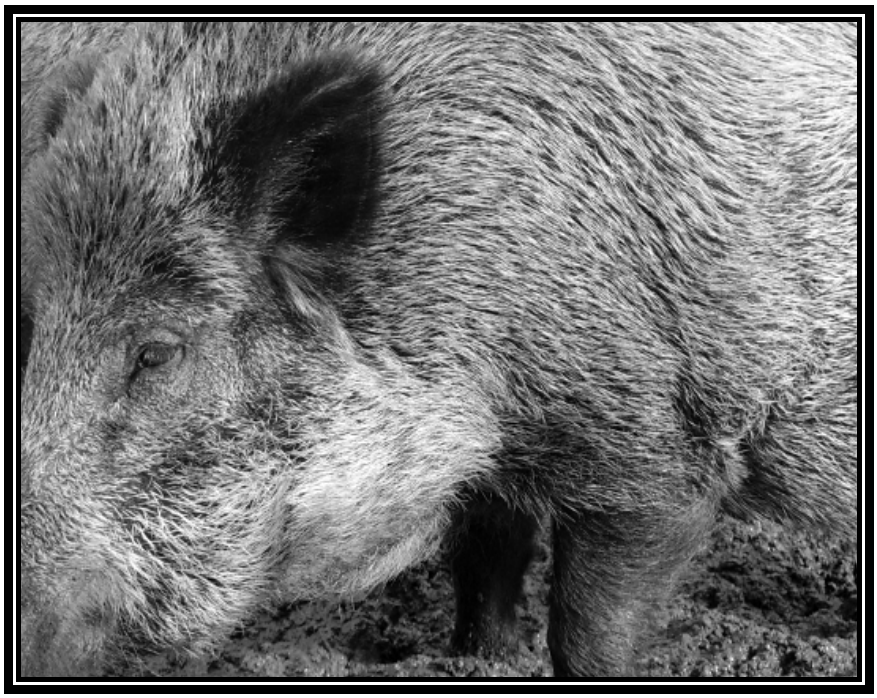
Examensarbete
i ämnet skoglig zooekologi

An application of the bait-marking method for the study of spatial activity of wild boar in southern Sweden

Sara Öhmark



Handledare: Kjell Sjöberg, Henrik Thurfjell & P-A Åhlén

20 Poäng, D-nivå

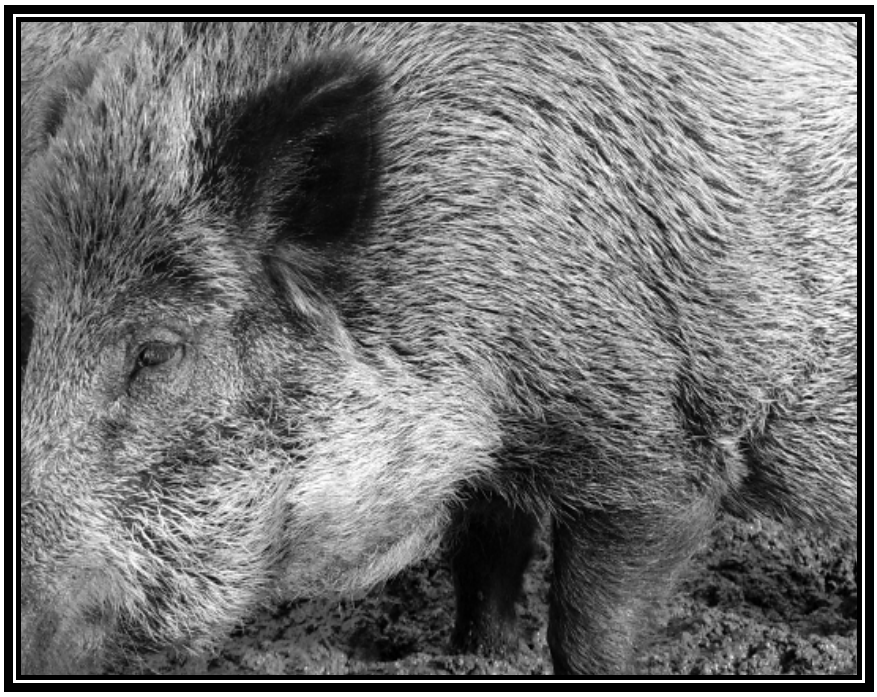
Institutionen för skoglig zooekologi
SLU
901 83 Umeå, Sweden

2006:8

Examensarbete
i ämnet skoglig zooekologi

An application of the bait-marking method for the study of spatial activity of wild boar in southern Sweden

Sara Öhmark



Supervisors: Kjell Sjöberg, Henrik Thurfjell & P-A Åhlén

20 Point, D-Level

Department of Animal Ecology
Swedish University of Agricultural Sciences
SE-901 83 Umeå, Sweden

2006:8

Abstract

In this study, the bait-marking method is for the first time tested on wild boar as a means to document movements. The results of the bait-marking study are compared to the results of a GPS surveillance study conducted in the same area. The mode of surveying animal movements by the use of tracking device such as GPS-transmitters is a well-established method which provides detailed data to many wildlife research-projects. Currently, some wild boars in the southern and middle parts of Sweden are the subjects of a GPS-study performed by researchers at the Department of Animal Ecology at the SLU in Umeå. The use of GPS-transmitters is a method that has some limitations, like high costs and that advanced equipment is demanded. The bait-marking method may offer a cheap and uncomplicated technique for indirect surveillance of spatial activities of wild boar. Indigestible markers are placed in bait, and findings of markers in faecal droppings provide information of the spatial activity of the animal in question. During April-May and September-October in 2006, bait containing plastic markers was placed on wild boar feeding sites on the Högestad estate in Skåne, southern Sweden. Estimations of home range size, position and overlap were made from the GPS-coordinates provided by the wild boar project at the SLU to compare with the results given from the bait-marking study and as a means to evaluate seasonal effects on the method. The method of delivery of the markers to wild boars proved usable during both seasons of the study as both bait and markers were consumed by boars at all observed occasions of pigs visiting feeding sites. Some feeding sites were during the study visited by wild boars originating from different home ranges. No markers were found at any of the fields that were searched during the study. There was a significant difference in the rate of recovered markers in faecal piles at feeding sites between spring and autumn. Altered ranging behaviour in terms of variance in autumn and spring home range sizes were found to be significant. An extended study is suggested for further analyses and development of the bait-marking method. Furthermore, some modifications of the method are suggested.

Sammanfattning

I denna studie testas för första gången *the bait-marking method* på vildsvin i syfte att dokumentera svinens rörelser. Studiens resultat jämförs med en GPS-övervakning av vildsvin i studieområdet. Att övervaka rörelser hos olika djur med hjälp av GPS-sändare är en väl etablerad metod som förser olika forskningsprojekt med detaljerad information. Vid intitutionen för skoglig zooekologi vid SLU i Umeå pågår för närvarande en studie där ett antal vildsvin i södra och mellersta Sverige följs med hjälp av GPS-sändare. Användandet av GPS för dylika studier är en metod som åtföljs av vissa begränsningar, eftersom dyr och tekniskt avancerad utrustning krävs. *The bait-marking method* kan fungera som en enkel och billig teknik för indirekt övervakning av den rumsliga aktiviteten hos vildsvin. Osmältbara markörer blandas med foder som sätts ut åt svinen och fynd av markörer i vildsvinens avföring kan sedan ge information om djurens rörelsemönster. Under april-maj och september-oktober 2006 placerades foder innehållande markörer av färgad plast ut på ett antal foderplatser för vildsvin på det skånska godset Högeststad. Beräkningar av hemområdesstorlekar, positioner och överlapp med andra hemområden gjordes utifrån koordinatangivelser från vildsvinsprojektet vid SLU. Detta användes som bakgrund för en jämförelse med de resultat som *bait-marking* studien gav, samt som ett sätt att utvärdera säsongsmässig påverkan på studiemetoden. Den metod som användes för att leverera markörer till vildsvin visade sig vara lämplig under de båda perioder då studien utfördes, då foder med markörer blev uppätna vid alla tillfällen som grisar sågs besöka foderplatser. Under studien visade det sig att flera av de foderplatser där foder med markörer placerades blev besökta av vildsvin från olika hemområden. Inga markörer återfanns dock på de fält som genomsöktes under studien. Det fanns en signifikant skillnad mellan de två studieperioderna under vår och höst, vad gäller mängden vildssvinsspillning innehållande markörer som återfanns på foderplatserna. Ändrade rörelsemönster hos vildsvinen yttrade sig genom varierande storlekar på hemområden mellan höst och vår. En utökad studie föreslås för vidare utvärdering och utveckling av *the bait-marking method*. Vissa modifieringar föreslås även för metoden.

Table of contents

Introduction

The wild boar (*Sus scrofa*) was part of the Swedish fauna until its extinction sometime during the 16th century (Welander 2000). No natural immigration of wild boar to Sweden has been observed in historical times and this species has therefore been absent in the Swedish fauna until recent decades (Kristiansson 1986). During the 1970s and 1980s, a number of wild boars escaped from enclosures at several localities in Sweden. These individuals formed some local establishments of which a few developed into stable populations. Areas in Skåne and Södermanland counties are considered the geographical centres for the spread of the Swedish wild boar population (Lemel 1999).

Increasing damage to agricultural land initiated a debate around the future existence of wild boar in Sweden. The Swedish government decided in 1980 that the wild boar in Sweden should be exterminated with the exception of two establishments in Tullgarn and Mörkö, situated on the border between the Stockholm and Södermanland counties. Between the years of 1979-1982 to 1983-1984, an increase of approximately 100 % was documented in this area, which did by that time harboured Sweden´s largest population of wild boar (Kristiansson 1986). In 1988 the Swedish government proclaimed that the wild boar should be considered a natural part of the Swedish fauna and the previous plan for the species extermination was therefore abandoned. The population of wild boar in Sweden is now growing steadily and the geographical distribution is increasing. The species is now established in the main parts of southern and central Sweden (Lemel 1999).

