Wild boar feeding site effects on targeted and non-targeted species

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Wild boar feeding site effects on targeted and non-targeted species

Effekter av utfodringsplatser för vildsvin på vildsvin och övriga arter

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Abstract

Wild boar (*Sus scrofa*) is an ungulate species that is increasing in Europe and Sweden, and with that causing conflicts and problems in agriculture. Wild boar are omnivores and are often rooting in the ground to find food items. It is a common management practice to establish artificial feeding sites for wild boar, and other wildlife species, as supplementary, diversionary or for baiting and hunting purposes. Such feeding sites may also influence the surrounding areas through the extra food and activities made by the animals visiting the site (rooting, trampling, etc.), including non-targeted species. In this study, situated in the Grimsö wildlife research area, South-Central Sweden, feeding sites were investigated through camera traps in September to January. The study was divided into a control year with no feeding, and an experiment year with feeding and control sites with no feeding. Rooting inventories around the sites were also conducted during the vegetation season. The research focus was laid on (1) how long time it takes for wild boar to find and use new feeding sites compared to already established, old feedings sites and control sites, and (2) if there is any relation between rooting level at a feeding site and the visitation rate of wild boar, as well as (3) whether feeding sites affect the local species richness.

The results showed that wild boar presence was higher at old feeding sites than at new (50% daily presence after ~35 and ~55 days, respectively), and both were different from the control sites in which presence did not change with time. There were also more wild boar and more rooting closer to the feeding sites, but the effect seemed to cease at a distance of 50 m from the feeder. The level of rooting was directly related to wild boar presence, i.e. the more wild boar, the more rooting. Finally, there was higher species richness at old feeding sites than at control sites, while the species richness at new feeding sites seemed to increase faster than at the old sites.

Rooting has been suggested to have both positive and negative impacts on plants and soil properties. A better understanding of how much area that is affected will be important for our understanding on the ecological impact on the surrounding. This study suggests that wild boar feeding sites seem to have a limited direct effect on the area and only affect the immediate surroundings, while on the other hand, attract several non-targeted species, whereof many birds. It is thus probably an important management consideration in choosing the placement of feeding sites in terms of limiting the impact on the surrounding species. However, to investigate long-term effects, a long-term study of feeding (more months) would be needed.

Keywords: artificial feeding, baiting, establishment, rooting, diversity, species richness

Populärvetenskaplig sammanfattning
- Samlingsplats för mat och bök

Vildsvin, den omdiskuterade vilda grisen, ökar i Europa och finns nu i större delen av både södra och mittersta Sverige. Ett vildsvin äter vad den kommer över, ofta genom att böka med trynet och vända marken uppochned. Bök kan påverka markens sammansättning och mikroorganismer samt växter både positivt och negativt och kan förändra ett områdes markstruktur från ena dagen till den andra. Det är vanligt för markägare att ge extra foder till vildsvin, speciellt i samband med jakten. Sådan utfodring, ofta bestående av majs, ärtor eller spannmål, kan också påverka andra arter eftersom det även är gratis mat för till exempel den hungriga räven då fodret drar till sig möss. I min studie gjord inom Grimsö forskningsområde (Lindesbergs kommun, Örebro län) undersöktes hur utfodringsstationer för vildsvin påverkade vildsvin och markens struktur runt omkring, samt vilka andra arter som rörde sig i närheten av utfodringen.

Jag använde kamerafällor för att undersöka vilka arter som rör sig i närheten av vildsvinsutfodring. Kamerorna placerades på olika avstånd (2, 10, 25 50, 100, 150 m) från utfodringsplatserna och fångade de arter som besökte platsen på bild under september till och med januari. Detta gjordes två olika år, först utan någon matning (2018) och sedan med matning (2020). Det var tre olika typer av platser som kamerorna satt på, det var platser utan någon utfodringsstation (13 stycken), platser med en utfodringsstation som använts tidigare (4 stycken) och platser med en ny utplacerad utfodringsstation (6 stycken). Totalt fångades 41 olika arter på bild. Förutom vildsvin var det ett flertal bilder på nötskrika och rådjur. Under matningsåret var det totalt 40 arter och under året utan matning var det totalt 19 arter. Det var mestadels fåglar som skiljde sig mellan åren men också kronhjort och lodjur syntes enbart under matningsåret.

Det visade sig att när matningen startade så gick vildsvinen först till de gamla utfodringsplatserna och var sedan där mer än vid de nya utfodringsstationerna. De platser som inte hade någon utfodringsstation blev knappt besökta alls. Eftersom de gamla utfodringsplatserna haft mat förut så kom troligen vildsvinen ihåg dem och visste vart de skulle gå. De gamla platserna var även valda för att underlätta för jakt, i områden där vildsvinen troligen rör sig annars också. De nya utfodringsstationerna var placerade mer slumpmässigt och kan därför ha hamnat i områden som vildsvinen generellt inte rör sig i. Vid 50m bort från utfodringen så var det färre vildsvin på bild, ungefär lika många som vid platserna utan utfodring. Vid 100 eller 150 m bort rörde sig färre vildsvin framför kamerorna vilket kan indikera att ett relativt litet område var påverkat av utfodringen.

Det samma visade inventeringar av bök som utfördes kring samma platser under tre somrar (2018, 2020, 2021). Vid samma avstånd som kamerorna placerades så uppskattades böket som skett och det påvisade att det var mer bök närmare utfodringsplatserna och redan 50 m bort så försvann effekten av matningen. En jämförelse mellan bök och vildsvin visade även att det var mer bök på sommaren där det föregående höst synts mycket vildsvin på kamerafällorna.

Denna studie uppmärksammar att vildsvinsutfodring påverkar området och arterna runt omkring inom relativt liten radie och under kort tid (September-Januari). Det är många arter som samlas vid maten samt att den närmaste marken blir uppbökad vilket kan påverka jorden och de växter som finns i området. Detta bör finnas i åtanke vid utplacering av utfodringsstationer. Denna studie pågår dock fortfarande, matningen fortgår och kameror sitter uppe. Så framtiden får berätta vad för effekter utfodring av vildsvin kan ha ur ett längre perspektiv.

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1. Introduction

1.1. Background

Wild boar (*Sus scrofa*) is an ungulate species that originated in Europe and Asia (Keuling & Leus 2019), but is also introduced in other parts of the world. The domestic pig (*Sus scrofa domesticus*, sometimes only called *Sus domesticus*) is a subspecies of the wild boar (Hoffman 2000), and as such it is possible for the two to reproduce with each other and produce fertile young (e.g. Moilanen 2021). The wild boar went extinct from Sweden in the 1800's, after being a part of the fauna for several thousands of years (Svenska Jägareförbundet 2015). It was later re-established by escaped individuals from an enclosure in Södermanland in the 1970's (Svenska Jägareförbundet 2015). The present distribution in Sweden is mostly in the more southern parts although they can be found in large parts of central Sweden as well (Svenska Jägareförbundet 2017). The population size is today estimated to be around 400 000 individuals and is rapidly growing (Evelina Augustsson, SLU, personal communication). In the period 2020/2021 close to 160 000 individuals of wild boar were shot by hunters (Svenska Jägareförbundet 2021), and wild boar has become the most common game species in Sweden.

Wild boar are omnivores and eat what they can get, e.g. crops, roots, insects, eggs, meat from for example carcasses, etc. To access food, wild boar turn the ground layer upside down, called rooting. Rooting is typically the first sign of wild boar in an area and may have both negative and positive impacts on flora, soil and microbes, although the negative consequences seem to have been more reported (Barrios-Garcia & Ballari 2012). Reported benefits include increasing nutrients or plant species richness, whilst adverse effects include decreasing nutrient and changing plant community composition. Often both negative and positive impacts have been observed in the same study (Barrios-Garcia & Ballari 2012; Parissi et al. 2014; Bongi et al. 2017; Pankova et al. 2020; Sütő et al. 2020). For example, in Skåne, Sweden, wild boar rooting decreased spring flora although the general species richness in plants increased (Brunet et al. 2016). Besides that wild boar eat crops, the rooting and trampling in fields complicates the work for farmers and costs a lot of money to mitigate the damages caused (Wretling Clarin & Karlsson 2010;

Naturvårdsverket 2020). Therefore, from an anthropogenic view rooting is mostly seen as something negative.

However, wild boar presence has been shown to be positive as well. For wading birds the presence of wild boar decreased the predation in nests (Carpio et al. 2016). Wild boar are also seed dispersers, both through seeds in faeces and in their fur and hooves (Heinken et al. 2006; Barrios-Garcia & Ballari 2012; Dovrat et al. 2012), which is important for plants especially with bigger seeds that need larger animals for longer dispersal. Although, since wild boar move in different areas and can walk far the seeds can come from far away and/or potentially be invasive (Heinken et al. 2006; Dovrat et al. 2012).

Wild boar choose nutritious food when possible, acorns if at hand otherwise artificially supplemented maize is preferred (Mikulka et al. 2018). Artificial feeding of wildlife can be called many things; diversionary, supplementary, or anthropogenic feeding, and these have slightly different meanings and purposes. Diversionary feeding is extra feeding for wildlife species, supposed to prevent damage to a certain area most often a crop field. Supplementary feeding, however, can be seen more as a way to help the targeted species to find food and gain fitness during periods of natural food shortage. It is especially common in the winter for landowners to put out extra food, and for example, in the Czech Republic supplementary feeding is obligatory by law (Bartos et al. 2010). Feeding stations can also be used as bait stations for hunters to attract target game species and making hunting more effective, or simply to keep the animals on their land to increase bag size.

Supplementary feeding also leads to conflicts, and it is debated if it should be practiced or not, as many ungulate species are increasing in Europe (Massei et al. 2015; Valente et al. 2020) and often cause problems in forestry (van Beest et al. 2010a, 2010b), traffic (Gren et al. 2016; Nationella viltolycksrådet 2021), and/or agriculture (Naturvårdsverket 2020; Valente et al. 2020). There are also inconclusive results regarding if diversionary feeding really work (Calenge et al. 2004; Borowski et al. 2019) or not (Geisser & Reyer 2004; van Beest et al. 2010a) and how the feeding affects the non-targeted species and the area around the feeding station (Milner et al. 2014; Kubasiewicz et al. 2016). Selva et al. (2014) for example found that ground-nesting bird nests that were closer to ungulate artificial feeding stations had a higher risk of predation.

