Baiting for brown bears(Ursus arctos) in Sweden

Bruk av åte på brunbjørn(Ursus arctos) i Sverige

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Summary

Hunting for brown bear (*Ursus arctos*) has a long tradition in Scandinavia, from the times when the populations of bears were far above the level that we have today, and for a century when the policy was to eradicate all predators in Scandinavia. However with successful management, the brown bear population grew from about 130 individuals to about 3,300 today. Quota hunting in Sweden began in 1943. Hunting with bait was an important hunting method before it was banned in 2001. Now interest groups want this method to be allowed again Sweden. Authorities want a better scientific basis for deciding the question of initiation of hunting with bait. The need for a scientific study that deals with hunting with bait and how bears use of bait site is great since there is little scientific knowledge on this topic.

To find out how bears use bait sites, I have used a remote camera to record the use of various bait sites types and in two areas of Sweden. Two of the main questions were whether the bears actually use the bait and time of day they visit bait site. Sweden has set a limit on when hunting starts and ends each day; one hour after sunrise and two hours before sunset respectively. The results of this study show that bears visiting bait sites, mostly in the morning before sunrise and after sunset in the evening. I have also examined whether there is any difference between the numbers of visits on bait sites that are permanent, i.e. actively baiting from the bears emerge from the den in the spring until denning in October or November, and temporary bait sites started a few weeks before the bear hunting period. The results show that permanent bait sites had the most visits throughout the season, whereas temporary bait sites had more visits in the hunting season, compared with permanent bait sites in the same period. Generally, hunting with bait could help to decrease the number of wounded bears and the necessity to search for wounded bears. Hunting with bait may also contribute to determining the age-and sex of harvested bears in those cases where the hunter has a better ability to determine age and sex, compared with a dog hunting. The conclusion of this study is that hunting with bait will not result in more harvested bears, because few bears visit the bait in the time window for legal hunting during the day, especially with the short daylight during the legal hunting season for bears.

Sammendrag

Jakt på brun bjørn (*Ursus arctos*) har en lang tradisjon i Skandinavia, fra tider der populasjonen av bjørn var langt over det nivået vi har i dag og gjennom et hundreår der politikken var å utrydde alt rovdyr i Skandinavia. Utrydningen var på sin side meget vellykket, men etter fredningen av bjørn var det bare rundt 130 individ igjen. Fredingen førte til at man kunne igjen starte opp en bærekraftig forvaltning av bjørnestammen og man kunne starte med kvotejakt. Åtejakt var en viktig jakt metode før det ble forbudt i 2001, men interesseorganisasjoner ønsker å få denne metoden lovlig igjen for Svenske jegere. Myndighetene ønsker seg bedre vitenskapelig grunnlag for å avgjøre spørsmålet om oppstart av åtejakt. Behovet for å utført et vitenskapelige studie som omhandler åtejakt og hvordan bjørnene benytter seg av åtene er stort siden det er lite vitenskapelig kunnskap om dette tema.

For å finne ut hvordan bjørnene benytter seg av åtene har jeg brukt viltkamera til å registrere bruken av ulike åtetyper og i to ulike områder i Sverige. To av de viktigste spørsmålene i et jaktøyemed er om bjørnene faktisk benytter seg av åtene og når på døgnet de besøker åteplassen. I Sverige har man satt en grense for når man kan starte jakten og når man må avslutte jakte på dagen hhv. en time etter soloppgang og to timer før solnedgang. Resultatene av denne studien viser at bjørner besøker åteplassen, med flest besøk om morgenen før soloppgang og etter solnedgang på kvelden. Videre har jeg sett på om det er noe forskjell mellom antallet besøk på åteplasser som er permanente, dvs. fra bjørnene kommer ut av hi våren og til de legger seg inn i hiet i oktober eller november, og temporære åteplasser som er laget et par uker før jaktstart på bjørn. Resultatet viser at permanente åter har flest registrerte besøk gjennom hele sesongen, mens temporære åter har flere besøk i jaktsesongen, sammenlignet med permanente åter i samme periode. Generelt kan åtejakt være med på å få ned skadeskytingsstatistikken og dermed minske sjansen for et ettersøk etter en skadet bjørn. Åtejakt kan også tenkes å være med på å bidra til et alders- og kjønnsuttak i de tilfeller der jeger har en bedre mulighet til å bestemme alder og kjønn, sammenlignet med en hundejakt. Konklusjonen på dette studiet er at åtejakt ikke vil være med på å bidra til flere skutte bjørn, under den forutsetning at tidsvinduet for lovlig jakt i løpet av et døgn er for lite, spesielt med tanke på det kortere dagslyset under den lovlige jakttiden for bjørn.

