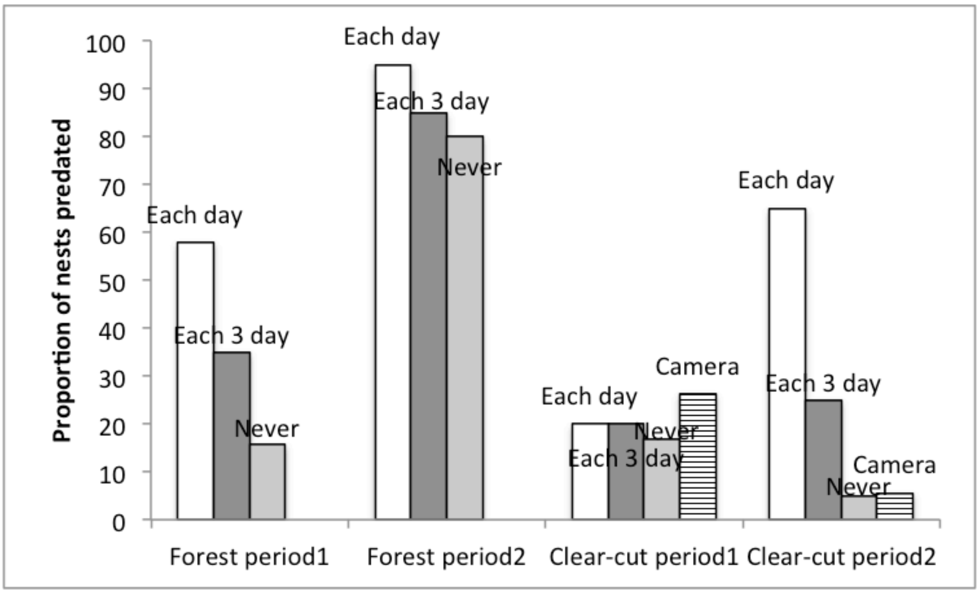

Figure 4 Proportion of nests predated in an experiment evaluating predation of artificial ground nests in relation to different visitation rates by an observer in Bø, Telemark, Norway, 2014. The compared the following visitation rates: each day; every 3 day; never; a camera was set up at a nest, but the nest was never visited afterwards.

Results of the statistical analyses – probability of nest predation

The probability of nest predation increased significantly with increasing visitation rate, was significantly higher in forest habitats (Figure 4, Table 1). There was a trend for higher predation probability in forest habitats in comparison to clear cut habitat, and the interaction habitat*study period shows that the probability for nest predation was significantly higher in forest habitats during the second study period in comparison to other habitats and study periods (Table 1).

Table 1 Results of a generalized linear, binomial response, to study the probability of predation of artificial ground-nests in relation to visitation rate in Bø, Telemark, Norway, 2014. The response variable was whether or not a nest was predated (0 = not predated, 1 = predated), and the explanatory variables were: visitation rate (each day, every 3 day, never), study period (period 1, period 2), habitat (forest, clear-cut), and the interaction 'habitat:study period'. *β* = parameter estimate, SE = standard error, Z = z-value, and P is the p-value.

Variable		*β*	SE	Z	P
Visitation rate					
	Every 3 day	0	0		
	Each day	1.004	0.382	2.631	0.009
	Never	-1.713	0.4227	-4.053	<0.001
Study period					
	Period 1	0	0		
	Period 2	0.780	0.457	1.707	0.088
Habitat					
	Clear-cut	0	0		
	Forest	1.026	0.457	2.247	0.025
Habitat Forest:Study period 2		1.902	0.673	2.826	0.005

The analysis on the probability of nest predation in relation to visitation rate restricted to habitat 'clear cut' but including visitation rate 'camera' showed that there was trend for higher predation probability for nests visited every day in comparison to all other visitation rates (Figure 4, Table 2). The second study period was not significant higher than the first study period ($\beta = 0.302$, SE = 0.390, Z = 0.776, P = 0.438). The variable 'habitat' was removed as non-significant from the analysis.

Table 2 Results of a generalized linear model, binomial response, to study the probability of predation of artificial ground nests in relation to visitation rate in clear-cuts habitat only in Bø, Telemark, Norway, 2014. The response variable was whether or not a nest was predated (0 = not predated, 1 = predated), and the explanatory variables were: visitation rate (each day, every 3 day, never, camera) and study period (period 1, period 2). β = parameter estimate, SE = standard error, Z = z-value, and P is the p-value.