The spatial distribution of wild boar has been the subject of numerous scientific publications, and surveillance studies of the species have been performed on a vast number of sites across the world (Gabor 1999; Sodeikat 2002; Cousse 1995; Saunders 1999). Tracking of wild boar with GPS transmitters is a practical tool for accurate and precise documentation of activity and movement of the animals (Hulbert 2001; Baubet 2004). At the department of Animal Ecology, at the Swedish University of Agricultural Sciences in Umeå, a monitoring study of wild boar is performed with GPS collars. The transmitters are placed on wild boars located in the southern and eastern parts of Skåne County, nearly 1000 kilometres from Umeå. The movements of adult wild boars, primarily females that have been recognised as leaders of social groups are documented by repeated transmissions of coordinates. Members of a family group of wild boars tend to stay in close connection to the leading sow (Pohlmeyer 2003). Therefore, tracking the movements of the leader sow of a family group gives the opportunity to conduct indirect surveillance of several individuals by the use of a single GPS transmitter.

However, not all wild boars move in stable groups, and even the family groups are prone to compositional change (Lemel 1999). Also, the use of GPS-transmitters on animals is a method that is rather expensive and demands technically advanced equipment. Therefore, this method is primarily available only for scientific projects by universities or larger companies. The average hunter or landowner is not likely to be able to use the method for monitoring populations or individuals on their premises.

A possibility for indirect surveillance of the spatial activity of numerous animals within a common area is provided by the bait-marking method. Indigestible markers placed in outlaid bait at a feeding site can give information of the movements of animals visiting the feeding site, as the markers are recollected from faecal dropping (Delahay 2000). The bait-

marking method is a well-established method applied in ecological research and wildlife management issues regarding the European badger *Meles meles*. For studies of European badgers that used bait-marking, the most commonly used type of markers are indigestible plastic pellets (Delahay *et al*. 2000; Tuyttens *et al.* 2001; Woodroffe *et al* 2006). This method has also been used for monitoring of other species such as red fox *Vulpes vulpes* and raven *Corvus corax* (Webbon *et al*. 2004; Rösner 2005). Chemical compounds of various types are other sorts of ingestible markers that can be used for studies comprising the bait-marking method. Iophenoxic acid may serve as a systemic blood marker, a method that has been performed in bait-marking studies on a wide range of animal species (Spurr 2002; Ogilvie 1998).

The bait-marking method has, to my knowledge, not been used in studies of wild boar. However, a similar type of method has been evaluated as a means to deliver oral vaccines to wild boar. This test implied that setting out bait may serve as an effective method for delivering ingestible objects to the vast majority of individuals within a population of wild boar (Fletcher 1990). The bait-marking method may comprise a low-cost and technically uncomplicated means for monitoring the movements and habits of wild boar. This makes the method useful as a tool for large-scale, advanced monitoring projects as well as for the management of wildlife performed by the local farmer or hunter.

Purpose and aim

In this study, the possibility of applying the bait-marking method on wild boar is tested and evaluated as a complementary method of surveying wild boar movement with GPS transmitters. The study can be regarded as a pilot study for a more widespread use of the method. The use of feeding stations and fields popular for feeding by wild boars is examined as a means to document their movements and habits. The method is evaluated and the following hypotheses are tested:

a) Sites used for supplementary feeding of wild boars will be visited by pigs associated with several different home ranges

b) Fields popular for food search by wild boars will be visited by pigs associated with several different home ranges

In addition, the bait-marking method as described in this study is predicted to be a suitable method for surveillance studies of wild boars´ spatial activity.

Material and methods

The study area

The field research was conducted on domains comprised to the Högestad and Christinehof estate, situated in Skåne County in southern Sweden (Fig 1). Being the southernmost landscape in Sweden, Skåne has the highest annual mean temperature in the country. The temperature varies over the year from between 0°C and -2°C in January to between 17°C and 15°C in July. Annual mean precipitation in the Skåne County ranges from 500-1000 mm. The above numbers are average values from the period 1961-1990 (Vedin 2003). Topography in the area is characterized by a gently rolling landscape with a mosaic of open fields and forest.

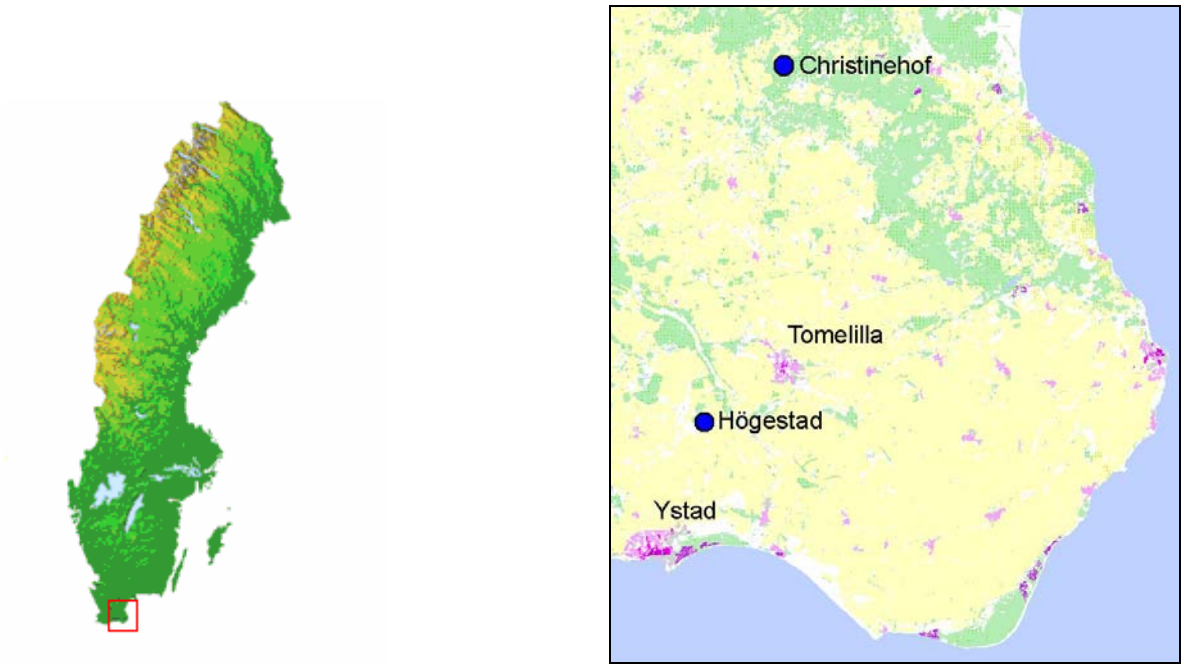


Figure 1. Location of the study area in southern Sweden.

The estate consists of some 13 000 ha of forest and agricultural land of which slightly less than 7000 ha is productive forest area, the main part of the coniferous forest is located around the Christinehof estate. Deciduous forest is the dominant forest type around Högestad, the most common tree species being European oak *Querqus robur* and beech *Fagus sylvatica*. The coniferous tree species are on the Högestad & Christinehof estate represented by Norway spruce *Picea abies*, Scots pine *Pinus sylvestris* and European larch *Larix deciduas*. The remaining part of the estate is agricultural land, mainly concentrated within the Högestad estate. Some 6000 ha of the Högestad & Christinehof estate constitute cultivation areas and pasture land, supporting a stock of cattle of approximately 250 animals. The main type of crops that are cultivated on the estate consists of different sorts of grain such as wheat, rye and barley, as well as of rapeseed and sugar beats. The estate is managed as part of the Högestad & Christinehof joint-stock company that was established in 1999. The estate itself, however has existed since its foundation by the countess Cristina Piper in 1749. In practice, the agricultural regions and forest areas of the estate are managed by the administrative company Högestad & Christinehof Förvaltnings AB (Comp. pres. HCF AB).

Natural predators of wild boar are absent in the area but hunting of boar is practiced on a yearly basis. Drive hunts are performed during autumn and winter, from the month of October to February. Annual hunting statistics vary: 46 pigs were shot during 2005, approximately 70 in 2004 and approximately 80 during the hunt of 2003. The yearly hunting bag is adjusted to the estimated level of the wild boar population on the estate. To minimize the stress imposed on the wild boars, hunting is performed with a rather high intensity during a short period of time. According to information provided by hunters at the Högestad estate, no hunting of boars at feeding sites had been performed for several months prior to the initiation of the bait-marking study of 2006 (pers. comm. A. Jonsson).

The wild boar in Western Europe is omnivorous although the main part of their diet consists of vegetable foods. Agricultural crops constitute a considerable part of the vegetable diet of wild boar (Schley 2003, Groot Bruinderink 1994, Durio 1995). The wild boar is known to cause damage to agricultural land, commonly through rooting or direct feeding on crops (Wilson 2004, Wilson 2005, Schley 2000). Several methods for reducing wild boar damage to agricultural and silvicultural land have been developed and are currently in use, such as supplementary feeding, fencing and hunting (Geisser 2004, Debernardi (1995). Setting out supplementary food has proven to be an effective method for reducing wild boar damage to crops. The pigs will be attracted to the feeding sites rather than to the agricultural areas (Calenge 2004).

As a means to reduce wild boar damage to agricultural areas, supplemental food is set out on a weekly basis at several feeding sites on the Högestad and Christinehof estate. These feeding sites are located separate from the cultivated areas that are prone to damage from wild boars, and often lie close to high vegetation that offers protection for visiting boars. Wheat is spread over feeding sites with the help of machines normally used to distribute artificial fertilizer (rather than in piles), in order to increase the time wild boars spend in searching for food at feeding sites. Sugar beats are used during autumn to spring, depending on harvest dates and amounts. Annually, approximately 35 tonnes of wheat and 150 tonnes of sugar beats are spread on the Högestad estate alone. At the Christinehof estate (with larger forested areas and a smaller amount of cultivated land), the amounts of supplemental food vary between approximately 30-40 tonnes of wheat per year (pers. comm. A. Jonsson).

The field research for the bait-marking study on the Högestad estate was conducted in 2006, during the periods of April 21-May 5th and September 26th-October 6th. The study was set on six feeding sites, which were originally set up and used by the estate management. In addition, six pasture fields on the estate were included in the study. The six fields and feeding sites were all chosen due to a high observed rate of wild boar activities at these sites as reported by the estate staff. The six feeding sites are geographically situated in a pair wise manner, in terms of in-between distances. The paired sites 1 and 4 are separated by 550 m, 560 m between sites 2 and 5, while sites 3 and 6 are separated by 1270 m (Fig. 2).