Artificial feeding is common, in Sweden and elsewhere, and typically it is only the consequences for the target species that is evaluated. However, the area surrounding a feeding site might also be affected directly or indirectly by the feeding. Disease spread is an important factor to have in mind since artificial feeding sites has been a reason for spread in several cases (Oja et al. 2017; Tryland et al. 2019, also see reviews Milner et al. 2014; Sorensen et al. 2014). One disease that is especially affecting wild boar and domestic pigs is the African swine fever (ASF) which can spread more easily at feeding sites where density of the animals is high (O'Neill et al. 2020). The effect feeding sites have can be hard to study and can possibly be seen over several trophic levels (Milner et al. 2014). By not including the area around or the non-targeted species crucial resulting effects, such as disease spread, species composition or movement change, might be missed.

Supplementary bird feeding is common, often privately at residences; this can spread diseases (Galbraith et al. 2017; Schaper et al. 2021) and those feeding sites can also attract non-targeted mammals (Reed & Bonter 2018). A brown bear (*Ursus arctos*) artificial feeding study focusing on the non-targeted species showed that 23 vertebrate taxa visited the 20 study sites, constituting 76% of all recordings (Flezar et al. 2019). A short-term camera trap study with white-tailed deer (*Odocoileus virginianus*) bait stations showed similar results with non-targeted species (Bowman et al. 2015). Another camera trapping study from Spain targeting small game also got results of non-targeted species, many of which were birds (Armenteros et al. 2021). All of these non-targeted species were in some way affected or took advantage of the new artificial feeding, even though that was not the intention of the feeding site.

This experimental study thus focused on comparing wild boar feeding sites with control sites (BACI approach: before-after control-impact) to determine the effect of feeding on wild boar and on non-targeted species, and to determine the effect of rooting on the surroundings.

1.2 Research questions

Three major research questions were formulated for the study and with them several hypotheses and predictions. These are presented below:

(1) How long does it take wild boar to find the feeding stations and use them more regularly?

Hypothesis 1: Wild boar presence differs between feeding sites and control sites without feeding. There will also be a difference between new and old already established feeding sites, regarding how quickly wild boar establish or re-establish their use of the sites.

Prediction: Wild boar will re-establish their use of old feeding sites faster and more intensively compared to the use of new sites since they know these sites from before. At the control sites there will be either no presence of wild boar or only sporadically.

Hypothesis 2: The number of wild boar caught on the camera traps will depend on the distance to the feeding stations.

Prediction: There will be more wild boar activity closer to the food than further away, at the feeding sites. At the control sites there will be less wild boar activity and the distance from the site pole will have no effect.

(2) Is there a relation between amount of rooting activity and number of wild boar?

Hypothesis 1: Rooting by wild boar will change with distance from the feeding stations.

Prediction: There will be a higher level of rooting close to the feeding stations, since they will spend more time close to the food, and rooting will decrease with distance to feeding station. At the control sites there will be less rooting and the distance from the site pole will have no effect.

Hypothesis 2: The level of rooting at a site is related to the number of wild boar at that site.

Prediction: The level of rooting at a site (estimated in the summer) will be positively related to the number of wild boar present at that site (estimated in the autumn of the preceding year), i.e. more wild boar increases the chance/risk of rooting at the site.

(3) Does feeding sites for wild boar affect local species communities in terms of diversity and species richness?

Hypothesis 1: Species richness differs between feeding sites and control sites.

Prediction: Species richness will be higher at the feeding sites than at the control sites since the feeding sites provides maize for those who consume that, as well as prey for predators. There will also be a higher species richness closer to the feeding station than further away because of the provided feed. At the control sites the distance to the site pole will have no effect.

2. Methods

2.1. The place, Grimsö, and the Wild boar project

Grimsö Research Station is situated in South-central Sweden, in Berslagen, in the county of Örebro, close to the borders of both Västmanland and Dalarna. The research area is approximately 14 000 hectares large, and several studies are conducted within the area, e.g. including studies on ticks (*Ixodes ricinus*), roe deer (*Capreolus capreolus*), moose (*Alces alces*), wolves (*Canis lupus*), lynx (*Lynx lynx*), etc.

The wild boar project started in 2018 and was conducted in six study areas, with Grimsö being the only area included in the study without any previous extensive feeding. One main focus of this project was to investigate how artificial feeding affects wild boar and also other species, both plants and animals. Camera traps was one of the different techniques used to investigate this.

2.2. Sites

At Grimsö there were 10 feeding sites for wild boar (Figure 1), consisting of a structure with a suspended barrel and an automatic forage spreader, whereof six were added at the start of the project (new) and four were already present (old). The new feeding sites were installed in May 2018, but they were not activated or filled with food until September 2020, at the beginning of the experiment year (Figure 2).

The four old feeding stations, used for hunting, had been installed for at least one year; three of them had been active since 2014. Two of the old stations had also been moved a short distance but placed at the present site (Figure 1) at least a year before the control year. These old sites had however not been systematically managed or been supplied with forage continuously and were from time to time left empty. The main feeding at the old feeding sites before the experiment happened in September to April, less after the end of January when the hunting season for females close. For at least the last three months before the experiment year (2020) began there were no feeding at the old sites at all (Figure 2).

There were also 13 control sites with no feeding at all (Figure 1). The minimum distance between a control site to a feeding site was 750m. The control sites were marked only with a numbered wooden pole. The feeding sites also have a numbered pole in close proximity (<5m) of the feeding station. All sites, except the old feeding sites, were randomly chosen in the area with the condition that they would be close to a road for easy access.

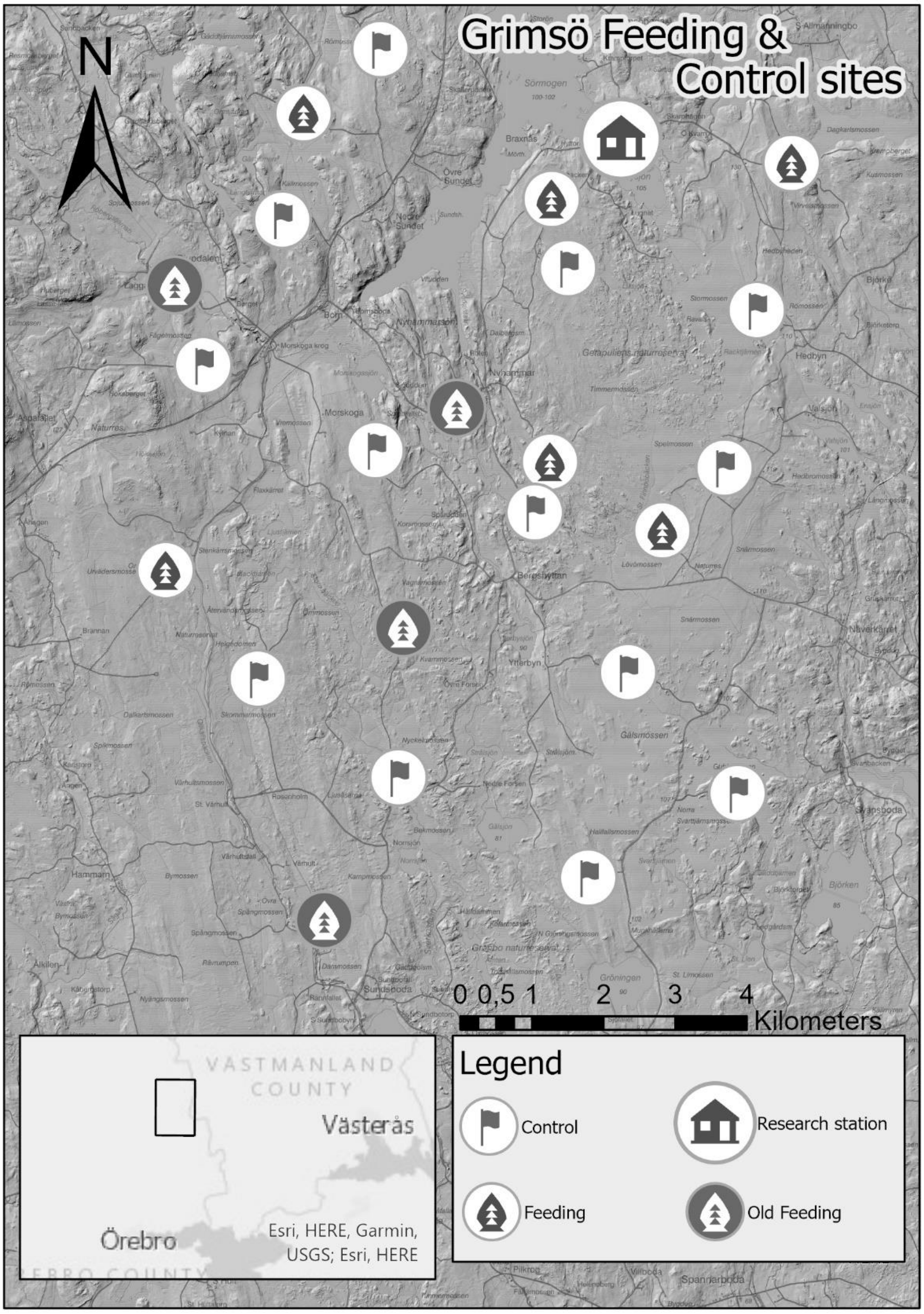

Figure 1. Map of the Grimsö wildlife research area, South-central Sweden. The small box to the left shows the geographic position of Grimsö in relation to cities Örebro and Västerås, Sweden. Control sites, feeding (new) sites and old feeding sites are presented as well as the location of Grimsö research station.

2.2.1. Control and Experiment year

The control year was comprised of September 2018 until January 2019 (Figure 2). Camera traps were then running at all 23 sites capturing wildlife, and potential humans, moving in front of the lens.

The experiment year began when the feeding started, on September 2nd, 2020 (Figure 2). The barrels at the feeding stations were then filled with maize and the automatic spreader was set to deliver approximately 700g of maize (± 150g) for two seconds directly on the ground, two times a day, at 8pm and 2am. A tree at each site was also chosen as a "tar tree" where tar was painted on the bark, which is attractive to the wild boar. More tar layers were added when estimated necessary. At each feeding site a silage bale (~600kg) was placed and opened on the 17-18th of December 2020. The control sites were kept the same in the experiment year with only the wooden pole marking the site.

