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Reducing the number of grazing geese on agricultural fields - Effectiveness of different scaring techniques

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ABSTRACT

Scaring is a widely used damage mitigation tool to make agricultural fields less attractive to wildlife and by that reduce crop damage. However, few experimental studies exist where the numerical response of different scaring devices has been compared. We tested experimentally the effect of three different scaring devices (kite, scarecrow, inflatable man) on the number of geese in fields with cereals, ley, rapeseed, potatoes, and carrots in Sweden. Geese were counted by camera traps and two approaches were used; in a first (model 1) only geese within 50–150m of the scaring devices were counted, and in a second (model 2) all geese in the field were included. A total of 42,281 geese were counted: Greylag goose *Anser anser* was the most common species (87%), followed by bean goose *Anser fabalis* (6%), greater white-fronted goose *Anser albifrons* (3%), barnacle goose *Branta leucopsis* (2%), and Canada goose *Branta canadensis* (2%). During scaring the number of geese significantly decreased for all three devices in model 2. The inflatable man decreased goose numbers by 90.0 %, scarecrow 64.6%, and kite 60.5%. A similar pattern was found in model 1, but the decrease was not significant. Our study shows that the scaring devices studied can reduce goose grazing pressure for some time and locally. However, since geese continue to graze during scaring, we conclude that scaring alone is not a final solution to mitigate crop damage. Future work to develop more effective control measures should address the efficiency of other management tools and scaring techniques in combination.

1. Introduction

A current and major challenge worldwide is to combine food production with biodiversity conservation (Brussaard et al., 2010). In many farmland bird species populations have decreased due to intensified agriculture (Donald et al., 2001, 2006; Wretenberg et al., 2006). However, expansion and intensification of agriculture is not necessarily negative for all; for example, several species of geese and cranes have benefitted from changed agricultural practices (Fox and Abraham, 2017; Hemminger et al., 2022).

Several goose species have increased in numbers in Europe and North America for more than five decades (Fox and Madsen, 2017; Lefebvre et al., 2017). This is partly due to improved foraging conditions provided by intensified farming systems, but also due to earlier conservation efforts and climate change (Fox and Abraham, 2017; Fox and Madsen 2017; Mason et al., 2018). Geese are obligate herbivores feeding on grain, roots, and green parts. They prefer a variety of crops such as wheat, maize, barley, and grasslands - all providing high energy content and high digestibility (Fox et al., 2017). Recently, many geese have shifted from using traditional natural foraging habitats to well-managed and fertilized agricultural crops. This increased grazing pressure on cropland causes conservation conflicts and management challenges due to crop damage (Fox et al., 2017). Greylag goose *Anser anser* and barnacle goose *Branta leucopsis* have recently been considered as superabundant and they cause major economic damage to crops in Sweden and other parts of Europe (Fox and Madsen, 2017; Montràs-Janer et al., 2019; Düttmann et al., 2023). Other less abundant species, such as greater white-fronted goose *Anser albifrons* and bean goose *Anser fabalis* can also occur in large numbers and cause damage in certain regions (Montràs-Janer et al., 2019; Düttmann et al., 2023). Recently, cases of up to 50% harvest loss due to goose grazing has been recorded and millions of Euros are used annually for compensation to farmers in Europe for harvest loss (Jensen et al., 2018; Montràs-Janer et al., 2019; Düttmann et al., 2023). Most European goose populations are

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considered as viable and in a favourable conservation status. Nevertheless, conservation conflicts occur since crop damage is often higher where important wetland reserves attract large number of geese to adjacent agricultural areas, and because some of the most abundant goose species are still protected (Si et al., 2011; Montràs-Janer, 2021; Månsson et al., 2023).