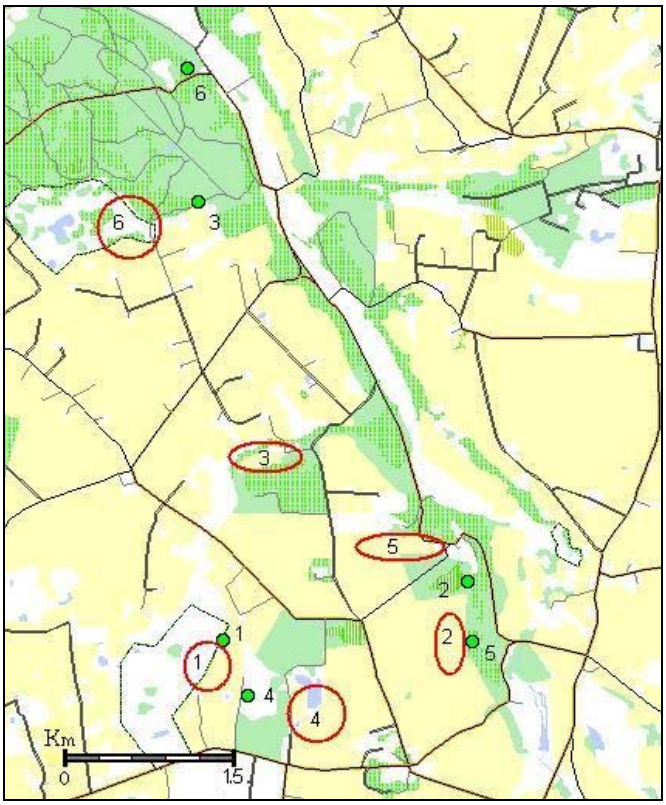


Figure 2. Map of the study area within the Högestad estate with an illustration of the feeding sites and pasture fields. Feeding sites are marked as dots and identified by numbers one to six. The fields are denoted by circles or ellipses, identified by numbers one to six.

Field methods

On each feeding site, a procedure of study was repeated six times during the two study periods, resulting in a total of twelve bait stations per site. During daytime, each site was prepared with a mixture of bait and markers. The bait consisted of whole wheat-grains which is the type of forage that is being spread on the sites by the land administrators of the Högestad and Christinehof estate. For each feeding site, ten litres of wheat was thoroughly mixed with one litre of markers and approximately five to ten litres of water in a plastic bucket. The adding of water made the mixture aggregate to some extent and was made as an attempt to complicate any efforts the wild boars might make to separate the bait from the markers. Separate buckets were used for each colour of markers to avoid any mix-up of markers. On each feeding site, the mixture was divided and placed in ten piles with approximately one litre in each pile (Fig. 3a-3c).

In this survey, a type of plastic beads sold commercially in toy stores was used as markers. These beads are of cylindrical shape, approximately 3 mm in diameter and 5mm long. They are available in a large variety of different colours, available at many toy-stores and supermarkets. The plastic is of a soft, non-toxic type, viscous enough not to brake when the boars chew the beads. Previous to the study, the beads were tested on wild boars kept in an enclosure. Markers mixed with bait was offered to four adult pigs, and at a visit to the enclosure 20 hours later, several faecal piles containing markers were found. These markers showed no alterations in colour, and seemed to have passed unaffected through the wild boar digestion system.

Figure 3a-3c. To the left: Plastic bottles containing the markers of six different colours used during the bait-marking study of 2006. In the middle: Plastic buckets filled with whole-wheat grain mixed with three types of coloured markers. To the right: A mixture of bait and markers spread over feeding site 1 in ten piles, with an separation distance of approximately one metre.

An examination of each feeding site was conducted repeatedly during every day following deployment of bait. The grounds surrounding the feeding sites were searched for wild boar faeces, up to a distance of approximately 30 metres. An approximate time of 30 minutes was spent searching each feeding site during every occasion. Each pile of wild boar faeces that was discovered on the searched areas was examined and findings of markers in faeces were noted. Due to relatively large areas of the six pasture fields and a limited amount of time during the field research, there could be no daily search for markers on the fields. Instead, each field was searched at the end of each study period. Following every setting out of bait, each feeding site was revisited during evening as studies of wild boar activity at the sites were conducted. For the search of each field, no time frame was determined for each search session. Instead, the search was adapted to the size of every field and the search was finished when all parts of the area were covered. During the springtime study, the evening surveillances of the feeding sites took place from 8pm to 11pm, and during the autumn study from 7pm to 10 pm. This was made as an attempt to adjust the observation periods to the three hours following sunset. The wild boar is a nocturnal species and the main activity takes place between sunset and sunrise. The initiation of the activity of wild boars has been found to correlate well to the sunset (Truvé 2004, Lemel 1999). Three persons conducted the night surveillances that were performed at fields and feeding sites. The pigs were studied by one person at each site, placed on a distance of approximately 40-70 metres from the feeding site. To make observations during night, red searchlights were used. The numbers of wild boar visiting the sites were noted, along with notes of time and behaviour.

Some alterations in the field methods were made between spring and autumn. During the study in spring 2006, three persons were available for the evening observations of pigs at the feeding sites and fields. The springtime study was performed during 14 days, and each feeding site and field was prone to observation during three evenings per location. Only three types of coloured markers were used, as bait was laid out on feeding sites 1, 2 and 3 during the first six days of this study. During the following six days the same study was repeated on the three remaining feeding sites. The feeding sites may be divided into three pairs by the aspect of their localities. The two sites within each pair lie in such close connection, that an assumption was made that the same individual wild boars would visit both sites. Therefore, the same colour of beads was used for both of the feeding sites in each pair during the springtime period. The aim of this method was to serve the bait to as

many individuals as possible within an area. During the autumn period, each of the six feeding sites was prepared with markers of an exclusive colour for each site. The search for markers at feeding sites was increased during the autumn study, and each site was then searched during seven occasions. The study that was performed during autumn took place during a shorter period of days and with only one person conducting the evening observations at the feeding sites. No surveillance at night on the six pasture fields was made during this part of the study. Also, the fields were searched on two occasions for markers in the spring, but only one search per field was made during autumn 2006.

Implications of the bait-marking study

The bait-marking study of 2006 was conducted during two seasons, April-May and September-October. Differing environmental conditions between the two periods were certainly evident. Any differences in the results of these two parts of the study might thus have been inflicted by differing conditions in the study area. Differences in vegetation on each of the feeding sites and fields are definitely one factor to consider, but other features may also differ between the seasons. To evaluate the rate of inflict on the result the chosen study period may constitute, results from the autumn study of 2006 is compared to results from the springtime study. For this evaluation, the amount of recovered faecal piles containing markers during each study period were chosen as a suitable way to compare the success of the method. The percentage of occasions when piles with markers were found during every search were compared for the two periods. To establish if any significant difference occurred between spring and autumn, a Chi-square test for two independent samples was made (Siegel 1988).

Coordinate transmissions

Information on the spatial activity among wild boars at and near the study area was provided by the wild boar project at the Department of Animal Ecology. Since the initiation of the project in 2004, a number of adult wild boars have been equipped with GPS-transmitters, sending transmissions of coordinates every half hour. Boars were sedated by the use of tranquilizer guns either on harvested crop fields or in stands situated closely to a feeding site (pers. comm. P-A Åhlén). With the exception of two adult solitary males, all animals included in this project up to the end of 2006 are females that have been identified as likely being the leading sows of family groups. The identification of a sow's status as the group leader was based first and foremost on size, but in addition, her position within the formation of a group was very important. The capture of boars was performed from cars used to follow a darted boar until the animal was sedated. There were good opportunities to study group formation during the boar's attempted escapes, and thus provided an opportunity to identify the leading sow (pers. comm. P-A Åhlén). Besides the wild boars at the Högestad and Christinehof estate, one adult sow located in the Bogesund area (situated east of Stockholm), and one adult male boar located at Öster-Malma, Södermanland County, are also included in the project.

Home range analyses

Home range sizes and positions were estimated by use of GPS coordinates transmitted during the seasons of April 20-May 5 and September 20-October 5 for the years 2004-2006. To maximize the dataset, transmissions from all functioning GPS-collars in use

between the initiations of the project in the autumn of 2004, up to the autumn of 2006 were included. Only the transmissions with a DOP-value (Dilution Of Position) less than or equal to five was included. To exclude information from malfunctioning transmitters, I used a minimum sample size of 100 transmissions for each season. A total of 20 transmission sets descending from the GPS-collars of 14 individual wild boars were used for the home range analyses (Table 6). One exception to the periods of dates was made for the spring period of the pig *Hanna*, whose GPS-collar initiated sending coordinates on the 17th of May. To obtain a required data set of 20 days, transmissions from this date and up to the fist of June were included. For the statistical analyses of the information provided from the SLU wild boar project, as for the results of the bait marking study, non-parametric tests suitable for small-sized data sets were used (Siegel 1988).

Kernel methods provide nonparametric estimations of an animal's utilization distribution from a random sample set of coordinates stating the animal's location. After smoothing the location data by a fixed factor, a line is drawn around a chosen percentage of the locations. In this study, home range analyses were made in the Arc Map 9.1 program by using kernel analysis in Hawth´s Tools. A fixed Kernel density test with a single parameter smoothing factor of 1000 and a 95% contour was performed to determine home range sizes (Worton 1989).

Seasonal variations in home range size

As mentioned in the section 2.3, the results of the analysis may be affected by factors differing between the study seasons. Any alterations in the behaviour of the wild boars could affect the results. To establish if any behavioural differences were significant for the wild boars between autumn and spring, home range sizes of the two periods were compared. The home ranges of wild boar might vary in size depending on characteristics of the individuals that inhabits the area, as well as on factors such as climate conditions, disturbance and food availability (Boitani 1994, Spitz 1995). It has been argued that the home range size of a wild boar is dependent upon the sex of the individual. Some research results points to population density and individual attributes such as body mass of the animals as important factors affecting home range size (Saunders 1999). To avoid any confounding of such variables, when comparing home range size, I used pair-wise tests to compare the same individuals in spring and autumn. A comparison between home range sizes of spring and autumn was made for all sows bearing transmitters whose dates of transmissions covered both one spring and one summer period. To determine if any significant difference in home range sizes occurred between autumn and spring, a binomial test was performed (Siegel 1988).