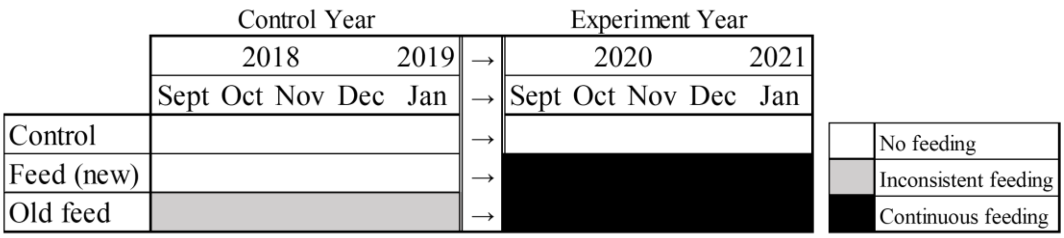

Figure 2. Time schedule of feeding at the different sites (13 control, 6 new feed, 4 old feed) in the control year (Sept 2018-Jan 2019) and the experiment year (Sept 2020-Jan 2021) when camera traps were present at Grimsö wildlife research area, South-central Sweden. Arrows in the middle indicate the intermediate time that was not part of this study, however the feeding was the same as in the control year except for at least three months before the start of the experiment year (Jun-Aug) when there were no feeding at old feeding sites either. Inconsistent feeding means feeding was not systematically managed, and was sometimes left empty. Continuous feeding means distributed feed twice every day.

2.2.2. Camera traps

To be able to investigate the activity and species at all sites camera traps were used. Most cameras were ScoutGuard SG562-12mHD (sense level normal) but in the control year BolyGuard BG-X26M 18SHD and ScoutGuard SG-550V-31B (sense levels high) were used as well. The detection ranges were between 20 – 25 m. The field of view was 60° (55° - 60°) with a working angle of 52°, trigger time was 1.2 seconds (1 - 1.2 sec). The cameras took a sequence of three photos every time they reacted, followed by an inactive period of 5 seconds before taking the next sequence. The cameras were placed according to a randomised schedule of six distances in every direction (North, South, East, West) from the centre pole (Figure 3). The distances were 2, 10, 25, 50, 100, and 150 m (Figure 3). Every second week cameras were moved to a new location, placed on a tree 60 – 80 cm from the ground with straps. The cameras were placed in a more or less northern or southern direction to avoid sunlight directly into the lens during sunrise or sunset (sunlight can warm and trigger the camera or make the taken photos too bright). Grass, twigs, or branches in the frame of the view were removed.

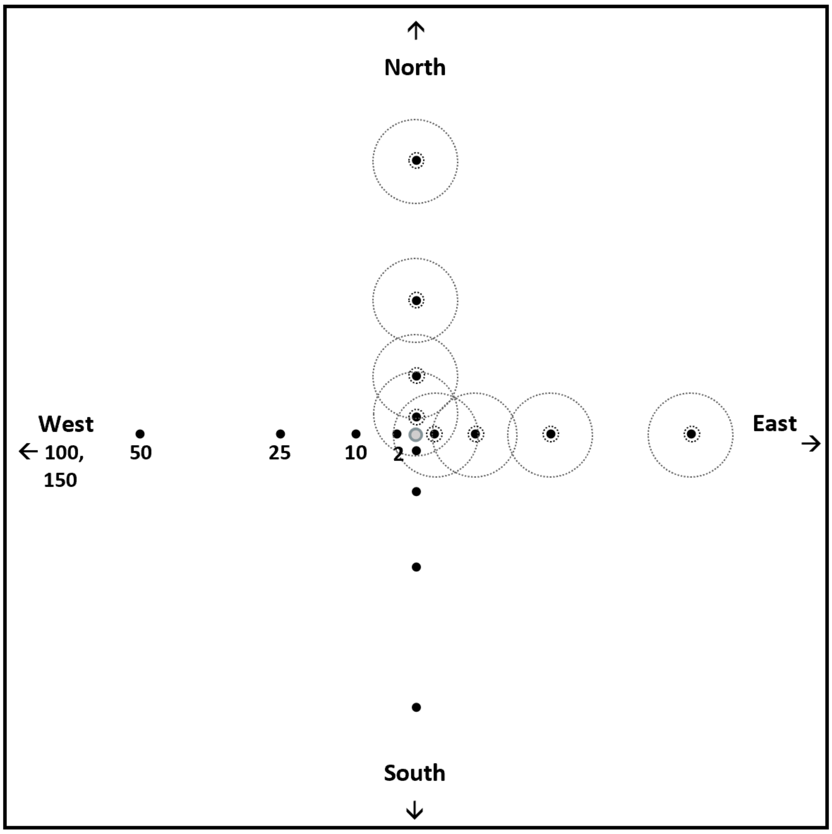

Figure 3. Camera trap placement at the 23 wild boar feeding or control sites at Grimsö wildlife research area, South-central Sweden, 2018-2021. Black dots indicate the distances (2, 10, 25, 50, 100, 150 m) from the site pole (marked in the middle with grey) where camera traps were placed. The cameras were moved to a new location every second week. The six distances were surveyed in every indicated direction (100 and 150 m not shown). The two circles around the black dots indicate the rooting inventory sampling plots (only in North and East direction). The small circle indicate 10 m^2 and the large circle 314 m^2.

The camera traps at each site also took three sequences of photos evenly divided throughout the day in the experiment year, as a control to make sure the camera was working. The camera trap experiment and feeding are still running, but in this study the focus was from the start of the feeding until the beginning of January 2021.

2.2.3. Photo handling

If an animal was present in a photo, they were recorded in a spread sheet. The spread sheet included information on where the camera was placed, which sequence the animal was in that occasion, the date and time, the species, and the number of individuals. Photos that were difficult to interpret were inspected by more than one person to ensure a more correct determination of species. In this study I analysed photos from September 2nd until the 8th of January, both during the control year (2018 - 2019) and the experiment year (2020 - 2021).

At a few sites early in the study the camera was accidentally changed from photos to video. In those cases, the video was treated as if it was a sequence of photos, meaning that the first three seconds were regarded as a sequence and only the animals visible during that time was recorded. Then the following five seconds were ignored and then a new sequence of three seconds was recorded. A sequence of photos were however usually not three full seconds long, approximately two seconds can be seen on the photos, and there were usually more than five seconds in between the sequences. In the control year there were 49 sequences from videos with animals distributed over one control site (one occasion) and one feeding site with no feeding (two occasions). In the experiment year there were 5 sequences from video with animals distributed over two control sites (two different occasions).

2.3. The rooting

In order to compare rooting made by wild boar between the feeding and control sites, vegetation inventories (which included estimates of rooting, Table 1) were carried out at each of the 23 sites. The first inventory was made in the summer of 2018, during the control year. A similar inventory was also carried out in 2020, before the feeding had begun. In the summer of 2021, I conducted a repeated inventory of only rooting by wild boar. All the inventories were made over a few weeks sometime from the end of July to beginning of September.

The rooting inventory was made at the same distances as the camera traps distances, namely 2, 10, 25, 50, 100, and 150 m from the site pole, however only to the North and East (Figure 3). At each distance the rooting was estimated on a 0 - 3 scale in 10 m^2 (~1.78 m radius) and 314 m^2 (~10 m radius) circular sampling plots (Figure 3), see Table 1 for definition of the scale levels. This means the sampling plots did overlap to a certain extent at the closest distances, but were still treated as different samples.

Table 1. Rooting estimation, made in 10 m^2 and 314 m^2 circles. Rooting level was determined depending on the estimated percentage of rooting in the sampling plot.

Level	Definition
0	Missing = 0%
1	Occasional = <10%
2	Moderate = 10 - 50%
3	Rich = 50 - 100%

2.4. Statistics

I conducted the statistical analyses using Rstudio (R Core Team 2021; RStudio Team 2021), especially used packages were lme4 (Bates et al. 2015) and vegan (Oksanen et al. 2020).

Observe that the used terminology of “number of wild boar” throughout the study is not indicating the number of individual wild boar; it is the number of wild boar captured on photos, meaning that it can be the same individual that was counted several times.

2.4.1. Wild boar establishment

I investigated and compared the wild boar establishment time in the experiment year for the three treatments. Establishment time was determined with logistic regressions, one model made for each treatment (new feed, old feed, control), with day from feeding start as an explanatory variable.

The difference in number of wild boar per 14 days between the treatments were tested with a generalised linear mixed model (GLMM), a Poisson regression, with treatment and distance (log) as explanatory variables and site as a random factor.

2.4.2. Rooting

Difference in rooting levels between treatments, years, and distances (log) was tested with GLMM with Poisson distribution. Treatment, year, and distance (log) were explanatory variables and site was a random factor. This was done for both the smaller (10 m^2) and the larger (314 m^2) sampling plots. There were three years included in this, however 2018 and 2020 were both control years and were therefore combined in a second test and the models were made again to investigate possible differences.

To investigate if the rooting level in the summer of 2021 (in both the smaller (10 m^2) and the larger (314 m^2) sampling plots) was related to the number of wild boar in the autumn of the experiment year (2020) the median of the rooting levels (North and East) at the six distances for the sites was transformed to percentage and decimals. Meaning for example that a level 1 equalled to 0.05 (between 0 - 10% rooting, see Table 1) and a level 3 equalled to 0.75 (between 50 - 100% rooting). The values were then logit transformed and used in a linear mixed model (LMM) with number of wild boar per 14 days (log) and treatment as explanatory variables, and site as random factor.

A total of 138 distances around the sites (six distances, at 23 sites, not separating the two directions) were checked for rooting. 32 of these were excluded from my analysis as they had not yet been surveyed in the camera trapping of the experiment year and could therefore not be included when comparing the number of wild boar with the rooting.

2.4.3. Species diversity

Species richness was analysed with a Poisson GLMM with treatment and year as explanatory variables and site as a random factor. A diversity index was also calculated, the Shannon index (Shannon 1948), also called Shannon-Wiener index, and tested similarly but with normal distribution (LMM). Shannon index takes both the number of species and the abundance of the species into account (evenness), the abundance in this study is the number of photo sequences taken of the species. This is in contrast to species richness which equals only to the number of species. A higher Shannon index can indicate more species and a higher evenness in abundance between them. Similar models were also made with distance (log) as a continuous explanatory variable to investigate if that affected the outcome of species richness or Shannon index.

3. Results

A total of 5129 camera days were analysed, combined over all sites from the control and experimental year. There was a total of 76,539 photos sorted through in the experimental year. In the control year a total of 27,304 photos were taken.

3.1. Wild boar establishment

There were significantly more wild boar present with time after the initiated feeding in the two feeding treatments (Figure 4; Appendix 1, Table 1). Presence was defined as at least one wild boar photo that day, and wild boar presence increased faster in the old feeding sites than in the new feeding sites. Old feeding sites reached 50% daily presence after approximately 35 days compared to around 55 days for new feeding sites. After 129 days the new feeding sites had not reached the same daily presence as at the old feeding sites. Wild boar presence on the control sites did not change over time (Figure 4; Appendix 1, Table 1).