Variable		β	SE	Z	P
Visitation rate					
	Camera	0	0		
	Each day	0.986	0.513	1.923	0.054
	Every 3 day	0.047	0.551	0.086	0.932
	Never	-0.867	0.664	-1.306	0.192

Results of the statistical analyses – temporal trend in daily nest predation probability

The probability for predation was significantly higher with visitation rate ‘each day’, and there was a trend for a higher predation probability in the habitat forest in study period 2. There was no temporal trend in predation probability, because the variable ‘visitation day’ was removed as non-significant from the analysis.

Table 3 Results of a generalized linear, binomial response, to study if there was a temporal trend in daily nest predation probability in artificial ground-nests in relation to visitation rate in Bø, Telemark, Norway, 2014. The response variable was whether or not a nest was predated (0 = not predated, 1 = predated), and the explanatory variables were: visitation rate (each day, camera), habitat (clear cut, forest), visitation day (range: 1-14), study period (period 1, period 2), and the interaction ‘habitat:study period’. β = parameter estimate, SE = standard error, Z = z-value, and P is the p-value.

Variable		β	SE	Z	P
Visitation rate					
	Camera	0	0		
	Each day	1.865	0.729	2.560	0.010
Study period					
	Period 1	0	0		
	Period 2	0.638	0.661	0.965	0.334
Habitat					
	Clear-cut	0	0		
	Forest	-1.178	0.923	-1.276	0.202
Habitat Forest:Study period 2		2.071	1.170	1.769	0.077

The analysis of a temporal trend in the probability of nest predation in relation to visitation rate restricted to habitat ‘clear cut’ showed that the probability for predation was significantly higher with visitation rate ‘each day’ ($\beta = 1.833$, $SE = 0.721$, $Z = 2.543$, $P = 0.011$). There was no temporal trend in predation probability, because the variable ‘visitation day’ was removed as non-significant from the analysis. Also, the variable ‘habitat’ was removed as non-significant from the analysis. Figure 5 illustrates predation happening close to each day for both habitats (clear-cut and forest) in the second study period, than in the first study period, and also how the predation rate is higher for nest visited by humans compared to camera disturbance.