Home range overlaps

An estimation of home range overlaps in the area where the bait-marking study was performed provides background information of territorial behaviour of the wild boars in the specific area. This may give a general idea of what results that can be expected from the bait-marking study and evaluate whether the results from the study seem reliable. Home range overlaps for wild boars ranging within the Högestad estate were calculated to gain knowledge of the behaviour of territoriality between groups of individuals that were possible subjects of the bait-marking study. The amount of collected coordinate transmissions of the wild boars differed substantially over time. For the spring period of 2005 only one wild boar wore a functioning GPS-transmitter. The following spring period of 2006, three functioning transmitters were in use within the premises of the Högestad

estate. This was not considered a large enough set of data to perform a reliable analysis of home range overlap. Therefore only the data sets from the autumn periods of 2005 and 2006 were included in the analysis of territoriality between family groups at the estate. The GPS-collars only report the whereabouts of a fraction of the total population of wild boar ranging within the Högestad estate because most animals are unmarked. Therefore, a calculation of mean overlap between family groups would not be representative of the actual conditions. Instead, a pair wise measurement of home range overlap for every individual may be more informative. The overlapping areas of home ranges were calculated using the Intersect-routine of Arc View.

Results

Spring 2006

Observations at feeding sites and fields

At the six feeding sites at the Högestad estate in April to May 2006, a total of 217 wild boars were observed during evening surveillances. Feeding stations 1, 4 and 6 were visited by boars on all of the three nights of surveillance for each site. For the remaining three feeding sites, wild boars were observed during two out of three nights on the sites 2 and 3, while no boars at all were spotted at site 5 (Table 2a-2b). During the bait-marking study in spring 2006, the bait was consumed at every occasion when boars were observed at a feeding site. Competition at the feeding sites occurred as several members of the same social group were feeding from the bait. Signs of aggression within groups of wild boars were documented at a number of occasions during the study, as one or several individuals were chased from the feeding site by one or several other boars. The individual that was chased from the site often returned within seconds and continued to eat from the bait. On a few occasions the feeding sites could be visited by a large number of pigs, as several different groups arrived at a site. Direct aggressions between groups at a feeding site were not observed, but in some occasions, one group of boars left the feeding site immediately when another group arrived at the site. More often, several groups remained together at the same feeding site. In these cases, it was sometimes evident that only some of the individuals at the site ate the bait with markers, while other pigs situated their food search in the periphery of the feeding site.

During several occasions, there were occurrences of other animal species at the feeding sites. On a number of occasions the piles of bait and markers had already been consumed when the observation session at a feeding site was initiated. Other than wild boar, the most common visitor at the feeding sites was fallow deer *(Dama dama)* and roe deer (*Capreolus capreolus*). Large herds of fallow deer were spotted several times near the feeding sites 3, 4 and 5. In addition, both roe deer and fallow deer were observed while eating from the bait at several feeding sites during the study. On the six pasture fields, the activity rate of pigs also varied among the sites. At fields 1 and 3, pigs were observed during all three nights of observation. Wild boars were observed during one out of three nights on field 2. In addition, observations of pigs were made on each of the three nights of surveillance on field 4 and 5, while no pigs at all were seen on field 6. During the 18 occasions of night surveillance at the six fields, 178 pigs were observed. The most common activity among

wild boars that was observed at the fields was rooting. This was in some cases also evident as large proportions of the surface of the fields were disturbed by the rooting.

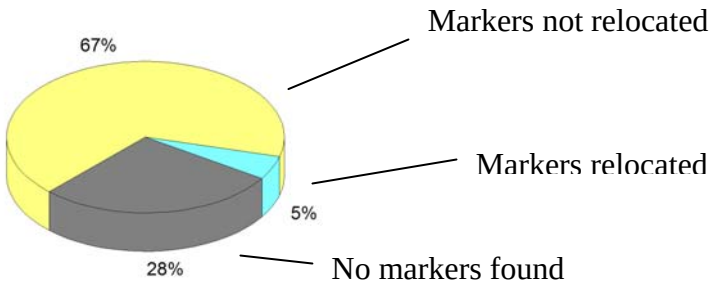


Figure 4. The result of the 39 search sessions that were conducted at feeding sites during the study period in spring 2006. The graph shows the outcome of the search session as the percentage parts of three possible scenarios: no findings of markers, findings of markers that had not been moved between distant feeding sites and findings of relocated markers.

Recovered markers

Markers in pig faeces were discovered on 28 of the 39 occasions of examinations of the six feeding sites used in the study on the Högestad estate in Skåne between April 22nd and May 5th. At 28 % of the occasions, no markers were found in pig faeces. During 67% of the search sessions, markers in pig faeces were found at the same feeding site as where it had previously been set out. Finally, during 5% of the occasions, markers were found at an feeding site other than where this particular coloured marker was provided (Fig. 4). Markers were found at every occasion when the feeding sites 1, 4 and 6 were searched for faecal piles containing markers. On feeding site 2, no markers were found at five occasions, but not during the first search at the site or during the last search that was performed six days after the last use of marked bait at the site. Markers in faecal piles were recovered just once at feeding site 3 and during three of the search sessions at site 5. During the study, most of the recovered markers were found at the same feeding site as where it had been set out, with a few exceptions. At the feeding site 2, where red markers were set out during the study, pig faeces with yellow markers were observed. Faecal piles containing red markers were found at feeding site 5, where yellow markers were set out. No findings of pig faeces containing markers were made on any of the six pasture fields, which were surveyed during the study.

Figure 4a-4b. To the left: view of field 3 during the time of the study period in spring 2006, showing traces of activity of rooting by wild boars. To the right: a pile of wild boar faeces containing several visible markers, as indicated by the arrows.

Autumn 2006

Observations of pigs

For the bait-marking study in the autumn of 2006, fewer evening surveillances can be presented. On the six feeding sites, pigs were observed during five of the six occasions of surveillance and a total of 60 pigs were seen. Only feeding site 3b was unvisited by boars at the night of surveillance of the site. No evening surveillances of the six pasture fields can be presented, but all three fields were searched once for markers in faecal piles at the end of the study period. Due to the lack of direct observations of wild boars at the fields, other indications of the presence of pigs were sought. Signs of rooting or trampling from wild boars were noted on all studied fields, in some cases at considerable rates (Fig 4a). Provided that the bait had not been consumed first by other species, I observed that wild boar always consumed marked food when they visited the site.

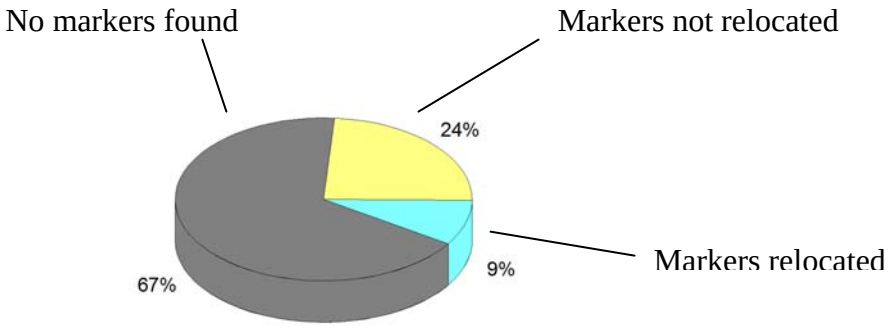


Figure 5. The result of the 42 search sessions that were conducted at feeding sites during the study period in autumn 2006. The graph shows the outcome of the search session as the percentage parts of three possible scenarios: no findings of markers, findings of markers that had not been moved between distant feeding sites and findings of relocated markers.

Recovered markers

As in the case of the study period of April-May, no markers were found at any occasion on the six fields. At the feeding sites, there were several findings of markers in wild boar faeces, but these findings were fewer than during the spring part of the study. At 67 % of the occasions, no markers were found in pig faeces. During 24% of the search sessions, markers in pig faeces were found at the same feeding site as where it had previously been set out. Finally, during 9 % of the occasions, I found markers at a feeding site other than the one were this particular marker was used (Fig. 5). At the feeding site 3, no markers were recovered in faeces and at feeding site 6, markers were recovered during only one of the seven searches of the site. Markers in wild boar faeces were found during two occasions on the feeding sites 1 and 5, and during four occasions at feeding site 2. At feeding site 4, markers were recovered during five out of seven occasions of search. Since the feeding sites 1 and 4 were situated with an in between distance of a few hundred meters, this was expected, as well as for the two feeding sites 2 and 5. However, markers deriving from sites 2 and 5 were found at sites 1 and 4, and markers deriving from site 1 were found at feeding site 2. In total, markers were found in 33% percent of the search sessions at feeding sites during autumn.

Because of the close geographical distance between the feeding sites 1-4, 2-5 and 3-6, a mix of the markers of yellow-white, red-orange and blue-green was expected. Any such event was therefore not noted as an actual relocation of markers. Such mix of colours appeared at four of the paired sites, but not at the sites 3 and 6. A mixing of different coloured markers occurred in wild boar faeces at some occasions. On the first of October, one pile of faeces containing yellow and orange droppings was found along with one pile containing yellow, orange and red markers.

Seasonal variations in home range size

The calculated home range sizes of the 20 wild boars included in the study varied between 2203 and 1039 hectares. Mean home range size during springtime periods was 1477 ha, St. Dev. = 579 and mean home range size for the autumn was 1697 ha, St. Dev. = 651. If the home ranges of the two male boars are excluded, the mean spring value of females is 1226 ha, St. Dev. = 228 and the mean autumn value for females is 1735 ha, St. Dev. = 669.

A significant difference in home range size between the spring and autumn periods was evident ($p = 0.03$) for the five sows whose GPS-transmitters had provided information for both one spring and one autumn coordinate set. All the five sows had a springtime home range that was of a smaller size compared to the autumn home range (Table I).

Table 1. Information of the wild boars that wore functioning GPS-transmitter collars during the period of autumn 2004 - autumn 2006. In the column that states the season of transmission for each individual, "A" stands for autumn and "S" for spring. The letter "F" and "M" indicate gender in the "Sex" column. The areas presented in this table indicate the locations of the home ranges of each wild boar. Here, "H" stands for the Högestad estate and "Ch" for the Christinehof estate. The sow Christina is located at the Bogesund area (Bog) near Stockholm, and the boar Leif ranges at Öster-Malma (Öst) in the Södermanland County.