There were wild boar at the old feeding sites from the first day of feeding. Wild boar came to the new feeding sites on the third day, and it took 27 days for wild boar to be seen on a camera trap photo at the control sites.

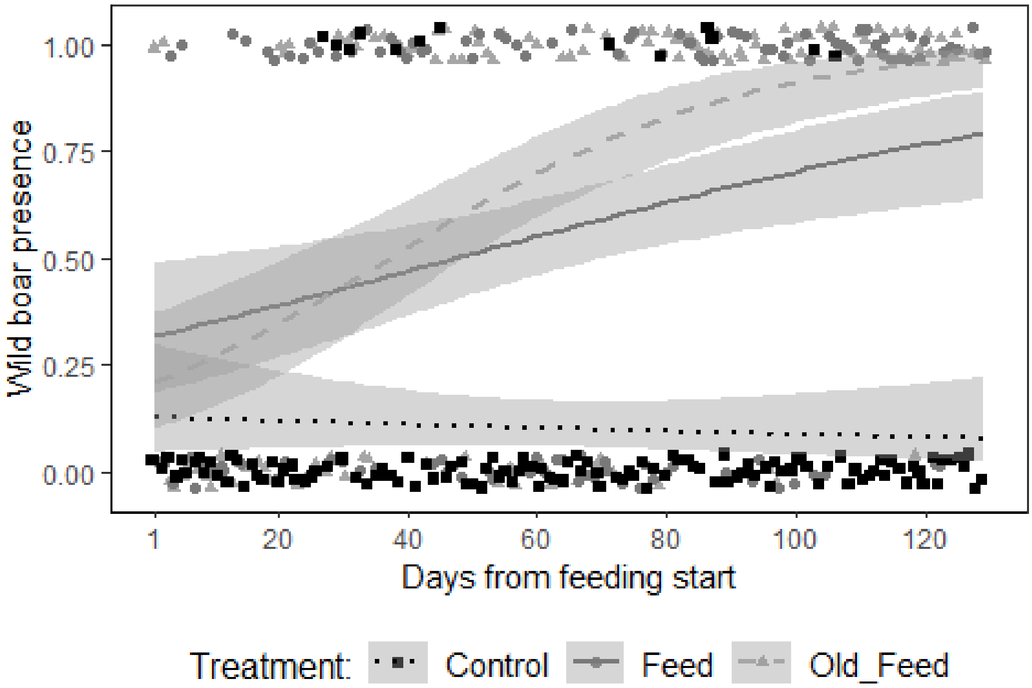

Figure 4. Result from a logistic regression of wild boar presence based on camera trap data when establishing new feeding sites (Feed) and reinitiating feeding at previously established feeding sites (Old Feed), compared to no feeding (Control), in the experiment year. Day 1 is the start of feeding, 2nd of September 2020 in Grimsö wildlife research area, South-central Sweden. Grey shaded areas around the curves represent 95% confidence intervals.

The number of wild boar per 14 days decreased significantly with the distance from the feeding station (Figure 5; Appendix 1, Table 2). Both the feeding treatments had more wild boar per 14 days than the control sites. The feeding treatments also have significantly less wild boar further away from the feeding station. After approximately 50 m there seem to be no effect of the feeding station (Figure 5).

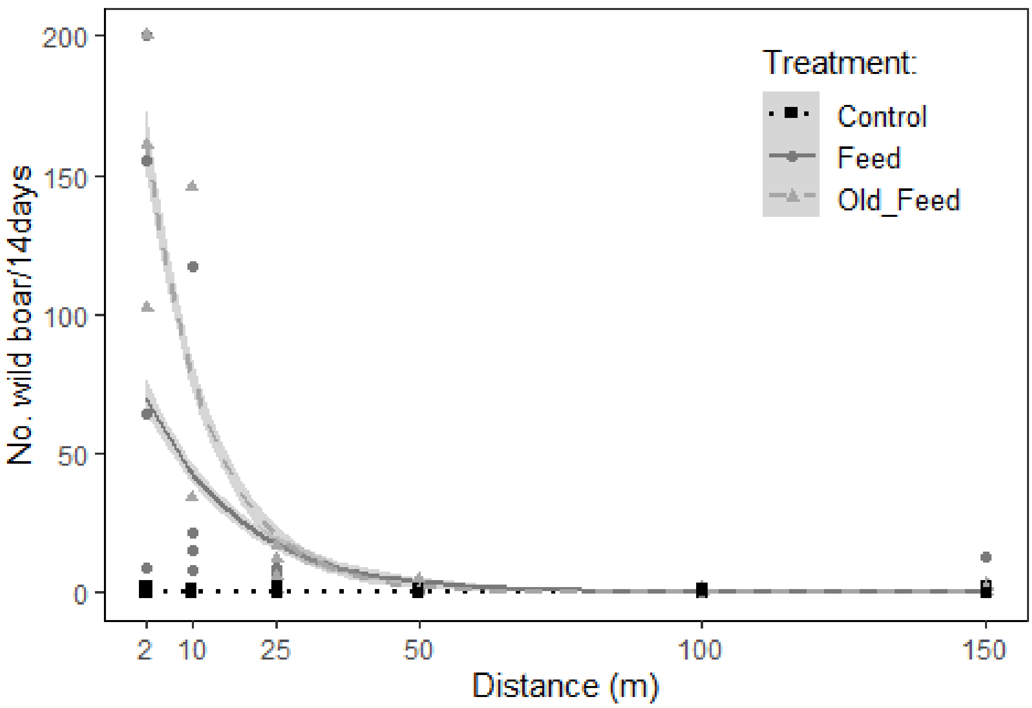

Figure 5. Number of wild boar per 14 days in relation to the distance to the feeding station (Feed and Old Feed, see Figure 4 for definition) compared to distance to no feeding (Control) where only a numbered wooden pole was used. The actual distance of the camera is rounded to the closest fixed distance (2, 10, 25, 50, 100, or 150 m). Three points (one from Feed and two from Old Feed at 247 - 350) are squished at 200 on the y-axis for graphical reasons only. Data from September 2020 to January 2021 in Grimsö wildlife research area, South-central Sweden. Grey shaded areas around the curves represent 95% confidence intervals.

3.2. Rooting

There was significantly more rooting in the experiment year than in the control years in the smaller (10 m^2) sampling plots (Figure 6; Appendix 1, Table 3). The old feeding sites had more rooting than the control sites for both the smaller (10 m^2) and the larger (314 m^2) sampling plots (Figures 6-7; Appendix 1, Table 3-4). During the experiment year there was more rooting in both feeding treatments, for both sampling plots. There was less rooting in both feeding treatments further away from the feeding station (Figures 6-7). Here the control year was the mean of both 2018 and 2020 since they were both control years before the feeding had started. Models were however tested with all years separated which can be seen in Appendix 1 (Appendix 1, Figures 1-2, Tables 5-6).

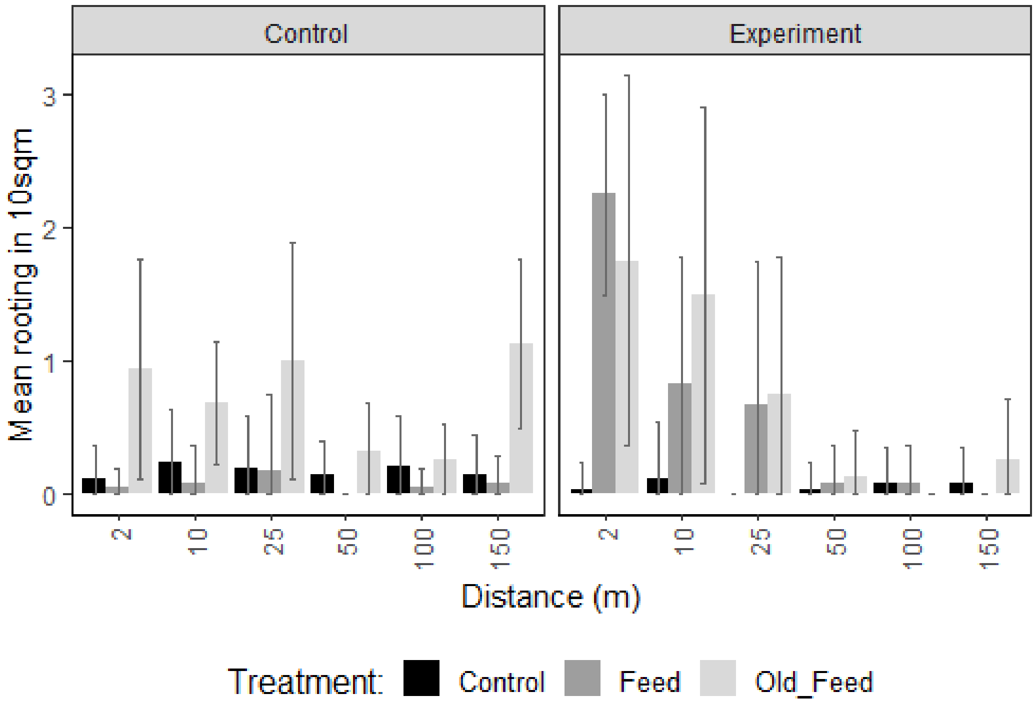

Figure 6. The mean rooting in a 10 m² circular sampling plot on a four-level scale (0 – 3), at each distance (2, 10, 25, 50, 100, 150 m) to the feeding station (Feed and Old Feed, see Figure 4 for definition) compared to no feeding (Control). Estimated in summer in Grimsö wildlife research area, South-central Sweden. Experiment year is 2021 and Control year is 2018 and 2020 combined. Feeding started in the autumn 2020. Error bars indicate standard deviation.