Scaring is widely used as a strategy to make agricultural fields less attractive to geese and by that reduce crop damage and conservation conflicts (Hake et al., 2010; Simonsen et al., 2016; Conover and Conover 2022). Scaring is assumed to provoke fear in geese by mimicking predators and human presence (e.g., hunting activities) and can affect their use of specific fields, foraging behaviour, energy gain, and habitat selection (Madsen 2001; Bechet et al., 2004; Teräväinen 2022). For example, techniques such as propane cannons, laser, kites, scarecrows, and firecrackers are used (Hake et al., 2010; Heim et al., 2022). The effectiveness of goose scaring can vary with the type of method, site, season, and species (Simonsen et al., 2016; Heim et al., 2022). Some scaring methods are used worldwide, but their effectiveness has surprisingly rarely been experimentally evaluated and compared (but see Månsson, 2017, Clausen et al., 2019; Heim et al., 2022). There is thus a need for experimental studies increasing the knowledge about their relative effectiveness to guide management and to improve crop protection measures.

There are many different scaring techniques available creating both visual and auditory stimuli to scare geese. In the present study, we choose to experimentally test the effectiveness of three devices creating visual cues, and which are widely used in Sweden and other parts of the world: scarecrow, kite, and 'inflatable man' (Marsh et., al 1992; Pendlebury et al., 2006; Hake et al., 2010; Conover and Conover, 2022). The scarecrow and the inflatable man both mimic human presence. However, the two devices differ in appearance, as the inflatable man is mostly hidden and pops up with a sound (more of a surprise), whereas the scarecrow is constantly visible and only moves slightly by wind. The kite used in our study mimics a soaring raptor and moves constantly if there is wind (i.e., weather dependent).

Practical experience of these techniques is available from both Europe and North America (Hake et al., 2010; Fox et al., 2017; Conover and Conover, 2022), but little has been published on their relative effectiveness. There is therefore a need for an evaluation under controlled conditions for further recommendations regarding crop protection. Our study aimed at evaluating the numerical response of geese created by the three scaring devices. We predicted that all three scaring devices would reduce the number of foraging geese at the field level, thus decreasing crop damage risk, but that there would be difference in effectiveness among them, as they mimic different kinds of threats (raptor vs. humans) to geese and differ in appearance (always visible vs. mostly hidden).

2. Methods

2.1. Study site

The study was carried out in an agricultural landscape in south-central Sweden (59°10′ N, 15°22′ E) (Fig. 1). The area has a humid continental climate (cold winters and warm summers) with four distinct seasons: winter, spring, summer, and autumn. The mean daily temperature in the area in summer is 15–18 °C, and around −2 to 0 °C in winter (average values 1991–2020). Precipitation is distributed evenly over the year, with slightly more rainfall in the summer months. The study area is a flat landscape with two restored wetland reserves (Kvismaren nature reserve), surrounded by farmland dominated by pastures and fields of mainly cereals, ley, rapeseed, potatoes, and carrots. The two wetlands are shallow and eutrophic, bordered by narrow belts of grazed wet meadows. Agricultural fields range between 1 and 72 ha in size. The area hosts large numbers of geese. Greylag geese and bean geese are the most numerous (staging in spring and fall), and both species use arable land to a large extent for foraging. In addition, greater white-fronted geese, pink-footed geese *Anser brachyrhynchus*, barnacle geese, and Canada geese stage in the area but in smaller numbers. The greylag goose is the only species breeding in large numbers, arriving to the area in March and departing in early October (Månsson et al., 2022).

2.2. Scaring devices

Three different devices were evaluated:

The kite consists of a pole 13 m tall, to which a plastic black silhouette is attached with a string, hence mimicking a bird of prey (1.4 m wingspan). The kite moves also in very light breeze, but the movement is nevertheless directly dependent on wind strength.