ID/ name	Season of transmissions	Sex	Area	Home range size (ha)	No. Positions
Amanda	A -05	F	Ch	2203	464
Anna	A -05	F	Ch/H	2669	539
Anne	A -05	F	H	2217	408
Anne	S -06	F	H	1644	290
AnneMai	A -06	F	Ch	1191	554
Christina	A -05	F	Bog	2942	306
Christina	S -06	F	Bog	1214	382
Hanna	A -06	F	H	1348	553
Hanna	S -06	F	H	946	610
Håkan	S -06	M	H	1700	433
Leif	S -06	M	Öst	2764	458
Leif	A -06	M	Öst	1276	415
Lena	A -05	F	Ch	1221	528
Lena	S -06	F	Ch	1202	451
Marlene	A -05	F	H	1273	260
Mia	S -05	F	H	1180	416
Mia	A -05	F	H	1782	391
Mikaela	A -05	F	H	1207	419
Märta	S -05	F	Ch	1169	376
VB	A -05	F	H	1039	352

Home range overlap

Transmissions from sows ranging within the Högestad estate during autumn periods provided a total data set of seven home ranges and 9 cases of overlap. Five transmitters were sending coordinates during autumn 2005, the remaining two during the following autumn of 2006. Percentage overlap of home ranges within each pair of sows was highly variable, spanning a range from 0.02% to 84%. Each of the five home ranges of autumn 2006 overlapped with more than one other home range. The two sows *Anne* and *Marlene* had home ranges overlapping with the ranges of four other sows. *VB* and *Mikaela* each had two overlapping areas in their home ranges, while the home range of the sow *Mia* overlapped with two other ranges (Table 2, Fig. 6a-6b).

Table 2. Calculation of the overlapping areas of the home ranges of seven sows ranging within the Högestad estate during the autumn study periods of 2005 and 2006.

Season A -05	**Overlap area (ha)**	**Percent overlap of total home range area**			
Anne/Marlene	1064	Anne	48%	Marlene	84%
Anne/Mia	288	Anne	13%	Mia	16%
Anne/Mikaela	92	Anne	4%	Mikaela	8%
Anne/VB	393	Anne	18%	VB	38%
Marlene/Mia	280	Marlene	22%	Mia	16%
Marlene/VB	436	Marlene	34%	VB	42%
Marlene/Mikaela	0.3	Marlene	0.02%	Mikaela	0.02%
Mikaela/VB	367	Mikaela	30%	VB	35%
Season A-06					
AnneMai/Hanna	961	AnneMai	81%	Hanna	71%

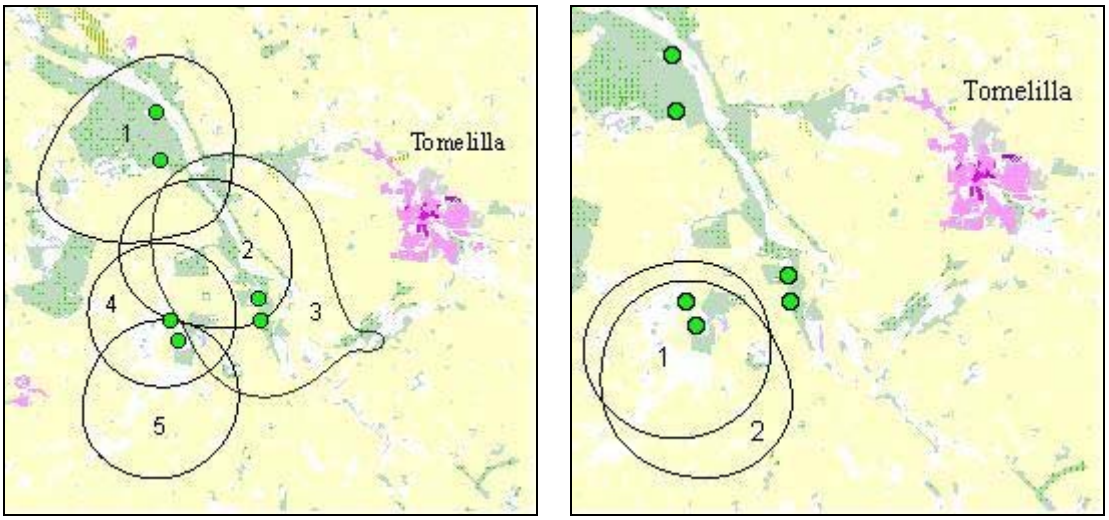


Figure 6a-6b. Maps showing the home range positions and overlaps of the wild boars at the Högestad estate wearing GPS-collars during the autumn periods of 2005 (to the left) and 2006 (to the right). The identities of the seven sows wearing the transmitters are presented by numbers at the maps. To the left: 1-*Mia*, 2-*Marlene*, 3-*Anne*, 4-*VB*, 5-*Mikaela*. To the right: 1-*AnneMai*, 2-*Hanna*. The six feeding sites used during the study are shown as circles.

Discussion

Method success

Delivery of markers to wild boars
An evaluation of the bait-marking method as a means to survey movements of wild boar can be made through measuring the success in delivering the oral markers to the animals, and to later recover the markers in faeces. The method for delivery of markers to wild boars proved to be quite functional. The beads used as ingestible markers were useful for many reasons. They are easily accessible since these beads are a common and wide-spread product on the market. In addition, these beads are relatively cheap when purchased in larger quantities from wholesalers. Furthermore, there were no visible sign that pigs would sort out markers from wheat grain while feeding on the set out bait. Some markers along with some of the wheat grain were left at every occasion on feeding sites when pigs had fed on the bait, but the proportion of markers to wheat grain did not seem greater than before pigs had visited a feeding site. Markers found in pig faeces were seemingly unaffected by the pigs digestion system. The colour of the beads remained unchanged and no other visible effect such as digestion of the plastic was noted during the study. The beads were also highly visible and thus easily detected in the faeces during investigations of faecal piles.

The choice of whole grain wheat as bait appears suitable since it was never observed to be rejected by any pigs, neither during the field study nor at the trial session on captive wild boars. At every occasion when pigs had been seen in the evening at a feeding site where bait had been set out, the bait had been mostly consumed when examination of the feeding site was conducted during the following day. On a few occasions, small pilings of chewed beads were found at or near the feeding sites. This might possibly come from some markers sticking to the teeth of wild boars during ingestion of bait.

Although the bait proved suitable for the study method, some failures to deliver markers to wild boars were evident during the study. On the feeding place 3a, partially consumed or untouched piles of bait were found during examination of the area on each day following the set-out of bait, with an exception of May 28. Pigs had been observed at this feeding place on the night before this date, for the first time during the study. Piles of unconsumed bait were also seen at the feeding place 5 on the 29th and 30th of April, dates that followed evenings of surveillance of the feeding site when no pigs had been observed at this site (Table 2). It can be argued that bait remaining at these feeding sites may come as a result of a low visitation frequency of wild boars at this site. Partially consumed piles of markers were discovered on some occasions as observers arrived at a feeding site to initiate a night surveillance of the site. Often, this occurred simultaneously with observations of other species of ungulates at or near the site. In all cases of observations of wild boars at a feeding site, a pile of bait was never left untouched or partially consumed at examinations of the site on the following day.

The European wild boar is a social animal, living in groups that are highly variable in terms of numerical size and the composition of sexes and ages within a group. The mean group size of wild boar in Western Europe has been measured to approximately 3-5 individuals although this has been documented to vary widely (Gabor 1999, Kristiansson 1986). Large groupings of animals were also observed on several of the feeding sites and up to 47 pigs were noted at the same night on a site during this study. As a feeding site for wild boar can

be expected to experience a large number of animals at the same time, the bait should be set in such a way that a many individual pigs can gain access to it at once and thus minimize competition for the marked food. Competition between individuals within a group at a feeding site did not seem to cause any wild boar to be driven away from the bait for more than a few moments. However, as many groups of wild boars visited a site at the same time, it was noted that one group often occupied the feeding site, while other groups remained nearby. Therefore, a more extensive spreading of the bait could possibly improve the success of delivering markers to a larger number of individual boars.

Recovered markers

Comparing the springtime study to the autumn study, there was a significant difference between the rate of number of search sessions and the amount of recovered faecal piles containing markers at feeding sites. The method of search remained the same throughout the two study periods, but there were notably environmental differences between spring and autumn at the feeding sites. In reports of the bait-marking method performed on European badger, dense vegetation during summer was pointed out as a complicating factor (Delahay 2000). The search for faeces was complicated during autumn as dense ground vegetation covered parts of the feeding sites in September and October. High grasses and herbs made the detection of faeces harder, as a pile was sometimes not detected unless viewed from directly above. These conditions not only affected the rate of recovered markers, but also made the dating of the appearance each faecal pile more difficult.

The rate of recovered markers in wild boar faeces at the feeding sites varied within as well as among different sites. It was notable that not one discovery of markers in faeces was made at any of the fields included in the study. This was in spite of the short geographic distances to adjacent feeding sites that sometimes were evident (Fig 2). Traces of wild boar activity at the fields were obvious during both study periods. Direct observations of pigs were made during the springtime study, and traces of trampling and rooting were noted during both spring and autumn. Faecal piles were not found at every session of search at the fields, although some discoveries were made. These results may be the outcome of several possible scenarios. Since the fields comprise relatively large areas, a substantial search effort is needed to cover all parts of every field. The chance of finding every faecal pile within a radius of 30 m of a feeding site is certainly higher than compared to a search of a considerably larger pasture field with dense ground vegetation. During the evening observations of feeding sites and fields during the spring of 2006, more wild boars were seen at the feeding sites than on the fields. Supplementary feeding of wild boars has been found to be an effective method for decreasing damage to agricultural areas. The boars are attracted to the supplied food and will spend less time on food search at farmlands. This should in return result in an increased amount of wild boar faeces at and around feeding sites, and a lower amount on agricultural fields.