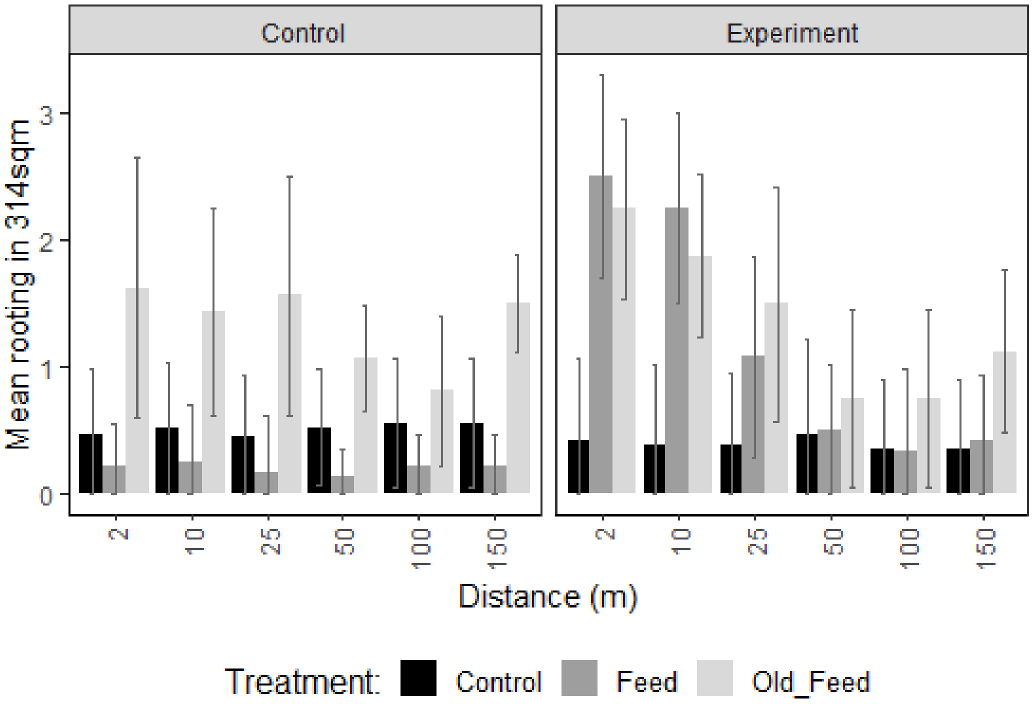

Figure 7. The mean rooting in a 314 m² circular sampling plot on a four-level (0-3), at each distance (2, 10, 25, 50, 100, 150 m) to the feeding station (Feed and Old Feed, see Figure 4 for definition) compared to no feeding (Control). Estimated in summer in Grimsö wildlife research area, South-central Sweden. Experiment year is 2021 and Control year is 2018 and 2020 combined. Feeding started in the autumn 2020. Error bars indicate standard deviation.

3.3. Rooting and number of wild boar

The rooting level, converted here to decimal numbers, in both the smaller (10 m^2) and the larger (314 m^2) sampling plots demonstrate a significant and positive relationship with the number of wild boar per 14 days (Figure 8; Appendix 1, Tables 7-8). There was more rooting, estimated during the summer, where there had been more wild boar in the previous autumn. The new feeding sites (Feed) had significantly higher rooting level compared to the control sites in the larger sampling plots; however, the old feeding sites were not significantly different. In the small sampling plots neither of the two feeding treatments were significantly different from the control treatment (Appendix 1, Table 7).

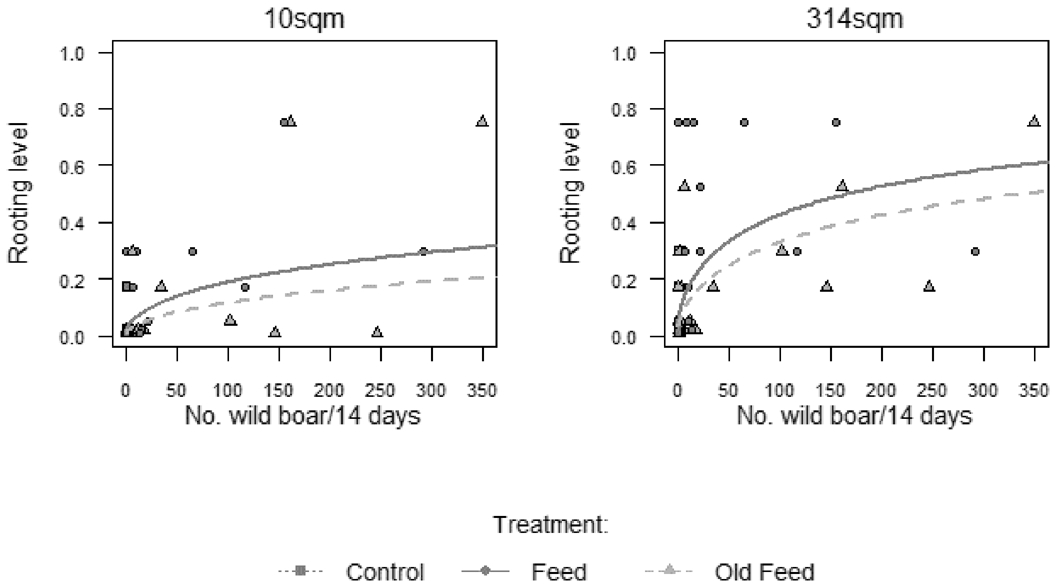

Figure 8. Amount of rooting in relation to number of wild boar per 14 days at new and old feeding stations (Feed, Old Feed) compared to no feeding (Control). The left plot includes rooting from the smaller (10 m²) sampling plots and the right plot is rooting from the larger (314 m²) sampling plots. Rooting was estimated in summer 2021 and number of wild boar in September 2020-January 2021, at Grimsö wildlife research area, South-central Sweden. The rooting levels (see Table 1 for definitions) are converted to decimal numbers between 0-1. The line for the control treatment is in the down left corners but is not visible since there were generally few wild boar caught on camera and less rooting at those sites. The short control treatment slope was however similar to both the other treatments in the smaller sampling plot and the old feed treatment for the larger sampling plot.

3.4. Species diversity

In total, 41 distinct species could be identified from camera trap photos (Appendix 2, Table 1): 40 in the experiment year and 19 in the control year. Species that differed between the control treatment and the two feeding treatments were mostly bird species.

The species richness was significantly greater in the experiment year than in the control year, all treatments included (Figure 9; Appendix 1, Table 9). The old feeding sites did also have a significantly larger number of species than the control sites. The new feeding sites did not have significantly more species than the control sites, but in the experiment year the new feeding sites did have a larger effect on species richness than the old feeding sites (Appendix 1, Table 9).

The Shannon index indicated a significant difference between the experiment and control year, the experiment year had a higher index (Figure 9; Appendix 1, Table 10), meaning a higher diversity (number of species and more even abundance).

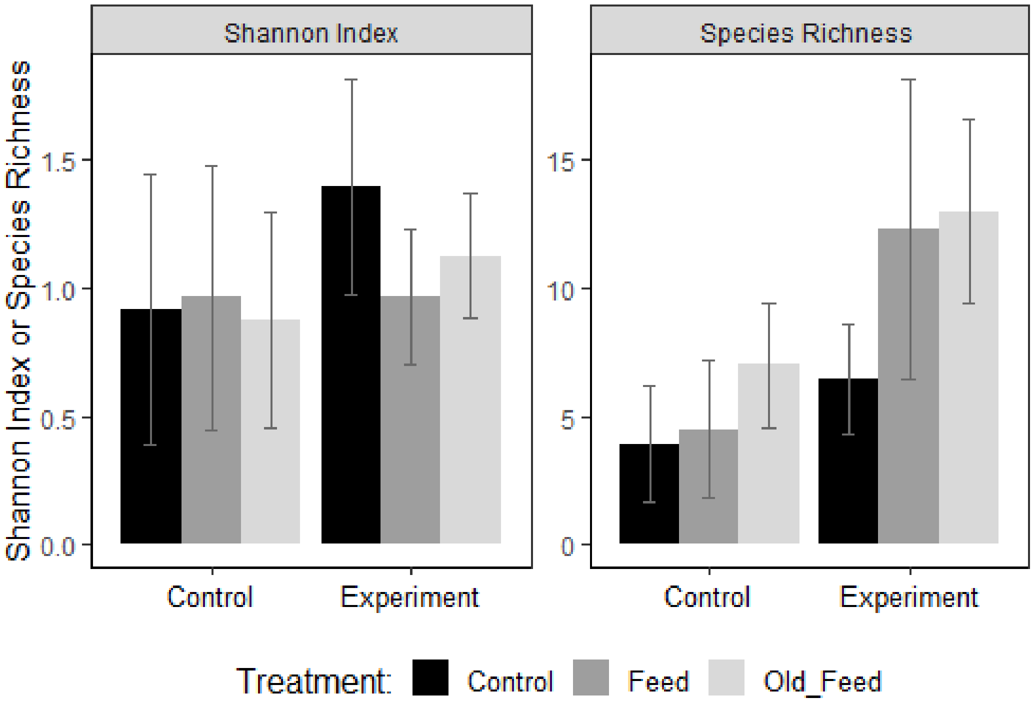

Figure 9. Mean Shannon index and mean species richness of animals seen in camera traps for the feeding treatments (Feed and Old Feed, see Figure 4 for definition) and the no feeding treatment (Control) in the Control year (2018) and the Experiment year (2020). Data from Grimsö wildlife research area, South-central Sweden. Error bars indicate standard deviation. Observe the different scales on the y-axes.

Including the distance to the feeding station, or site pole, the species richness results looked somewhat different (Figure 10; Appendix 1, Table 11). The old feeding sites still had significantly more species than the control sites. At the new feeding sites species richness was significantly different from the control sites in the experiment year. There were more species at the new feeding sites closer to the feeding station than further away, in the experimental year (Figure 10). The old feeding sites indicated a similar but not significant pattern.

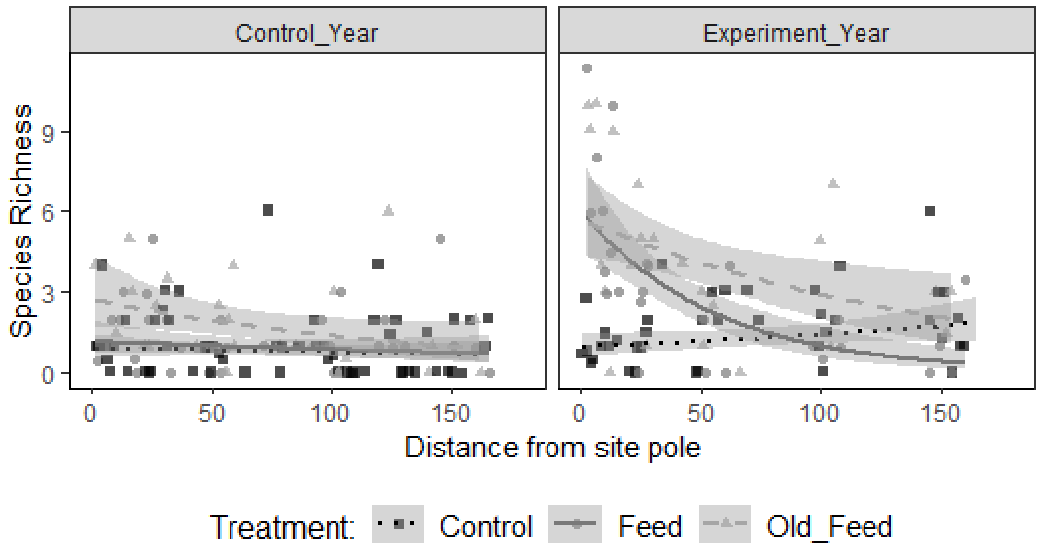

Figure 10. Mean species richness of animals seen in camera traps in relation to the distance to the feeding station (Feed and Old Feed) compared to no feeding (Control) where only a pole was used. One point from the control treatment in the control year at approximately 200m on the x-axis is not visible for graphical reasons. Data from September to January in the Control (2018) and the Experiment (2020) year, from Grimsö wildlife research area, South-central Sweden. Grey shaded areas around the curves represent 95% confidence intervals.