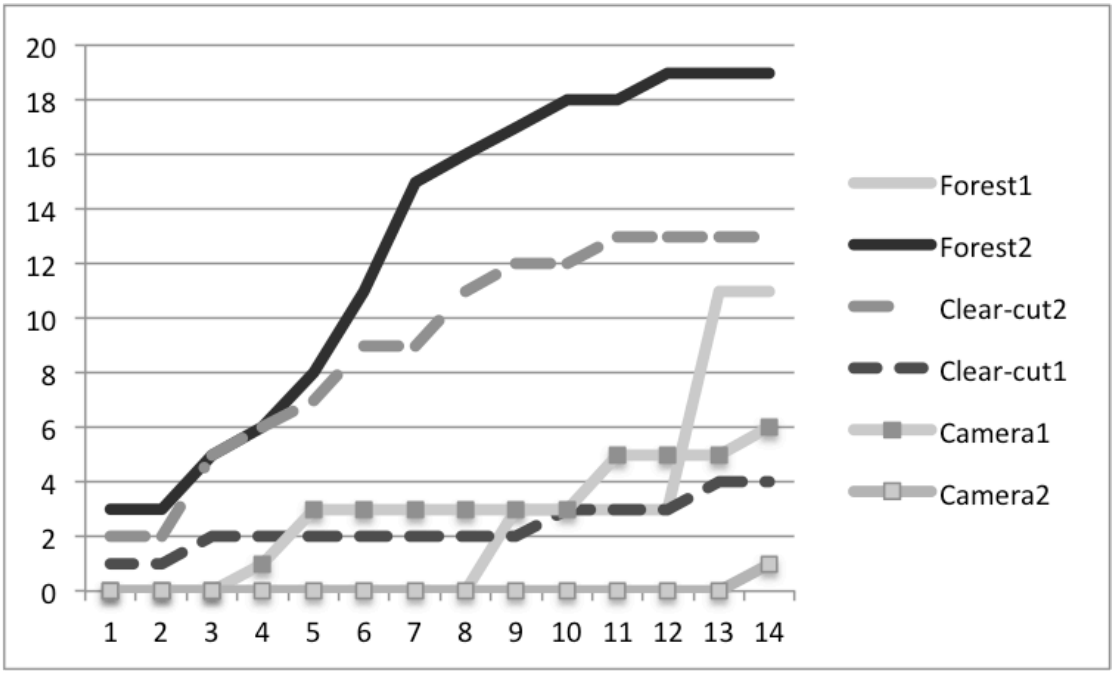

Figure 5 The daily trend for predated nests visited each day and camera, for all six study areas, Forest1: forest in the first period, Forest2: forest in the second period, Clear-cut1: clear-cut in the first period and Clear-cut2: clear-cut in the second period. Camera1: clear-cut in the first period with camera disturbance and Camera2: clear-cut in the second period with camera disturbance. Observer in Bø, Telemark, Norway, 2014.

DISCUSSION

In accordance with several other studies (e.g. Safina and Burger 1983; Major 1990; Giese 1996; Beale and Monaghan 2004) I found that an increase in human disturbance does affect nest predation negatively. Higher visitation rates leads to higher predation rates. Beale and Monaghan (2004) found that the nest predation rate was determined by the number of visits, and that the distance between nests and the disturbance (i.e. humans) had a significant effect on the predation rate; the closer the stronger effect. Götmark (1992) reviewed 225 studies performed on the effect of human disturbance on artificial and natural nests, and he found that it had a negative effect on reproductive success.

The use of artificial nests compared to natural nest can lead to different predation rates, but can also change the composition of predators (Angelstam 1986; Eriksson 2001; Zanette 2002). Visual predators, such as corvids, are common predators of artificial nests, while olfactory mammalian predators are more common for natural nests (Andrèn 1992; Angelstam 1986). Zanette (2002) argued that even though predation rates are higher for artificial nests, it is comparable to predation rates for natural nests and the effect humans have on the reproductive success of birds.

Similar to several other studies (Rangen *etal*. 2000; Miller and Hobbs 2000; Thorington and Bowman 2003, Pangau-Adam *etal*. 2006) quail eggs were used in this study. Quail eggs are easy to obtain in great quantity, and they are a perfect proxy for natural eggs due to their cryptic colouration. Using white eggs have shown to have grater predation rates, than cryptic coloured (Gillis *etal.* 2012). However, the eggshell for quail eggs is harder for small rodents to penetrate (Rangen *etal*. 2000). Mice is one possible predator with good olfactory system, and has shown to be attracted to the odour of quail eggs “polluted” with human smell (Rangen *etal*. 2000), but with the quail eggshell hard to penetrate makes them not a likely candidate as predators.

In the forest habitat for the first period nine nests were all predated at the same time, and possibly by the same predator, because they were all located on the same transect. Predators can associate and use human odours or visual movement as cues to find prey (Bêty and Gauthier 2001). Based on these cues predators can develop a search pattern aiding them in the search for food (Eriksson 2001). Bart (1977) found that predation was most likely to occur the day after visitation by humans. However, this is only possible if the predator is “lucky” and associates the scent of humans with where to find food (Rangen *etal*. 2000; Bêty and Gauthier 2001; Eriksson 2001). Several studies have shown that nests with human scent have higher predation rates than those without, or with other animal scents (Vacca and Handel 1988; Whelan *etal*. 1994; Rangen *etal*. 2000; Donalty and Henke 2001). This confirms that human presence have an impact on the predation rate of nests. However, there are studies that contradict these results, where no correlation between visitation frequency and predation rates has been found (Gottfried and Thompson 1978; Mayer-Gross *etal*. 1997; Ibáñez-Álamo *etal*. 2012). One possible explanation could be that the number of visits was too few, or that the study period was too short. For example, recreational activities and ecotourism can have many visits per day and also occurs close to the nests, which then leads to high nest predation (Miller and Hobbs 2000; Bolduc and Guillemette 2003; Finney *etal*. 2005).