At two occasions during the springtime study, findings of faecal piles containing markers derived from another site were noted. This indicates movement of wild boars between feeding sites 1 and 4. It is not certain that any of these two discoveries had been overlooked at a search of the sites on a previous day, but if this is not the case, the piles will both have happened between May 2nd and 5th. There is then a possibility that these markers were the results from a visit of just one individual, or at least from one group of individuals and of one isolated event. During the autumn study, a mix of colours in the faecal piles found at feeding sites was noted at nine occasions. Five of these mixes of colours came from

movements of pigs between paired feeding sites, but in four cases, markers were moved between the feeding sites 1-4 and 2-5. Since the search for faeces was complicated by dense ground vegetation, dating of these can only be speculative. The fact that faeces containing markers of several colours were found at five different occasions at four sites, might thus indicate either that movements between these sites were undertaken by several different individuals, and possibly at more than one occasion.

Average ranging distances for Swedish wild boars have been measured to seven kilometres during one session of activity (Lemel 1999). Adult males show a more extensive pattern of spatial activity than family groups. Females with piglets move over short distances relative to other group types and show a repetitive spatial behaviour, as they often return to a limited number of favourite sites within their home ranges (Janeau 1995, Spitz 1990). Resting areas are continuously used while feeding areas may be visited periodically as the abundance of food in different areas shifts with season of the year (Boitani 1994, Spitz 1995). It is impossible to determine what type of individual wild boar that had left behind each pile of faeces containing markers. However, it might be argued that there is a greater chance that the exchange of markers between feeding sites 1-4 and 2-5 that was observed during both of the two study periods at Högestad have been caused by groups known to have a wider ranging behaviour, than by groups that have a narrower observed ranging behaviour. On the other hand, the distance between feeding sites 1-4 and 2-5 was less than 2.25 km, a distance that would fit in to any of the measured home ranges for the sows at the Högestad estate.

The findings of markers that had been allocated between feeding sites 1-4 and 3-5 show that the hypothesis **a)** is correct. The results of the study confirm that feeding sites were visited by wild boars associated to several different home ranges. Hypothesis **b)** was not supported, as there were no findings of markers at any of the fields.

Home range analyses

Seasonal variations in home range sizes

Average home range estimations for wild boar in Sweden range between 300-400 hectares. Home range average size for family groups including piglets has been documented to vary between 800-1700 hectares. The mentioned numbers are the result of an earlier performed Adaptive Kernel home range analysis conducted in the mid parts of Sweden (Lemel 1999). This analysis method is considered being more accurate than the fixed Kernel (Worton 1989). The main part of the collar-bearing wild boars participating in the SLU wild boar project are sows leading family groups. The calculated spring values of home range sizes for sows of 1226 ha and the autumn values of 1735 ha are in well accordance with the results of the study of 1999.

Difference in home range sizes and shape following season of the year has been documented in several studies of wild boar. These variations have been found to follow alterations in behaviour such as food search patterns, hunting pressure and sexual competition between males (Boitani 1994, Spitz 1995, Maillard 1995). The amount of food that is available for the boars is very important for the range of movement and activity. A poor food supply forces the animals to move and seek food over larger areas. Hence, supplementary feeding by landowners as an effort to limit agricultural damage or improve

hunting can result in decreased home range sizes (Geisser 2005). The results of this study should be viewed in the context of the prevailing conditions at the study sites during the time of the study. Setting out supplementary food is, as previously mentioned, done regularly on the Högestad and Christinehof estate. Masting periods of tree species bearing nuts, such as chestnut, oak and beech are identified as an important factor influencing wild boar food search behaviour (Boitani 1994; Geisser 2005; Groot Bruinderink 1995). As oak and beech are the two tree species dominating the forest areas of the Högestad estate, masting periods during autumn may well be an important factor affecting the observed home range adaptations.

Apart from variations in food availability, differing social behaviour of different seasons of the year will affect the spatial behaviour of wild boar. The most stable type of social structure among wild boar is the family herd consisting of one or several adult females and their sub adult offspring. The family herd is led by a matriarch -- an old and experienced sow (Pohlmeyer 2003). As juvenile pigs reach sexual maturity they separate from their family groups, often to disperse from their natal area. Males disperse at earlier ages; move over larger distances and to a greater extent than female wild boars (Truvé 2004). Such events of dispersal are one explanation for altered ranging behaviour in different seasons of the year, apart from the previously mentioned variations in home range sizes. Since the collar-bearing wild boars at the Högestad estate are almost exclusively represented by group-leading sows, the results derived from the GPS study may indicate a different ranging behaviour than what the results of the bait-marking study might suggest. Groups of young wild boars were observed at several occasions during night surveillances at feeding sites and fields at the Högestad estate.

Home range overlaps

It has been argued, that members of a social group move within a common home range that to a great extent is separate from the home ranges of adjacent groups (Boitani 1994). Home ranges of female wild boars overlap with those of other boars to a relatively great extent, while overlap between home ranges of male boars occurs to a lesser extent. This indicates a greater competitive behaviour among adult males, than among females (Gabor 1999, Janeau 1995). A low rate of territoriality among sows was indicated by the results of the home range overlap analysis performed as part of this study, since none of the pigs at Högestad during the autumns of 2005 and 2006 had exclusive home ranges. The home range overlap measurement at Högestad does however only show conditions of one season of the year. The home range overlap of male wild boars have been noted to decrease during winter, a pattern that follows the winter mating season that reaches a peak between November-March (Boitani 1994). Note however, that mating can sometimes occur in any season (births take place mostly in early spring to late summer, but can happen throughout the year) (Moretti 1995, Durio 1995, Boitani 1995). The previously discussed seasonal modifications of home range size may also result in variation in home range overlaps also for sows and family groups.

Implications for further methodological developments

The bait-marking method is certainly advantageous as a complementary study method for the direct surveillance method provided by GPS transmitters. No individual information is provided for the animals that are the subjects of a bait-marking study but in return, more wild boars within a population are included in the study. The coordinate transmissions of a

GPS transmitter gives direct information on location, but each transmitter gives direct information of only one individual. To further improve the method of delivering markers to a maximum number of individual pigs at a feeding site, the mode of bait placement at feeding sites should be improved if possible. Setting out bait in several clusters of piles at each site, with a distance of approximately 10-20 m between each cluster could improve the delivery success. This method would make the bait accessible to several groups of wild boars feeding simultaneously at a site. The influence of other animal species on the rate of marking wild boars via their food is unknown. The method of delivery of the markers to wild boars could be further improved if the bait is set out shortly before dusk at each site. This would decrease the risk that the markers might be consumed before any wild boars arrive at a feeding site, by animals that are active during daytime. The bait-marking study of 2006 was performed in a small scale in terms of both time period and replicates of feeding sites. To gain a broader knowledge of the habits of food search by wild boar at different feeding sites and to further evaluate the method, a more extensive study is recommended. By including more feeding sites in a study, detailed information in terms of ranging behaviour and food search can be gained.

Conclusions

My analysis suggests that the bait-marking method is cheap, easily conducted and effective in terms of success of delivering the markers to wild boar and recovering the markers from faecal piles. It is not a method for observation of individuals, but it can be a good method for studying movements between a feeding station and its surrounding areas.

My analysis also showed that some wild boar feeding sites on the Högestad estate are visited by pigs from several different home ranges. The main part of the recovered markers was however found within a short distance from where it was offered. No faecal piles containing markers were found at any of the fields that were included in the study. It could therefore not be established that these fields were the subjects of visits from wild boars associating to several different home ranges.

A significant difference in the rate of recovered markers was evident for the part of the study that was performed in April-May 2006, compared to the study period of September-October in the same year. Dense vegetation the autumn period complicated the search for faecal piles considerably. This result might however be affected by several other factors, such as the behaviour of the wild boars, and other animal species.

The home range sizes of wild boars was found to differ between spring and autumn, a result that is in accordance with several previous studies of the ranging behaviour of wild boar throughout the world. The test of the success rate of recovered markers during spring and autumn showed a significant difference between the two periods. Home range sizes were significantly larger during autumn compared to spring for sows leading family groups. Home range overlaps could only be presented for the autumn periods of 2005 and 2006, but the results indicated a low level of territoriality among sows at the Högestad estate.

Acknowledgements

First and foremost, I would like to thank my supervisors, Kjell Sjöberg, P-A Åhlén and Henrik Thurfjell at the department of Animal Ecology at the SLU in Umeå. Their support

and engagement during the process of my work has been a tremendous help. Furthermore, I am truly grateful for all the help that was provided the management and staff at the Högestad and Christinehof estate. Thank you Håkan, Hans, Björn and all other people at the estate for aiding me during my visits in Skåne! I would like to express my sincere gratitude to Andreas Jonsson, who made my fieldwork at Högestad possible by his incredible helpfulness and valuable words of advice. Åsa Söderberg and Maria Hovelius, thank you for your good company and your energetic spirit during the adventurous spring fieldwork, with its many dark and chilly hours of night watch. Mikael Tham enabled me to test my method by generously gaining me the access to his captive wild boars. Also, I would like to thank Count Carl Piper, for access to the land and the possibility to study wild boars, and the management and staff at Simontorp manor for allowing me to visit wild boars within their enclosures.

Finally, if wild boars were of a literate nature I would thank all the dear pigs at the Högestad estate for their friendly behaviour whenever they encountered a student walking alone in the dark woods of their territories, and for their grand appetite for coloured plastic beads!

References

Baubet, E., Brandt, S., Vassant, J., Gendner, J-P. & Klein, F. (2004). Can wild boar be surveyed using GPS? -Mem. Natl Inst. Polar Res., Spec. Issue. 58: 188-195.

Boitani, L., Mattei, L., Nonis, D. & Corsi, F. (1994). Spatial and activity patterns of wild boar in Tuscany, Italy. -J. Mamm. 75: 600-612.

Boitani, L., Trapanese, P. & Mattei, L. (1995). Demographic patterns of a wild boar (*Sus scrofa*) population in Tuscany, Italy. -J. Mamm. Ecol. 3: 197-201.

Callenge, C., Maillard, D., Fournier, P. & Fouque, C. (2004). Efficiency of spreading maize in the garrigues to reduce wild boar (*Sus scrofa*) damage to Mediterranean vineyards. - European J. Wildl. Research. 50: 112-120.