The Shannon index also differed when including the distance to the feeding site or the site pole. The index was higher at the feeding sites in the experiment year than the control year (Figure 11; Appendix 1, Table 12). The index also decreased significantly for the new feeding sites with increasing distance to the feeding site, in the experiment year. The index at the control sites, however, seemed to increase with a longer distance to the site pole.

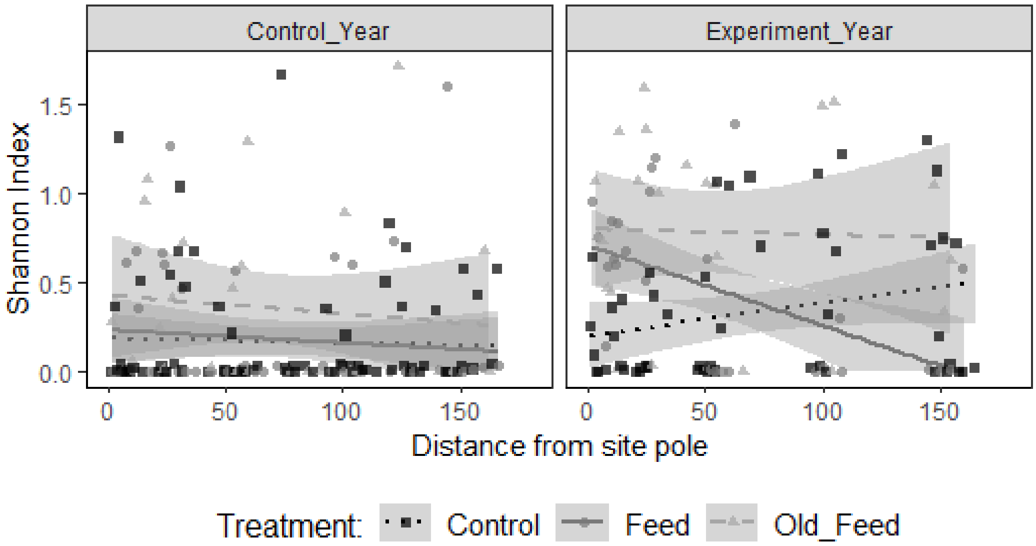

Figure 11. Mean Shannon index of animals seen in camera traps in relation to the distance to the feeding station (Feed and Old Feed, see Figure 4 for definition) compared to no feeding (Control) where only a pole was used. One point from the control treatment in the control year at approximately 200 m on the x-axis is not visible for graphical reasons. Data from September to January in the Control (2018) and the Experiment (2020) year, from Grimsö wildlife research area, South-central Sweden. Grey shaded areas around the curves represent 95% confidence intervals.

4. Discussion

In this study, I found support for my first hypothesis and the derived prediction (research question (Q) 1, hypothesis (H) 1) that wild boar presence was higher at old feeding sites than at the new feeding sites (50% daily presence after ~35 and ~55 days, respectively), and both were different from the control sites in which wild boar presence did not increase with time. There were also more wild boar and more rooting closer to the feeding sites (Q1:H2 and Q2:H1), and the effect seem to cease at a distance of approximately 50 m from the feeder. The level of rooting was directly related to wild boar presence, i.e. the more wild boar, the more rooting in the following year (Q2:H2). Finally, there was higher species richness at old feeding sites than at control sites (Q3:H1), while the species richness at new feeding sites indicated a stronger increase than at the old sites. Thus, all my stated hypotheses were supported and below follows a discussion on these results and their implication in more detail.

4.1. Wild boar establishment

The wild boar in this study established faster at old feeding sites than at the new sites. The old feeding sites had been present for at least a year before the control year (2018), some for a total of four years. Unfortunately, no systematic documentation exists of when feed was provided and how much forage that was used in these four sites before the experiment was initiated. The stations were used for hunting of wild boar, for keeping wild boar close by to ease the hunt. When the feeding experiment started the 2nd of September 2020, the wild boar were already familiar with the old feeding sites and apparently became aware of the feeding faster and visited them more regularly than the new sites (Figure 4).

The estimated number of wild boar used in this study was in fact the number of wild boar captured on photos, this meant it could be the same wild boar individual captured over and over again. However, for the purpose of the questions asked here this should have no implication, since I studied the accumulative effect of wild boar presence, irrespective of if it was for example one wild boar individual visiting 10 times or 10 different individuals visiting one time each. Therefore, I believe it is a good approximation on wild boar presence at the site. However, this means I cannot comment on the density of wild boar at the sites, but with a higher density at feeding sites diseases can more easily spread (O'Neill et al. 2020). Diseases are an important factor to have in mind with the management of artificial feeding sites (Milner et al. 2014; Sorensen et al. 2014).

It would take more than the 129 days analysed in this study, for wild boar to potentially establish an equally high presence at the new feeding sites as at the old feeding sites. Even though wild boar in this study did find both feeding treatments within the first three days the presence still differed. One reason for the difference between the old and new sites may be that wild boar visit old sites occasionally because they have found food there before. Thus, they will detect new forage more easily than at new sites. The ability to learn and remember in pigs has been studied on several occasions and it has been shown that pigs do remember and know where to move to get to their food (e.g. Morelle et al. 2015). Another plausible reason for wild boar being present more regularly and faster at the old feeding sites could be that the old feeding stations were not randomly placed but in areas that were believed to be suitable for wild boar (and beneficial for hunting). The new feeding stations on the other hand, were randomly placed in the Grimsö area with the only condition that they had to be close to a road for easy access. This meant that they could be placed in a low productive pine stand or close to a bog that wild boar rarely visit. In addition, old feeding sites had a shorter mean distance to crop fields than the new feeding sites, with almost 600 m difference (rough estimate made by me). Wild boar, who often eat from crop fields, would therefore also prefer the old feeding sites since they would be closer to those crop fields. There are several possible reasons for this difference, but it is beyond the scope of my study.

The experiment year started in September, at the end of the vegetation season and the use of feeding sites could potentially differ depending on the season. Further into winter, with snow coverage and frozen grounds, wild boar might use the feeding sites more since other food resources, like crops, will be less available. In the Czech Republic a study has shown that during the winter months over 50% of wild boar stomach contents consisted of feed from artificial feeding (Miloš et al. 2016). The summer months showed similar results (Miloš et al. 2016), but it was not possible to tell if that originated from artificial feeding or crop fields since artificial feeding often consists of different variants of crops. Another aspect in winter could however be that wild boar walk less and shorter distances during winter (Thurfjell et al. 2014) and therefore only visit feeding stations depending on how close they are. A study in Estonia by Oja et al. (2014) concluded that wild boar had a higher abundance where there was supplementary feeding, and that supplementary feeding was a more important factor explaining abundance than winter severity, such as snow cover. This is not something that can be evaluated from my study.

4.2. Rooting

A wild boar group can walk many km within just a few days to reach a preferred food source, as has been shown in Slovenia (Jerina et al. 2014) but also with the GPS collared animals around the Grimsö area (Jaktjournalen 2021; Evelina Augustsson, SLU, personal communication). Supplementary feeding stations can be a preferred food source, and this study shows (Figure 4) that it does not take many days after the feeding stations were activated for the wild boar presence to increase. A 50% daily presence was reached in approximately 35 - 55 days for the feeding sites (Figure 4). A 16 day long study on white-tailed deer showed that the detection of the targeted species at artificial feeding sites initially increase and later decrease again (Bowman et al. 2015). Supplementary feeding of wild boar can make the animals stay in an area (Oja et al. 2014) and thus affect the surroundings. New presence of dispersing or introduced wild boar can quickly affect the local flora and fauna.

There were more wild boar closer to the feeding sites than further away and the effect of the feeding seem to stop at around 50 m away (Figure 5). Comparing this with the result from the rooting it seems like the effect declines at the same distance, 50 m (Figures 6-7). The area in relatively close proximity to a feeding station is affected the most and further away there is less evidence of wild boar presence. In a study in Hungary generally 30% of the studied oak forest was always affected by wild boar rooting (Sütő et al. 2020). Rooting has been suggested to change the species richness of an area (Bongi et al. 2017). Although a study in western Siberia concluded that it did not affect the species richness of the plant cover, but a decrease in shrub, moss and lichen species could be seen (Pankova et al. 2020). How the rooting has affected the plant composition at Grimsö is yet to be investigated with the vegetation inventories. However, research regarding rooting and the distance to or from a feeding site seem to be scarce.

4.3. Species richness

There was also higher species richness closer to the new feeding sites than further away (Figure 10). This was not the pattern observed around the old feeding sites, that have been used for a longer time. Perhaps the surroundings of the old sites have been exploited of the natural food sources close to the feeding stations to a larger extent. The area is therefore barer close by, and animals have to move further away to find preferred resources, other than the artificial food. A somewhat similar idea has been tested in a long-term study with moose supplementary winter feeding in Norway (van Beest et al. 2010a), where the moose used areas around the feeding stations more after a longer time (15 - 20 years) compared to earlier (5 - 10 years).

However, an increase in browsing pressure close to the feeding station only occurred on one tree species (van Beest et al. 2010a). So, with time the decrease in browsing with distance disappeared and areas around a feeding site had similar risk of browsing. In this study at Grimsö, in the areas around the feeding stations, it was possible to see how the ground and surrounding was barer compared to further away. In the summer of 2021, it was still possible to see a difference between the old and new feeding sites as well, in how bare the ground was (not formally investigated here).