The scarecrow is 1.4 m tall, made of grey fibre cloth, and has a yellow plastic head. The scarecrow was attached to a wooden pole with rubber bands allowing it to move in the wind. Two hanging plastic tapes

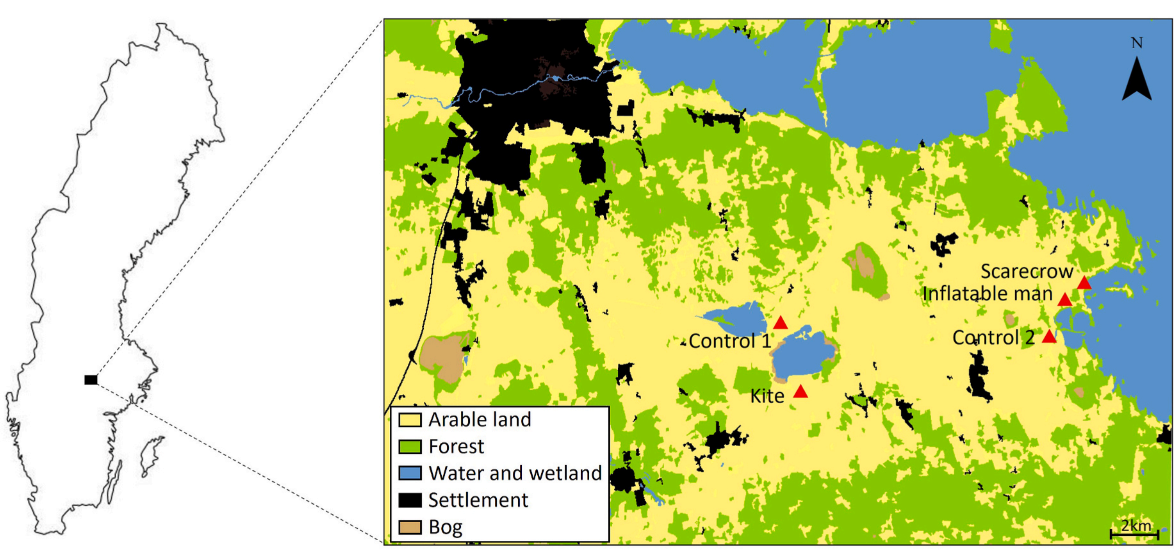

Fig. 1. Location of the area in Sweden where we studied effects of three different scaring devices (inflatable man, kite, and scarecrow). Two lakes (the Kvismaren nature reserve) provide safe roosting sites for geese in the landscape. The panel shows main land cover types and one example of an experimental setup of a scaring trial, including four different treatments (two fields as controls, one field with inflatable man, kite, and scarecrow). In total, 15 trials were conducted from 2020 to 2022.

were attached to the silhouette to mimic moving arms.

The inflatable man is 1.7 m tall and operated by a battery power source. It is made of bright orange cloth in the shape of a man. A timer activates a fan to inflate the figure and an artificial sound goes off simultaneously (a siren similar to a car alarm). The operation interval was set to every 30 min, and when in operation the man pops up several times.

2.3. Scaring trials and experimental set-up

In total 15 independent trials were conducted from February to October in 2020–2022 (see Fig. 1 for an example of the setup of one of the trials and Table 1 for characteristics of included fields). In each trial we used four or five fields with four different treatments to compare the effect on the number of geese. The three scaring devices (kite, scarecrow, inflatable man) and one or two controls were used in each trial. In 10 trials we used two control fields and in 5 trials one control field. Two treatments in two of the trials had to be excluded because the farmer ploughed the field (kite, trial 3) or camera malfunction (scarecrow, trial 1; Table 1). The trials were conducted on growing wheat, barley, and ley fields, but in some trials stubble fields (harvested wheat and barley) and fallow were used for practical reasons (i.e. when no fields with growing crops could be used as controls because farmers wanted to scare in all fields to mitigate damage). We assumed that the inclusion of different crops and crop stages in the trials should not affect the relative scaring effect, as the number of geese was compared before and during treatment within the same field. Each trial was designed as a Before-After-Control-Impact (BACI) set-up (Smith et al., 1993). First, four to five similar fields with respect to crop type and stage, crop height and with occurrence of geese were selected (Fig. 1). The fields included were all situated within the same staging area and at a maximum of 14 km from the main night roost in the area (i.e. within maximum goose foraging flight distance <32.5 km; Johnson and Schmidt, 2014). The minimum distance between the treatment fields were more than 600 m in all cases except in five trials. In these five trials the minimum range between treatment fields was between 250 and 430 m but in all these cases vegetation was obstructing visibility between fields. Camera traps were installed in the fields to take images of geese for two days (48hrs) without any scaring device. After two days, three fields were randomly selected for each of the three scaring devices and one or two fields as controls. The devices were then placed in the field (Fig. 2) and geese were counted in images taken for another five days (120hrs).