Company presentation HCF AB. (2004). Att leva av landskapet. En presentation av jord- och skogsbruksföretaget Högestad & Christinehof Förvaltnings AB.

Cousse, S., Janeau, G., Spitz, F. & Cargnelutti, B. (1995). Temporal ontogeny in the wild boar (*Sus scrofa* L.): A systemic point of view. -J. Mamm. Ecol. 3: 122-125.

Debernardi, P., Patriarca, E. & Sabidussi, R. (1995). Wild boar (*Sus scrofa*) control in regional park “La Mandria” (Piedmint, NW Italy). -J. Mamm. Ecol. 3: 237-240.

Delahay, R. J., Brown, J. A., Mallinson, P. J., Spyvee, P. D., Rogers, L. M. & Cheeseman, C. L. (2000). The use of marked bait in studies of the territorial organization of the European badger (*Meles meles*). -Mamm. Rev. 30: 73-87.

Durio, P., Fogliato, D., Perrone, A. & Tessarin, N. (1995). The autumn diet of the wild boar (*Sus scrofa*) in an Alpine valley. Preliminary results. -J. Mamm. Ecol. 3: 180-183.

Durio, P., Gallo Orsi, U., Macci, E. & Perrone, A. (1995). Structure and monthly distribution of a wild boar population living in mountainous environment. -J. Mamm. Ecol. 3: 202-203.

Fletcher, W. O., Creekmore, T. E., Smith, M. S. & Nettles, V. F. (1990). A field trial to determine the feasibility of delivering oral vaccines to wild swine. -J. Wildl. Diseases. 26: 502-510.

Gabor, T. M., Hellgren, E. C., Van Den Bussche, R. A. & Silvy, N. A. (1999). Demography, sociospatial behaviour and genetics of pigs in a semi-arid environment. -J. Zool. 247: 311-322.

Geisser, H., Reyer, H. E. (2004). Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boars. -J. Wildl. Manage. 68: 939-946.
Geisser, H. & Reyer, H-E. (2005). The influence of food and temperature on population density of wild boar *Sus scrofa* in the Thurgau (Switzerland). -J. Zool. 267: 89-96.
Groot Bruinderink, G. W. T. A, Hazebroek, E. (1994). Diet and condition of wild boar, *Sus scrofa scrofa*, without supplementary feeding. -J. Zool. 233: 631-648.
Hulbert, I. A. R. & French, J. (2001). The accuracy of GPS for wildlife telemetry and habitat mapping. -J. App. Ecol. 38: 869-878.
Janeau, G., Cargnelutti, B., Cousse, S., Hewison, M. & Spitz, F. (1995). Daily movement pattern variations in wild boar (*Sus scrofa* L.) -J. Mamm. Ecol. 3: 98-101.
Kristiansson, H. (1986). Vildsvinets biologi och skadegörelse. Naturvårdsverkets rapport 3239. (In Swedish)
Lemel, J. (1999). Populationstillväxt, dynamik och spridning hos vildsvinet, *Sus scrofa*, i mellersta Sverige. Slutrapport, forskningsavdelningen Svenska Jägareförbundet, Uppsala. (In Swedish)
Maillard, D., Fournier, P. (1995). Effects of shooting with hounds on size of resting range of wild boar (*Sus scrofa*) groups in Mediterranean habitat. -J. Mamm. Ecol. 3: 102-107.
Moretti, M. (1995). Birth distribution, structure and dynamics of a hunted mountain population of wild boar (*Sus scrofa*), Ticino, Switzerland. -J. Mamm. Ecol. 3: 192-196.
Ogilvie, S. C. & Eason, C. T. (1998). Evaluation of iophenoxix acid and rhodamine B for marking feral ferrets (*Mustela furo*). -N. Z. J. Zool. 25: 105-108.
Pohlmeyer, K & Sodeikat, G. (2003). Population dynamics and habitat use of wild boar in Lower Saxony. Workshop on CSF, Institute of Wildlife research at the School of Veterinary Medicine Hannover.
Rösner, S. & Selva, N. (2005). Use of the bait-marking method to estimate the territory size of scavenging birds: a case study on ravens *Corvus corax*. -Wildl. Biol. 11: 183-191.
Saunders, G. & McLeod, S. (1999). Predicting home range size from the body mass or population densities of feral pigs, *Sus scrofa* (Artiodactyla: Suidae). -Aus. J. Ecol. 24: 538-543.
Schley, L. (2000). The badger *Meles meles* and the wild boar *Sus scrofa*: Distribution and damage to agricultural crops in Luxembourg. Thesis submitted for the degree of Doctor of Philosophy, School of Biological Sciences, University of Sussex.
Schley, L., Roper, T. J. (2003). Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. -Mamm. Rev. 33: 43-56.
Sodeikat, G. & Pohlmeyer, K. (2002). Temporary home range modifications of wild boar family groups (*Sus scrofa* L.) caused by drive hunts in Lower Saxony (Germany) - Z. Jagdwiss. 48: Supplement, 161-166.
Spitz, F. & Janeau, G. (1990). Spatial strategies: an attempt to classify daily movements of wild boar. -Acta Theriologica. 35: 129-149.
Spitz, F., Janeau, G. (1995). Daily selection of habitat in wild boar (Sus scrofa). -J. Zool. 237: 423-434.
Spurr, E. B. (2002). Iophenoxix acid as a systemic blood marker for assessment of bait acceptance by stoats (*Mustela erminea*) and weasels (*Mustela nivalis*). -N. Z. J. Zool. 29: 135-142.

Truvé, J. (2004). Pigs in Space. Movement, dispersal and geographic expansion of wild boar (Sus scrofa) in Sweden. Doctoral thesis, Department of Applied Environmental Science, Göteborg University

Tuyttens, F. A. M., Long, B., Fawcett, T., Skinner, A., Brown, J. A., Cheeseman, C. L., Roddam, A. W. & MacDonald, D. W. (2001). Estimating group size and population density of Eurasian badgers *Meles meles* by quantifying latrine use. 38: 1114-1121.

Vedin, H. Skånes klimat. Sveriges landskapsklimat. Väder och vatten 2/2003, SMHI. [WWW-document]. http://www.smhi.se (In Swedish)

Webbon, C. C., Baker, P. J., & Harris, S. (2004). Faecal density counts for monitoring changes in red fox numbers in rural Britain. -J. Appl. Ecol. 41: 768-779.

Welander, J. (2000). Spatial and Temporal Dynamics of a Disturbance regime. Wild boar *Sus scrofa* and its effects on plant species diversity. -Silvestria 127

Wilson, C. J. (2004). Rooting damage to farmland in Dorset, southern England, caused by feral wild boar *Sus crofa*. -Mamm. Rev. 34: 331-335.

Wilson, C. J. (2005). Feral wild boar in England. A Report on behalf of Defra European Wildlife Division.

Woodroffe, R., Donnelly, C. A., Cox, D. R., Bourne, F. J., Cheeseman, C. L., Delahay, R. J., Gettinby, G., McInerney, J. P. & Morrison, W. I. (2006). Effects of culling on badger *Meles meles* spatial organization: implications for the control of bovine tuberculosis. -J. App. Ecol. 43: 1-10.

Worton, B.J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. -Ecology 70: 164-168.

Index of personal comments

Jonsson, Andreas. 2006. Wildlife management, Högestad

Åhlén, Per-Arne. 2006. Department of Animal Ecology, SLU Umeå

SVERIGES LANTBRUKSUNIVERSITET Skoglig zooekologi

Examensarbeten (under institutionsnamnet Viltekologi)

1993:1 Olsson, Ulf. Bopredation i olika häckningsbiotoper och dess betydelse för kullstorleken hos skogshöns.
1993:2 Jarnemo, Anders. Spegeluppfällning hos rådjur; signal till predator eller artfränder?
1993:3 Ericsson, Göran. The impact from hunting on moose movements.

1994:1 Seebaß, Armin. Habitat selection by common buzzards (*Buteo buteo L.*) in central Sweden.
1994:2 Blomquist, Sofia. The insect community on (*Salix phylicifolia L. X myrsinifolia*) Salisb.

1995:1 Hjelm, Birger. Barkgnag och övriga stamskador förorsakade av älg i tallplanteringar.

Examensarbeten (under institutionsnamnet Skoglig zooekologi)

1995:1 Lundin, Lilian. Source-sink dynamics: a study of bank vole, (*Clethrionomys glareolus*), in wet and dry forest habitats during 1990-1994.
1995:2 Lindberg, Niklas. Skogsstrukturens betydelse för mönster i nordligt boreala fågelsamhällen samt något om fåglars lämplighet som signalsystem för biologisk mångfald.

1996:1 Broman, Emil. Habitat- och födoval under försommaren hos älgkor (*Alces alces*).
1996:2 Olsson, Gert E. Movements, home ranges and habitat selection of mountain hares in a managed, boreal forest.
1996:3 Kullberg, Ylva. Biodiversity of spiders (*Arachnida, Araneae*) in a naturally fragmented boreal forest-wetland mosaic: Implications for theory of habitat fragmentation and nature reserve design.
1996:4 Östergren, Anders. Movements of a female lynx, (*Lynx lynx*), in Lappland during the early nursing season.
1996:5 Persson, Jens & Östergren, Anders. Järvens markeringsbeteende - en spårstudie.
1996:6 Bergman, Margareta. Interactions between insect and mammalian herbivores sharing a common food source.
1996:7 Persson, Jens. Vargars populationsdynamik - ett svenskt perspektiv.
1996:8 Villumsen, Anders. Dispersal and habitat selection by Muskrat (*Ondatra zibethicus L.*) in Sweden.

1997:1 Nordengren, Caroline. Environmental factors influencing seasonal migration of moose (*Alces alces*) in northern Sweden.
1997:2 Edman, Mattias. Avian habitat use of forest-mire edge in an old-growth forest-wetland mosaic in northern Sweden.
1997:3 Hägglund, Åsa. How beaver dams affect the fish fauna in boreal forest streams.
1997:4 Friberg, Urban. Habitat selection of Lesser White-fronted Goose, (*Anser erythropus*), during the breeding season in Northern Finland and Norway.
1997:5 Qian, Hao. Dynamics of small mammals populations in a naturally fragmented forest-wetland mosaic.
1997:6 Johansson, Fredrik. Kan ensilageutfodring vintertid minska betesskador orsakade av rådjur?
1997:7 Mårell, Anders. Interaktionen mellan järv och lodjur i Sarekområdet.
1997:8 Lindroth, Johan. Animal dispersal as an ecological phenomenon in relation to landscape structure and conservation.