More non-targeted species were found at the old feeding sites compared to the control sites, but the new feeding sites did not significantly differ from the controls. However, since the new feeding sites seemed to increase more in number of species (Appendix 1, Table 9) the new sites might reach the same or higher number of species as the old sites, in a longer time perspective. Thus, more time is needed to conclusively investigate this. Feeding sites have also been shown to be able to alter non-targeted species movements, where individuals move to feeding sites more often than random (Selva et al. 2017). This can also be a reason as to why the old, already known feeding sites here have more species. Previous artificial feeding research has shown similar results as here; non-targeted species are a major part of the resulting conclusions about the feeding (Bowman et al. 2015; Reed & Bonter 2018; Flezar et al. 2019; Armenteros et al. 2021). Not all species that were seen on photos were species eating the provided maize, there were herbivores (e.g. roe deer), omnivores (e.g. badger (*Meles meles*)), and carnivores (e.g. lynx). Carnivores, and omnivores, can visit the feeding sites for the prey that is eating the maize, for example there was one photo sequence with a lynx staring at a black bird (*Turdus merula*). Hunting or stalking for prey has been seen by wildcat on rodents by a corn feeding station in Slovenia (Flezar et al. 2019). In Spain, predators were observed at feeding sites and water troughs, but the authors could not rule out that their visits were to the site itself and not for the prey at the site (Armenteros et al. 2021). Moreover, some of the birds seen in this study are carnivores (e.g. sparrowhawk (*Accipiter nisus*)) or omnivores (e.g. raven (*Corvus corax*)) and can also visit the feeding sites for other reasons than the maize.

A relatively similar study to this, focusing on brown bear feeding sites and non-targeted species, showed that bird species were a major part of the animals visiting the sites (Flezar et al. 2019). That result is similar to the findings here where 59% of the determined species were different bird species (all treatments, both years, see Appendix 2, Table 1). Wild boar eat eggs from ground nesting birds and one concern of an increasing wild boar population is the effect they might have on local bird populations. A Polish study has shown that ungulate feeding sites increased the predation on ground nests compared to sites with no feeding (Selva et al. 2014). The closer the nests were to the feeding the higher the risk of being predated upon

(Selva et al. 2014). However, a Swedish study investigating artificial bird nests in areas with or without wild boar showed that the bird nests were more often predated in the areas without wild boar (Carpio et al. 2016). Bird nests were not observed or investigated in this study but many bird species, including some ground nesting birds (black grouse (*Lyrurus tetrix*), capercaillie (*Tetrao urugallus*), and Eurasian woodcock (*Scolopax rusticola*)), were observed in both the control and experiment year and in all treatments.

Species richness seems to be the best way to estimate differences in diversity between the treatments, at least compared to the Shannon diversity index used here. In this study there were relatively few species included, only 41 in total (Appendix 2, Table 1), and the abundances of the species were highly variable. There were often many wild boar, roe deer or Eurasian jay (*Garrulus glandarius*) compared to a single lynx or capercaillie at a site. Diversity indices most often require many more species, which could be a reason as to why the Shannon index was not suitable for this study.

Conclusions

In conclusion, wild boar respond quickly to newly established feeding sites even though it can take up to 50-60 days before they are regularly present. Feeding sites affect the immediate surroundings and attract non-targeted species. This is an important consideration in the placement and evaluation of feeding stations. It is quite likely that plants growing in the surrounding will be affected by the rooting made by wild boar at a feeding site, and that animals will be affected by the extra feed. Disease spread is another factor that might also be in need of investigation plans and evaluation. These are a few thoughts to have in mind, in addition to remember that this study was just a few months long (Sept-Jan), more time is needed for investigating long-term effects.

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Appendix 1

Result from rooting estimation where the control years were separated into 2018 and 2020 for both the smaller (10 m^2) and the larger (314 m^2) sampling plots (Appendix 1, Figures 1-2, Tables 5-6). The rooting level (see Table 1 for definitions) was tested in relation to the year, treatment, and distance. The rooting levels were significantly different and higher in the old feeding sites compared to the control sites (both sampling plots, i.e. 10 m^2 and 314 m^2). The new feeding sites in 2021 also has more rooting in both sampling plots. Old feeding sites in 2020 did however have less rooting in the smaller sampling plots (Appendix 1, Figure 1). The distance did not affect the result.

The summer of 2018 and 2020 were however both control years, so combining these two generate a better control and can potentially also decrease the person bias of the inventory since there were different people in charge all three years.

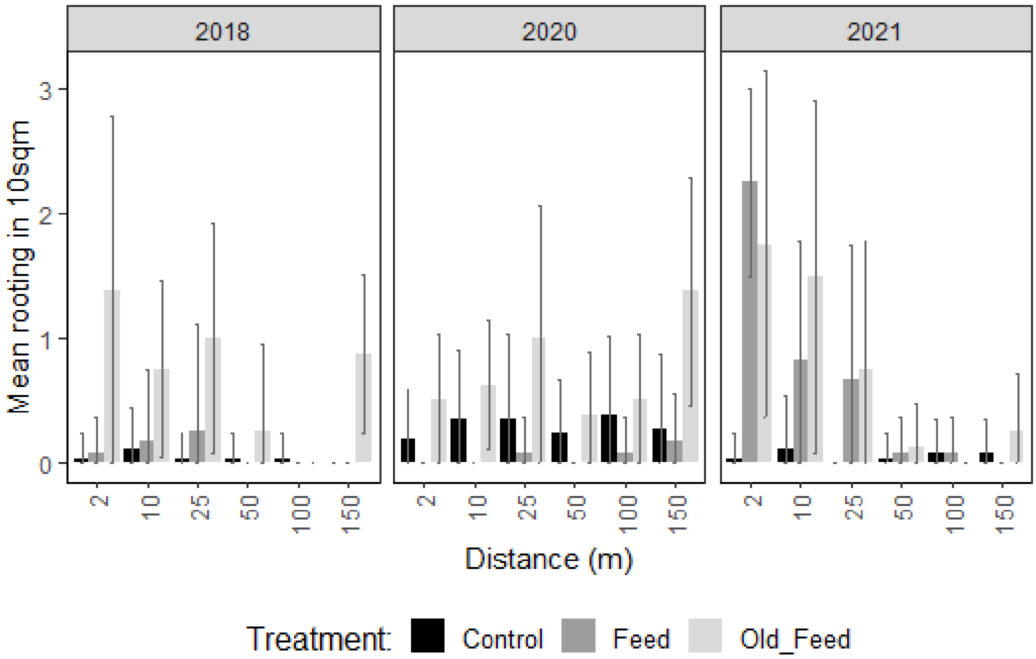

Figure 1. The mean rooting in a 10 m² circle on a scale with levels 0 - 3 at each distance (2, 10, 25, 50, 100, 150 m) to the feeding station (Feed and Old Feed) compared to no feeding (Control). Estimated in summer in Grimsö wildlife research area, South-central Sweden. The feeding started in the autumn of 2020 making both 2018 and 2020 control years. Error bars indicate standard deviation.

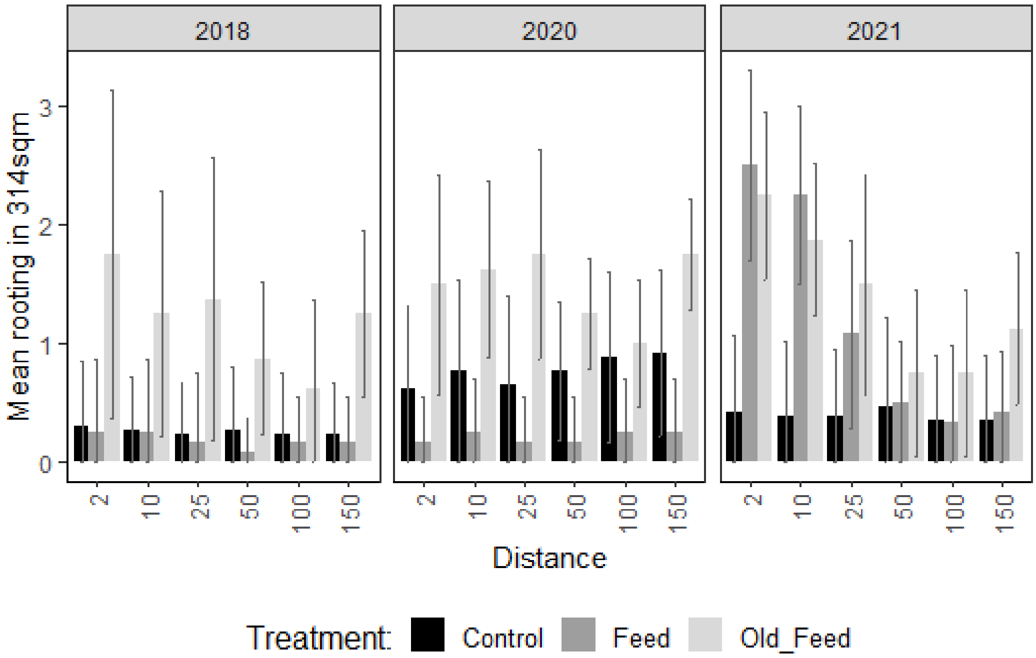

Figure 2. The mean rooting in a 314 m² circle on a scale with levels 0-3 at each distance (2, 10, 25, 50, 100, 150 m) to the feeding station (Feed and Old Feed) compared to no feeding (Control). Estimated in summer in Grimsö wildlife research area, South-central Sweden. The feeding started in the autumn of 2020 making both 2018 and 2020 control years. Error bars indicate standard deviation.

Table 1. Results of the logistic regressions for wild boar establishment with day from feeding start as explanatory variable. One model for each treatment (Feed, Old Feed, Control). P-values in bold are significant (<0.05).