2.4. Goose counts

The cameras were placed 100 m from the scaring device and were set to take an image every 30 min during the seven days of each trial (Fig. 2). For each field we used two cameras, one pointing at the scaring device and one in the opposite direction. Two marking poles were placed 50m from the cameras. These poles allowed us to assess the distance between the geese, the camera and the scaring device (zone 1 and zone 2 in Fig. 2) when counting geese in the images. The number of geese counted within both zone 1 and zone 2 were 50–150 m from the scaring device. In zone 1 and 2 (within 50m of the cameras) it was possible to identify geese to species in 49% of the cases. Greylag goose was the most common species (1,896 identified individuals), followed by bean goose (135), greater white-fronted goose (71), barnacle goose (45), Canada goose (44). A total of 2,270 geese could not be identified to species. In addition to the counts in zones 1 and 2 we counted all geese beyond the marking poles as long as they were in the experimental field and possible to identify as geese (i.e. these were counted regardless of distance to the scaring device).

2.5. Data management and statistics

General Linear Mixed Models (GLMM) were used to evaluate the effect of the treatments on the number of geese in each trial. The number of geese per image (Fig. 2) was used as a dependent variable. Treatment (kite, scarecrow, inflatable man, and control), time period (before/during) and the interaction term between the two (treatment*period) were used as fixed explanatory variables. Trial_id (1–15), treatment, and day (1–7) were included as nested random factors to account for the repeated measures within each trial and to combine data from the same trial.

The analyses were conducted using two different models. Model 1) only included geese at a known distance (i.e. within 50–150m) from the scaring device (or the marker pole in case of control treatment; i.e. zones 1 & 2; Fig. 2). Model 2) included the total number of geese counted in images from the two cameras in each field (i.e. independent of distance to the cameras). In the ten cases where two control fields were used, we used the mean rounded to closest integer. The total number of observations was 11,705 for model 1. For model 2 it was slightly less, 10,520, as we had to exclude some observations because weather and light conditions restricted visibility at further range than zone 1 and 2 (Fig. 2). Each observation is based on the sum of geese counted on the images from both cameras (Fig. 2). The total number of nested groups (Trial:Treatment:Day) was 412 for model 1 and 393 for model 2. All

Table 1

Characteristics of each of the 15 scaring trials and 68 fields included in the study. Trials were conducted from February to October 2020–2022. Each trial included four different treatments (control, inflatable man, kite, and scarecrow). Most of the trials (10 out of 15) included two control fields. Trials were conducted in fields with wheat (W), barley (B), ley (L) or fallow (F) with two different crop stages: growing/unharvested (U) or stubble/harvested (H) and two crop height classes: 0–15 cm and 16–30 cm. Two treatments had to be excluded, because the farmer ploughed the field (kite, trial 3) or because of camera malfunction (scarecrow, trial 1).