1998:1 Hörnell, Maria. Bedsite and habitat selection by capercaillie (*Tetrao urogallus L.*) in central Sweden during summer.

1998:2 Rooke, Tuulikki. Responses to simulated browsing in five savanna shrubs.
1998:3 Engman, Maria C. Patterns of activity and movements in a female lynx, (*Lynx lynx*), during early nursing season in Lappland, northern Sweden.
1999:1 Sundström, David. Factors affecting tree recruitment of aspen (*Populus tremula*) in northern Sweden - the importance of browsing.
1999:2 Lodin, Lars. Morphological responses to simulated browsing on conifer seedlings and subsequent browsing by large herbivores.
1999:3 Dahl, Fredrik. Survival and spatial characteristics of wild and released mountain hares (*Lepus timidus*).
1999:4 Redin, Andreas. Effects of beaver dams on invertebrate drift in forest streams.

2000:1 Sjögren, Henrik. Composition and structure of woody vegetation in a semi-arid savanna with particular reference to browsing.
2000:2 Brodin, Tomas. How does natural fragmentation in an old-growth forest landscape affect the performance of the Siberian Jay?
2000:3 Näslund, Peter. Moose, (*Alces alces*) perception of aspen (*Populus tremula*) in a northern Swedish landscape – an applied test of aspen stands as patches.
2000:4 Granström, Åke. Sårbarhetsanalyser – vägledning eller vilseledning. Tillämpning vid förvaltning av björn, lo, järv och varg.
2000:5 Dahlgren, Jonas. Road fence, roads and habitat effects on moose (*Alces alces*) browsing on pine.
2000:6 Lund, Ulrica. Environmental influences on reproduction in moose (*Alces alces*).
2000:7 Karlsson, Sara. Älgskador i tallungskog.
2000:8 Ståhl, Per-Olof. An experimental evaluation of a method for the rapid assessment of browse availability to moose.
2000:9 Löfstrand, Ronny. Wolverine habitat selection- a GIS approach.
2000:10 McGuire, Rebecca. Dispersal and the inheritance of spatial and temporal movement patterns in moose: Following in mother´s footsteps?
2000:11 Hammarström, Angelica. Long time fluctuations of three willow grouse populations in Sweden.
2000:12 Roos, Henrik. The role of habitat complexity versus landscape structure in explaining boreal forest breeding bird assembly composition in northern Sweden.
2000:13 Almqvist, Lisa. Plant development and palatability to herbivores – are shoots from the top of trees more palatable to hares than shoots from the base?

2001:1 Adolphson, Karolina. Bird community responses to different levels of nature consideration measures on clear-cuts.
2001:2 Pettersson, Viktoria. The response of Scots pine (*Pinus sylvestris*) and pubescent birch (*Betula pubescens**) to fertilisation*: a test of the carbon nutrient balance hypothesis.
2001:3 Åhlén, P-A. The Parasitic and Commensal Fauna of the European Beaver (*Castor fiber*) in Sweden.
2001:4 Scheurer, Maik. Evaluation of habitat quality for moose (*Alces alces* L.) in northern Sweden.
2001:5 Jonsson, Anna. Moose movements in winter: barrier effects and fractal analyses.
2001:6 Zakrisson, Christer. Do brown bear (*Ursus arctos*) females with cubs alter their movement pattern in order to avoid infanticidal males?
2001:7 Högberg, Marianne. Three trophic interactions in the field layer of the boreal coniferous forest.
2001:8 Wiklund, Linda. Short-term effects of fire on beetles; diversity and community structure.
2001:9 Sahlin, Erik. Pyrophilous and saproxylic beetles three years after fire in northern Sweden.

2002:1 Bernhold, Andreas. Predicting distribution of forest birds in managed boreal forest, using GIS and remote sensing.
2002:2 Andersson, Johan. Characteristics of summer habitats used by capercaillie (*Tetrao urogallus*) females in the Mountain region of northern Sweden.

2002:3 Davidsson, Anders. Resting site patterns and hiding cover of female capercaillie (*Tetrao urogallus L.*) with or without brood in the Scandinavian mountain region – nocturnal perspective.
2002:4 Carlsson, Annica. Resting site patterns and hiding cover of female capercaillie (*Tetrao urogallus. L.*) with or without brood in the Scandinavian mountain region – diurnal perspective.
2002:5 Sandström, Frida. The effect of wildfire on flat bugs, *Aradidae* (Hemiptera, Heteroptera), in interior Alaska.
2002:6 Karlsson, Therese. Effects of dead wood quality on beetles (*Coleoptera*) in three forest types in northern Sweden.
2002:7 Johansson, Magnus. Effects of large mammalian herbivores in southern Sweden: responses in the invertebrate community.
2002:8 Norehag, Gunvor. The avifauna of summer farms in Klövsjö, central Sweden.
2002:9 Wikström, Therese. The influence of climate variation on the food quality of two important forage species for ungulates, pubescent birch (*Betula pubescens*) and fireweed (*Epilobium angustifolium*).
2002:10 Lans, Linnea. How browsing effect tree recruitment of aspen (*Populus tremula*) in central Sweden.
2002:11 Salomonsson, Daniel. Jaw morphology and long-lasting cohort effects among moose born in different years.

2003:1 Curros, Manuell. Ant colonisation in artificially disturbed forests.
2003:2 Constantinides, Anna. Effects of fire on invertebrates, especially insect species attracted to damaged and dead trees, in a boreal forest in interior Alaska.
2003:3 Stenbacka, Fredrik. Dead wood amounts and cambium utilization by saproxylic insects on boreal clear-cuts in northern Sweden: Edges and spatial distribution.
2003:4 Grundström, Hanna. Permanent snowmobile trails – effects on wildlife distribution.
2003:5 Bohlin, Jonas. Interspecific competition between ants in the boreal forest. – Testing a linear competition hierarchy model.
2003:6 Lindström, Elisabeth. Food quality in bilberry (*Vaccinium myrtillus*) and how it may affect moose (*Alces alces*) populations in boreal forests.

2004:1 Bohman, Petter. Saproxylic and pyrophilous beetles on prescribed burned clear-cuts in northern Sweden.
2004:2 Garpebring, Andreas. Saproxylic beetles on pine logs with *Antrodia xanta*.
2004:3 Landin, Jenny. Activity and movement patterns of the Siberian jay (*Perisoreus infaustus*) in relation to habitat fragmentation at the home range scale.
2004:4 Andersson, Eva-Stina. Effect of herbivory on aspen (*Populus tremula*) recruitment in relation to major disturbance.
2004:5 Nyqvist, Johan. Ecological possibilities for musk oxen (*Ovibos moschatus*) in the Swedish mountain range.
2004:6 Engvall, Hanna. Habitat selection in the Swedish mountain region by female Capercaillie (*Tetrao urogallus*), in relation to predator abundance.
2004:7 Kleemann, Holger Maximilian. Resource preference of European beaver (*Castor fiber L.*) related to felling activity in Southern Russian Karelia.
2004:8 Kohlmann, Daniel. Differences in home range size and quality between female moose with calves versus females without calves.

2005:1 Ohlanders, Nils. Modelling the risk for lynx depredation on livestock.
2005:2 Niesner, Jochen. Influence of moose *(Alces alces)* browsing on deciduous tree succession, dwarf shrub layer and fireweed *(Epilobium angustifolium)* occurrence in Northern Sweden.
2005:3 Burström, Linda. Summer browsing on Scots pine (*Pinus sylvestris*) by moose (*Alces alces*) - effects of simulated browsing and a survey of natural browsing.

2005:4 Skord, Jimmy. Substrate and habitat preference for the longhorn beetles *Monochamus sutor* and *M. urussovi*.
2005:5 Tillander, Carina. Using dendrochronology to date beaver settlements - a method study.
2005:6 Ekedahl, Fredrik. Migration patterns and habitat characteristics of capercaillie (*Tetrao urogallus* L.) in the mountain region of northern Sweden.
2005:7 Bengtsson, Anders. Modelling specialized forest bird species – a comparison between south-central Sweden and Latvia on two macroecological scales.
2005:8 Jansson, Ingela. A pilot study of brown bear (*Ursus arctos*) habitat use in central Sweden at two temporal scales using GPS.
2005:9 Berggren, Lars. Occurrence of Swiss stone pine (*Pinus cembra*) in a boreal forest landscape in relation to regeneration characteristics and habitat preferences by nutcrackers (*Nucifraga caryocatactes*).
2005:10 Granath, Gustaf. Abundance of fungal endophytes in grass species (*Festuca* sp.) along altitudinal gradients with varying grazing pressures.
2005:11 Nystedt, Ellen. Feeding stations as a measure to re-distribute moose (*Alces alces*) in their winter habitat.
2005:12 Nilsson, Anders. Jakten, jägarna och viltvården på Holmen Skog AB:s marker.
2005:13 Rimpi, Christian. The effect of hunting ground experience for hunting success of Willow Grouse (*Lagopus lagopus*).

2006:1 Wedholm, Per. Territoriality and social organization in Scandinavian wolverines *Gulo gulo.*
2006:2 Johansson, Leif. Enhancement of wildlife forage in northern Sweden – establishment of four different species of willow.
2006:3 Binette, Sylvie. Short-term Response of Beetles to Fire in the Northern Boreal Forest of Alaska: Conservation Implications.
2006:4 Roos, Ulrika. Nest-site selection in relation to ground temperatures in Curlew and Lapwing.
2006:5 Zakariasson, Per. Hunter observations of moose *Alces alces*: How good are they?
2006:6 Kornacher, Peter. Wild boar *Sus scrofa* damage reduction through large scale management: Applying hunting and feeding as management tools.
2006:7 Ekenstedt, Johan. Sex-ratio and genetic structure of the Gyrfalcon *Falco rusticolus* population in Norway and Sweden.
2006:8 Öhmark, Sara. An application of the bait-marking method for the study of spatial activity of wild boar in southern Sweden.