Model	Variable(s)	Estimate	Std. Error	z-value	P-value
WB est. Feed	Intercept	-0.078	0.371	-2.094	**0.036**
	Day	0.016	0.005	3.172	**<0.01**
WB est. Old Feed	Intercept	-1.375	0.423	-3.249	**<0.01**
	Day	0.037	0.007	5.130	**<0.001**
WB est. Control	Intercept	-1.925	0.560	-3.437	**<0.001**
	Day	-0.004	0.008	-0.553	0.594

Table 2. Results from the GLMM Poisson regression for the number of visiting wild boar per 14 days with treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	-2.204	0.730	-3.022	**<0.01**
log(Distance)	0.198	0.180	1.100	0.271
Feed	6.743	0.803	8.395	**<0.001**
Old Feed	8.340	0.833	10.011	**<0.001**
log(Distance):Feed	-1.050	0.184	-5.697	**<0.001**
log(Distance):Old Feed	-1.278	0.183	-6.986	0.594

Table 3. Results from the GLMM Poisson regression with rooting in the smaller (10 m^2) sampling plots. Year (Experiment, referenced to Control (2018 & 2020)), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	-0.409	0.360	-1.134	0.257
Experiment	-1.203	0.313	-3.844	**<0.001**
Feed	0.005	0.671	0.008	0.993
Old Feed	2.572	0.668	3.852	**<0.001**
log(Distance)	0.024	0.042	0.572	0.567
Experiment:Feed	5.261	0.472	11.139	**<0.001**
Experiment:Old Feed	2.429	0.349	6.968	**<0.001**
Experiment:log(Distance)	0.036	0.085	0.429	0.668
Feed:log(Distance)	-0.029	0.105	-0.276	0.783
Old Feed:log(Distance)	-0.101	0.055	-1.823	0.068
Experiment:Feed:log(Distance)	-0.788	0.133	-5.918	**<0.001**
Experiment:Old Feed:log(Distance)	-0.509	0.099	-5.136	**<0.001**

Table 4. Results from the GLMM Poisson regression with rooting in the larger (314 m^2) sampling plots. Year (Experiment, referenced to Control (2018 & 2020)), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	1.227	0.188	6.535	**<0.001**
Experiment	-0.015	0.133	-0.112	0.911
Feed	-0.522	0.366	-1.429	0.153
Old Feed	1.607	0.360	4.457	**<0.001**
log(Distance)	0.043	0.025	1.721	0.085
Experiment:Feed	2.932	0.249	11.779	**<0.001**
Experiment:Old Feed	0.489	0.179	2.728	**<0.01**
Experiment:log(Distance)	-0.076	0.037	-2.059	**0.040**
Feed:log(Distance)	-0.078	0.062	-1.257	0.209
Old Feed:log(Distance)	-0.124	0.036	-3.453	**<0.001**
Experiment:Feed:log(Distance)	-0.331	0.071	-4.628	**<0.001**
Experiment:Old Feed:log(Distance)	-0.075	0.052	-1.455	0.146

Table 5. Results from the GLMM Poisson regression with rooting in the smaller (10 m^2) sampling plots. Year (2021, 2020, referenced to 2018), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	-2.820	0.791	-3.566	**<0.001**
2020	0.958	0.846	1.132	0.258
2021	-0.652	1.139	-0.572	0.567
Feed	1.223	1.133	1.084	0.278
Old Feed	3.222	0.928	3.472	**<0.001**
log(Distance)	-0.230	0.239	-0.965	0.335
2020:Feed	-6.179	3.190	-1.937	0.053
2021:Feed	3.550	1.388	2.557	**0.011**
2020:Old Feed	-2.249	1.026	-2.192	**0.028**
2021:Old Feed	1.317	1.221	1.078	0.281
2020:log(Distance)	0.298	0.260	1.146	0.252
2021:log(Distance)	0.291	0.332	0.878	0.380
Feed:log(Distance)	-0.112	0.352	-0.318	0.750
Old Feed:log(Distance)	-0.046	0.263	-0.174	0.862
2020:Feed:log(Distance)	0.999	0.754	1.325	0.185
2021:Feed:log(Distance)	-0.705	0.435	-1.621	0.105
2020:Old Feed:log(Distance)	0.124	0.308	0.402	0.688
2021:Old Feed:log(Distance)	-0.564	0.368	-1.535	0.125

Table 6. Results from the GLMM Poisson regression with rooting in the larger (314 m²) sampling plots. Year (2021, 2020, referenced to 2018), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	-1.346	0.395	-3.408	**<0.001**
2020	0.577	0.439	1.314	0.189
2021	0.324	0.475	0.682	0.495
Feed	0.002	0.749	0.003	0.998
Old Feed	1.946	0.553	3.520	**<0.001**
log(Distance)	-0.064	0.105	-0.611	0.541
2020:Feed	-1.104	1.000	-1.104	0.270
2021:Feed	2.332	0.789	2.957	**<0.01**
2020:Old Feed	-0.728	0.596	-1.221	0.222
2021:Old Feed	0.067	0.608	0.111	0.912
2020:log(Distance)	0.161	0.123	1.302	0.193
2021:log(Distance)	0.031	0.135	0.227	0.820
Feed:log(Distance)	-0.080	0.208	-0.383	0.702
Old Feed:log(Distance)	-0.083	0.136	-0.614	0.539
2020:Feed:log(Distance)	0.049	0.283	0.172	0.863
2021:Feed:log(Distance)	-0.329	0.236	-1.396	0.163
2020:Old Feed:log(Distance)	-0.041	0.170	-0.240	0.811
2021:Old Feed:log(Distance)	-0.116	0.179	-0.651	0.515

Table 7. Results from the linear mixed model with logit-transformation of rooting levels converted to percentage and decimals (see Method for explanation) in the smaller (10 m^2) sampling plots. Wild boar per 14 days and treatment (Feed, Old Feed, referenced to Control) as explanatory variables and site as a random factor. Wild boar per 14 days has +1 added to be able to use more numbers. T-values in bold are significant (rule of thumb >1.96).

Variable(s)	Estimate	Std. Error	t-value
Intercept	-4.370	0.119	**-36.869**
log10(WB/14days+1)	1.234	0.167	**7.397**
Feed	0.452	0.254	1.782
Old Feed	-0.115	0.283	-0.410

Table 8. Results from the linear mixed model with logit-transformation of rooting levels converted to percentage and decimals (see Method for explanation) in the larger (314 m^2) sampling plots. Wild boar per 14 days and treatment (Feed, Old Feed, referenced to Control) as explanatory variables and site as a random factor. Wild boar per 14 days has +1 added to be able to use more numbers. T-values in bold are significant (rule of thumb >1.96).

Variable(s)	Estimate	Std. Error	t-value
Intercept	-3.895	0.197	**-19.748**
log10(WB/14days+1)	1.341	0.193	**6.939**
Feed	0.914	0.388	**2.356**
Old Feed	0.496	0.439	1.131

Table 9. Results from the GLMM Poisson regression with species richness. Year (Experiment, referenced to Control), treatment (Feed, Old Feed, referenced to Control) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	1.367	0.140	9.761	**<0.001**
Feed	0.137	0.238	0.576	0.564
Old Feed	0.579	0.235	2.462	**0.014**
Experiment	0.499	0.178	2.811	**<0.01**
Feed:Experiment	0.509	0.287	1.778	0.075
Old Feed:Experiment	0.120	0.294	0.408	0.683

Table 10. Results from the linear mixed model with Shannon index. Year (Experiment, referenced to Control), treatment (Feed, Old Feed, referenced to Control) as explanatory variables and site as random factor. T-values in bold are significant (rule of thumb >1.96).

Variable(s)	Estimate	Std. Error	t-value
Intercept	0.916	0.123	**7.463**
Feed	0.049	0.218	0.222
Old Feed	-0.041	0.253	-0.163
Experiment	0.484	0.174	**2.786**
Feed:Experiment	-0.480	0.309	-1.552
Old Feed:Experiment	-0.231	0.358	-0.646

Table 11. Results from the GLMM Poisson regression with species richness. Year (Experiment, referenced to Control), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. P-values in bold are significant (<0.05).

Variable(s)	Estimate	Std. Error	z-value	P-value
Intercept	0.236	0.377	0.625	0.532
Feed	-0.001	0.625	-0.002	0.999
Old Feed	1.293	0.583	2.217	**0.027**
Experiment	-0.184	0.433	-0.425	0.671
log(Distance)	-0.137	0.096	-1.427	0.154
Feed:Experiment	2.685	0.685	3.922	**<0.001**
Old Feed:Experiment	1.281	0.664	1.930	0.054
Feed:log(Distance)	0.061	0.159	0.389	0.697
Old Feed:log(Distance)	-0.121	0.151	-0.802	0.423
Experiment:log(Distance)	0.120	0.113	1.761	0.078
Feed:Experiment:log(Distance)	-0.675	0.184	-3.672	**<0.001**
Old Feed:Experiment:log(Distance)	-0.315	0.180	-1.744	0.081

Table 12. Results from the linear mixed model with Shannon index. Year (Experiment, referenced to Control), treatment (Feed, Old Feed, referenced to Control) and distance (log) as explanatory variables and site as random factor. T-values in bold are significant (rule of thumb >1.96).

Variable(s)	Estimate	Std. Error	t-value
Intercept	0.258	0.156	1.657
Feed	-0.001	0.267	-0.003
Old Feed	0.214	0.344	0.623
Experiment	-0.062	0.185	-0.334
log(Distance)	-0.024	0.038	-0.630
Feed:Experiment	0.937	0.334	**2.806**
Old Feed:Experiment	0.530	0.436	1.215
Feed:log(Distance)	0.005	0.067	0.073
Old Feed:log(Distance)	-0.008	0.086	-0.093
Experiment:log(Distance)	0.063	0.048	1.320
Feed:Experiment:log(Distance)	-0.232	0.088	**-2.633**
Old Feed:Experiment:log(Distance)	-0.074	0.114	-0.651

Appendix 2

*Table 1. The species seen in camera trapping photos, in alphabetical order, and the number of photo sequences the species were observed in. There were 41 species in total. Data from September to January in the Control (2018) and the Experiment (2020) year, from Grimsö wildlife research area, South-central Sweden. *only seen in Control year, **only seen in Experiment year.*

Species		No. seq.	Species		No. seq.
Accipiter nisus	**	1	*Meles meles*		161
Alces alces		213	*Parus major*	**	52
Anura	**	1	*Pica pica*		13
Apodemus sp.	**	18	*Picus viridis*	**	2
Canis lupus		5	*Poecile palustris*	**	1
Capreolus capreolus		1167	*Sciurus vulgaris*		29
Cervus elaphus	**	5	*Scolopax rusticola*	**	4
Columba palumbus	**	30	*Sitta europaea*	**	6
Corvus corax	**	7	*Sus scrofa*		3471
Corvus cornix	**	5	*Tetrao urogallus*		10
Cyanistes caeruleus		9	*Turdus iliacus*	**	3
Dendrocopos major	**	2	*Turdus merula*	**	17
Dryocopus martius	*	3	*Turdus philomelos*		2
Erithacus rubecula	**	1	*Turdus pilaris*	**	1
Fringilla coelebs	**	3	*Turdus viscivorus*	**	1
Garrulus glandarius		3542	*Unknown*		321
Lepus europaeus		55	*Unknown Bird*		230
Lepus timidus		37	*Unknown Lepus*		65
Lynx lynx	**	1	*Unknown Rodent*	**	31
Lyrurus tetrix	**	1	*Vulpes vulpes*		260
Martes martes		11			