Trial	Month	Year	Control 1			Control 2			Inflatable man			Kite			Scarecrow		
			Crop	Stage	Height	Crop	Stage	Height	Crop	Stage	Height	Crop	Stage	Height	Crop	Stage	Height
1	July	2020	L	U	0–15	–	–	–	–	–	–	L	U	0–15	L	U	0–15
2	Aug	2020	W	H	0–15	B	H	0–15	W	H	0–15	B	H	0–15	B	H	0–15
3	Aug	2020	W	H	0–15	W	H	0–15	B	H	0–15	–	–	–	W	H	0–15
4	Mar	2021	W	U	0–15	W	U	0–15	W	U	0–15	W	U	0–15	W	U	0–15
5	Apr	2021	L	U	0–15	L	U	0–15	L	U	0–15	L	U	0–15	L	U	0–15
6	May	2021	W	U	0–15	W	U	16–30	W	U	0–15	W	U	0–15	W	U	0–15
7	July	2021	L	U	16–30	L	U	0–15	F	U	16–30	L	U	16–30	L	U	16–30
8	Sep	2021	L	U	0–15	L	U	0–15	W	U	0–15	W	U	0–15	L	U	0–15
9	Oct	2021	W	H	16–30	W	H	16–30	W	U	0–15	W	H	0–15	W	H	16–30
10	Feb	2022	L	U	0–15	–	–	–	W	U	0–15	W	U	0–15	W	U	0–15
11	Mar	2022	L	U	0–15	–	–	–	W	U	0–15	W	U	0–15	W	U	0–15
12	Mar	2022	W	U	0–15	–	–	–	W	U	0–15	W	U	0–15	W	U	0–15
13	Mar	2022	W	U	0–15	L	U	0–15	W	U	0–15	W	U	0–15	W	U	0–15
14	Sep	2022	W	H	0–15	W	H	0–15	W	H	0–15	W	H	0–15	W	H	0–15
15	Feb	2022	W	H	0–15	–	–	–	W	H	0–15	W	H	0–15	W	H	0–15

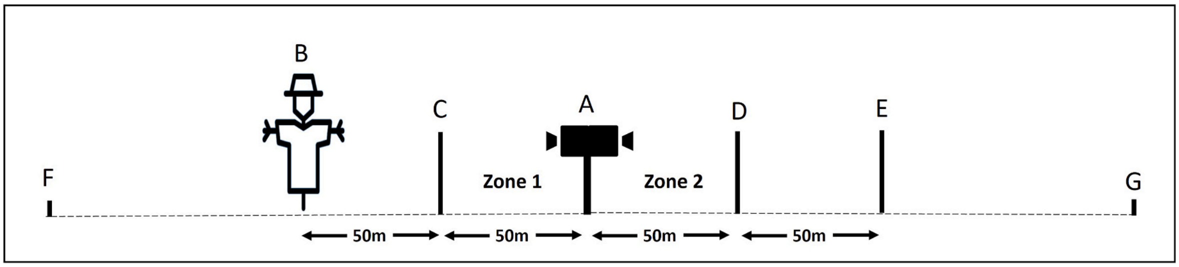

Fig. 2. Experimental design of scaring trials, where A is two camera traps, one pointing towards the scaring device (B) and the other in the opposite direction. Three different scaring devices were tested; inflatable man, kite, and scarecrow. In all controls the scaring device was replaced by a marker pole. The poles (C, D and E) indicate the distance between the camera and scaring device. All geese in the field possible to identify as geese were counted regardless of distance (here indicated as F and G). In zones 1 and 2 (within 50m of the cameras) it was possible to identify geese to species in 49% of the cases. Scarecrow and camera icons by Tanga Vignesh and Brianna Holmes from NounProject.com.

analyses were performed in the statistical software R version 3.6.6 (R Core Team, 2013; packages lme4 and ggplot2).

3. Results

3.1. Number of geese and species

Over the 15 trials (Table 1), 42,281 geese were counted in the images, out of which 4,468 were within 50–150 m of the scaring devices (zones 1 & 2). Greylag goose was by far the most common species among the identified individuals (87%), followed by bean goose (6%), greater white-fronted goose (3%), barnacle goose (2%), and Canada goose (2%).