Habitat differences can have an effect on the predation rate of nests placed on the ground. Studies have found that predation is higher in areas with a high degree of edges between different habitat types, in fragmented landscapes, and in habitats close to human settlement (Huhta *etal*. 1996; Haegren and DeGrafe 1996; Zanette and Jenkins 2000; Eriksson 2001). In this study I found a higher predation rate in the forest than in the clear-cuts. The forest area in the second period had the highest predation rate (95%), while the second highest predation rate was found in the clear-cut area in the second period (65%). Both of these habitats were situated close to urban areas and agricultural landscapes. For the first period both the forested and the clear-cut areas were further away from human settlements, which might explain why the first period resulted in lower predation rates. For clear-cuts another explanation could be that the area in the second period was divided into many small patches, which could lead to a stronger edge effect and possibly higher predation rates. The forest area in the second period was close to farmland with an enclosure of domestic pigs. This generates a higher number of possible predators e.g., domestic dogs (*Canis familiaris*), domestic cats (*Felis catus*), typical farm animals, and fox (*Vulpes vulpes*), badger (*Meles* meles) and common raven (*Corvus corax)*, generalist predators common close to human settlements and fragmented landscape (Wilcove 1985; Eriksson 2001). All of these species are common nest predators (Wilcove, 1985; Evans 2004; Schneider *etal*. 2012), and they were observed close to the farm or where I walked daily. A red fox was observed at the farm and was probably the culprit for the loss of 11 piglets. Giving the possibility that predators associate human odours with food, this makes it possible that they can track or observe humans from a distance, a type of eavesdropping (Lenington 1979; Bêty and Gauthier 2001).

In the study period the breeding season for most predators had started, but it was most pronounced for the second period. This could explain why there was an increase in predation rates for both forest and clear-cut in the second period.

Wildlife cameras

Two predators were photographed predating on nests; a crane (*Grus grus*) and a European badger (*Meles meles*). Other possible nest predators or nest tramplers were moose (*Alces alces*), roe deers (*Capreolus capreolus*), and domestic cat (*Felis catus*) and Eurasian jay (*Garrulus glandarius*) was observed. The animals did not seem to take any notice of the camera, nor were they affected by it. This is in accordance with the meta-study done by Richardson et.al. (2009) who showed that camera disturbance did not have any negative effect on reproductive success as a result of predation. Overall the predation rate for camera-disturbed nests was low in my study. One possible explanation could be that cameras have a different effect on different predators. Well-camouflaged cameras will lead to higher predation rates than conspicuous ones (Herranz et. al., 2002). It could also be explained by the fact that wildlife cameras were only placed in clear-cut areas, where predation rates were low compared to forested areas.

Daily predation

My results show that in the second period predation was evenly distributed over time in both habitats. This is opposite to the findings of Bart (1977) who found that most predation events usually occurred right after the disturbance. If this were true most of the nests in my study would have been predated the first day, and not as sequential predation events throughout the 14 days study period. For the first period the predation is infrequent, and for forest it occurs only on 2 days, with 9 of the nests are predated in one day. This suggesting that most likely olfaction predator has followed human odour and/or visual cues to find each nest.

The temporal trend in daily nest predation rate, both with habitat, forest and clear-cut, and without (only clear-cut predated nest), has ‘each day’ visited nest with highest predation rate compared to ‘camera’. But the ‘visitation day’ was not significant, which tells that the predation rate for ‘each day’ visited nest and ‘camera’ does not increase with time, and happens random throughout. It looks like, in most cases, that predators visually spot the observer in the field and predates the nest right after, since olfaction predator most likely would have followed the path and predated more nest, which could have been the case in the first study period forest. So a good mix of both visual and olfaction predator is most likely the case for nest predation in this study.

CONCLUSION

This study illustrates that predation on ground-nests is strongly affected by daily human visits. Mainly in areas close to human settlements. Caution should be taken when visiting ground-nesting birds, avoiding damage to the area around the nest and not walk the same path to each nest upon visits and keeping number of visits to a minimum. In further studies, researchers should keep a distance to the nest, path made between nests should be as random as possible and visits should occur as seldom as possible to minimize the effect we humans have on the predation rate of ground-nests. The nest predation occurs arbitrary, so probability of predation happening increases with the amount of visits, and can occur at any day of visit.

How nest predation is affected by human visits could further be studied by using wildlife cameras, looking at which predators are most common nest predators and how they locate nests, by using humans as a cue. This study furthermore found that cameras do not cause higher predation rate. This makes cameras an efficient and good device to use, to further study how the predators eavesdrop on humans and how they use humans to identify prey. However, cameras are still very expensive and time consuming to use, but it is a device that is interesting to use in further studies.

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