3.2. Numerical response

Based on predicted values from the two models, on average 0.52 and 10.20 goose individuals were in the images during the two days before treatment (models 1 and 2, respectively; Figs. 3 and 4). After treatment started, there was a significant decrease in goose numbers for all three scaring devices in model 2 (parameter estimates for the interaction term in Table 2). The effect of scaring on goose numbers was similar in model 1 to the pattern found in model 2, but it was not statistically significant in model 1 (compare Figs. 3 and 4).

There was no significant difference in relative change between the periods before and during treatment (i.e. the slope of the interaction term; Table 2) when comparing the three different scaring devices ($p > 0.41$ in all cases; t-tests based on model parameters in Table 2). Still, in absolute terms the reduction of number of geese varied considerably between the three devices. For the inflatable man, the predicted mean decreased by 81.3% and 90.0% (models 1 and 2, respectively), for scarecrow (61.1% and 64.6%), and kite (40.7% and 60.5%) (Figs. 3 and 4). In control fields, the predicted mean number of geese instead increased by 5.1% and 21.7% (models 1 and 2, respectively) from the first (before) to the second (during) period.

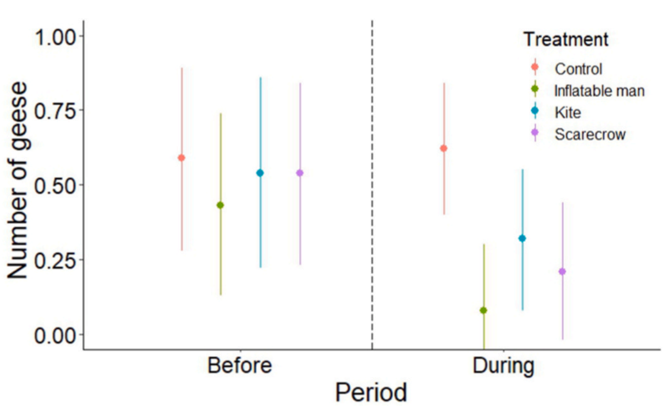

Fig. 3. Predicted means and CI 95% for number of geese counted per image 50–150 m from the scaring devices (zone 1 and 2) before (left of dashed vertical line) and during scaring (right).

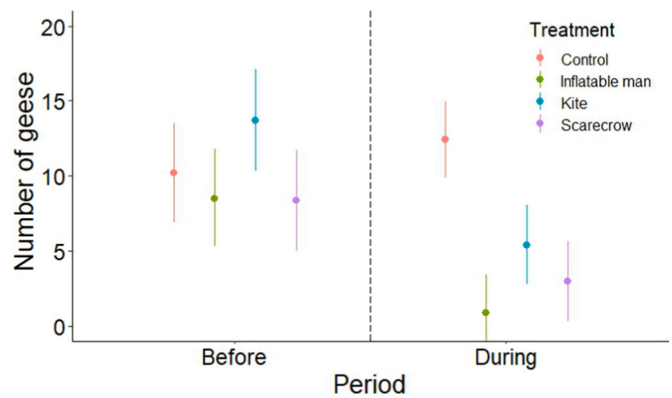

Fig. 4. Predicted means and CI 95% for the number of geese counted per image regardless of the distance to the scaring device, before (left of the vertical dashed line) and during scaring (right).

Table 2
Parameter estimates of the general linear mixed model (models 1 and 2) predicting the effect of three different scaring devices on the number of geese. Period (before/during scaring), treatment (control, inflatable man (I), kite (K), scarecrow (S)) and the interaction term between period (P) and treatment were used as explanatory variables. The categorical estimates are in comparison to the intercept (i.e. the control before scaring).

	Estimate	S.E.	t-value	p-value
Model 1				
Intercept	0.59	0.16	3.76	<0.001
Period	0.03	0.18	0.19	0.84
Inflatable man	−0.15	0.22	−0.69	0.49
Kite	−0.05	0.22	−0.21	0.49
Scarecrow	−0.05	0.22	−0.23	0.82
P * I	−0.39	0.25	−1.57	0.12
P * K	−0.26	0.25	−1.01	0.31
P *S	−0.35	0.25	−1.43	0.15
Model 2				
Intercept	10.21	1.68	6.09	<0.001
Period	2.22	1.73	1.28	0.20
Inflatable man	−1.68	2.35	−0.72	0.47
Kite	3.50	2.42	1.45	0.15
Scarecrow	−1.85	2.40	0.77	0.44
P * I	−9.90	2.44	−4.06	<0.001
P * K	−10.52	2.50	−4.21	<0.001
P *S	−7.61	2.51	−3.03	<0.01

4. Discussion

This study shows that the tested scaring devices can substantially decrease the number of geese in agricultural fields. Both models showed the same pattern, but the effect on goose abundance was significant only when all geese in the field were included (i.e. model 2) and not limited to the closest vicinity of the scaring devices (i.e. model 1). There was no significant difference in scaring effect between the three devices. However, there was still a considerable variation in the relative change in number of geese before and during scaring among the three methods (ranged between 61 to 90% based on parameter estimates in model 2).

Given the increasing crop damage caused by growing goose numbers and the effort put into crop protection, surprisingly few experimental studies exist where the effect of different scaring devices has been tested with a consistent methodology allowing comparison. We chose to include three different devices commonly used to scare geese in Sweden and other parts of the world (Hake et al., 2010; Conover and Conover 2022). Earlier studies have evaluated the effect of other methods, such as propane cannons, flags, and fire-crackers on a wide range of bird species including geese (Conover, 2002; Bishop et al., 2003; Conover and Conover 2022). The results have been mixed, from no effect to a reduction of number of birds ranging between 19 and 82% (Summers, 1990; Percival and Houston, 1992). The differences in effect between studies may be due to factors such as method (e.g. time window for scaring, in our case relatively short i.e. five days), group of species, and landscape composition. Moreover, a study on the grazing effect by brent geese (*Branta bernicla*) in winter showed that scaring devices (scarecrows, propane cannons, and bags on poles) reduced yield loss by 10%–75% in three different fields (Summers, 1990). Similarly, Summers and Hillman (1990) showed that scaring of brent geese from winter wheat fields by using a line of red tape reduced yield loss by 5%. Compared to these studies, the relative scaring effect found in our study is in the upper range (i.e. 61-90%). Our results thereby support earlier findings that scaring devices placed in agricultural fields can reduce the number of foraging birds in general and geese in particular. We did not measure the true harvest gain of scaring as in Summers (1990) and Summers and Hillman (1990) but instead used goose number as a proxy of damage risk. Several studies have shown a clear relationship between goose numbers and harvest gain/loss (Percival and Houston 1992; Düttmann et al., 2023; Buitendijk et al., 2023).

When it comes to more active scaring techniques, e.g., when people scare geese by walking approach, drones, bangers, or lethal scaring, some recent studies have compared different methods (Heim et al., 2022; Teräväinen, 2022). The effect on goose numbers in the present study are in line with those found for active scaring techniques. For example, lethal scaring showed a ~60% reduction in goose numbers for three days (Månsson, 2017). Moreover, a recent study to reduce the number of geese grazing in agricultural grassland showed that fields subjected to laser treatments experienced seven times lower density of goose droppings than control fields where geese were not exposed to lasers. However, the latter study also found that the scaring effort was as costly as the resulting harvest gain (Clausen et al., 2019).

Scaring can be labour intensive and costly (Vickery and Summers, 1992). In some situations, the economic costs of scaring may even outweigh the potential economic benefits as shown in Clausen et al. (2019). Few cost-effective solutions are available to farmers at present (Sausse et al., 2021). In our study the three devices varied considerably in cost: ~400 Euros, ~40 Euros, ~20 Euros for the inflatable man, the kite, and the scarecrow, respectively but they did not differ significantly in absolute scaring effect (i.e. reduction in number of geese). The time needed to mount the devices in the field was quite similar (~2 min for the scarecrow and inflatable man and ~10 min for kite). In our specific case, an extra cost of several hundred Euros (purchase price of inflatable man) does not seem to reduce the number of geese more than the much cheaper scarecrow. Still, several devices may be needed for alternating the measures and thereby reduce the risk of habituation (Steen et al., 2015). Moreover, several devices will most probably be needed to cover fields larger than the areas surveyed in our study. The aim of our study, though, was to compare the effectiveness of the three devices. Consequently, further studies are needed to understand how many devices are needed to cover a certain field size.

In the present study, scaring was performed for five days, therefore possible habituation (here defined as increasing goose numbers over time due to a diminishing response to repeated scaring) to the devices could not be studied properly. Moreover, the time need for habituation may also vary between different types of stimuli (in our case we had devices mimicking both natural predators and humans) and can therefore vary between different types of scaring devices (Askren et al., 2022). Habituation of geese is one of the critical issues when it comes to long-term effectiveness of scaring (Bradbeer et al., 2017; Fox et al., 2017). For example, a study by Platteeuw and Henkens (1997) showed that birds tend to habituate to repeated disturbance, leading to decreased scaring effect as the response to the fear-provoking stimuli does not affect fitness. It is therefore reasonable to assume that geese will habituate to the devices used in our study too, and that they only remain effective as long as the neophobia (fear of the new) of the birds persists (Baxter et al., 2010). Thus, there may be a need to move and switch scaring devices between locations to achieve a sustained effect over periods longer than five days.

As shown in earlier studies, the effect of scaring can vary among different types of devices and species, but it can also be context dependent (e.g. season, food availability, and internal stage of the birds) (Bishop et al., 2003; Simonsen et al., 2016; Fox et al., 2017). For example, there are studies indicating differences in the reaction to scaring among goose species; e.g. barnacle geese tended to be harder to scare than greylag geese and bean geese (Kvarnbäck, 2021). Generalisation of our results should therefore be made with some caution since the vast majority (86%) of the identified geese in our study were greylag geese and the results are most probably mostly mirroring the behaviour of this species. Still, we found that several other goose species occurred in the fields (white-fronted goose, pink-footed goose, barnacle goose, and Canada goose) but unfortunately, we could not perform a species-specific analysis since there were too few observations of the other species.

This study covered several seasons and most of the months (February to October) when geese are present in the study area (Månsson et al., 2022). From a goose perspective this includes the period from arrival at the breeding area to autumn migration. The study period also covers the sequence and shifts in agricultural practices from sowing, growing season to harvest. Hence, the intrinsic state and energetic needs of geese (Fox et al., 2017) but also the availability of suitable fields and food varied during the study period (see for example the supplemental information in Nilsson et al., 2016). Consequently, the scaring effect, too, may have varied over the studied period, as found for other bird species (Enos et al., 2023). Unfortunately, sample size restrictions did not allow us to do analyses by season. Although nutritional and energetic needs of geese vary with season, they do feed on crops in vulnerable stages and cause damage from March to October, in this part of Sweden with a peak in June to September (Montràs-Janer et al., 2020). Our study thereby provides a general result for the entire period in the area when scaring devices are used by farmers and managers. However, more studies are needed to provide insights about possible interseasonal variation in the effect of scaring.

In sum, scaring is not a final solution to mitigate crop damage by geese, but the methods studied here can reduce goose numbers and grazing pressure locally and for some time. The extent to which these methods may reduce yield loss in absolute terms requires further study. Future work should also address the efficiency of other management tools and scaring techniques, especially when combined, to lead to more effective control in the future. For example, the evaluation of ‘push’ (scaring) techniques needs to be combined with ‘pull’ strategies, such as accommodation fields, to avoid the problem simply being moved around in the landscape (Heim et al., 2022; Teräväinen, 2022).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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