1. Introduction

The Scandinavian brown bear (*Ursus arctos*) population was estimated, based on bounty data, to number 4,000–5,000 individuals on the Scandinavian Peninsula in 1850 (Swenson et al., 1994a). Bounty systems had been in place in Norway and Sweden since 1733 and 1647, respectively. These systems were removed in Sweden in 1893, and in Norway in 1930. The persecution of brown bears resulted in the near extinction of brown bears in Scandinavia around 1930 (Swenson et al., 1995). At this time ~130 bears were left in four distinct subpopulations, all located in Sweden. Due to various conservation measures implemented in the early 20th century, the brown bear population in Sweden started to increase (Swenson, 1994b) and the population size was estimated at 3,298 individuals (range: 2.968-3.667) in Sweden in 2008 (Kindberg et al., 2011).

Hunting bears with conservative quotas was started again in Sweden in 1943 (Swenson et al. 1994b). Due to increasing population numbers, quotas were increased gradually, and the annual harvest rate was estimated to range from 4.1 % to 5.1 % of the total population estimate (Kindberg and Swenson, 2006) in 2005. From 1981-2011, 2.590 bears were harvested in Sweden (Bischof et al., 2008, SVA, 2012). Today, bear hunting is legal in nearly all of Sweden were bears occurs. The annual hunting season starts on 21 August or lasts until the quota has been filled, but not later than 15 October, except in Norrbotten County inland, where the hunting season ends on September 31, due to an earlier beginning of the denning period (Boström and Lännbjers, 2008).

Bear hunting with baits is well established in several countries in Europe, such as Estonia, Slovenia, Croatia, Slovakia, and Russia (Sahlén, 2007). Bait hunting has also been one of the most popular bear hunting methods in Sweden. Bischof et al. (2008) showed that of 887 bears shot in Sweden from 1981-2004, 18% were harvest over bait sites, 37 % by using dogs, 16 % by stalking, and 30 % by still hunting. Until 2000 hunting of bears with baits was allowed in Sweden (Bischof et al., 2008, Sahlén, 2007). In 2001 The Swedish Environmental Protection Agency (Naturvårdsverket) banned bait hunting, based on the arguments that bears commonly attending bait sites may become food conditioned and human habituated, and thus become so-called problem bears (Herrero et al., 2005, Schneider, 2012), and the fear of accidentally shooting bears from family groups at bait sites (killing of bears in family groups is illegal) (Schneider, 2012). Currently political pressure is being applied by interest groups to re-allow bait hunting in Sweden. Commonly mentioned advantages of hunting over bait are that

hunters have more time to place a well-aimed shot at an animal (Stokke et al., 2008), and that females with dependent offspring may not visit bait site (Sahlén, 2007). Bait hunting could thus reduce the number of wounded bears, and also give the hunters a better opportunity of more selective harvest. On the other hand, baiting could also lead to more bears becoming food conditioned and human habituated due to a large food supply in connection with human smell or even human presence, and thus increase the number of nuisance bears. An additional disadvantage of bait hunting could be that people recreating in the forest (e.g. berry picking, mushroom picking) might meet bears that are defending their food source, i.e. a bait site.

No scientific studies have been carried out to evaluate the proposed advantages and disadvantages of bait hunting of brown bears, and there are also no clear indications whether the occurrence and amount of problem bears in countries with baiting hunting is connected to baiting (Sahlén, 2007). The Swedish government has initiated a study evaluating the effects of bait hunting on brown bears and their behavior. As part of this study I evaluated visits of bears to two types of bait sites (i.e. permanent, temporary) equipped with remote cameras to study the following questions: 1) is there a difference in the number of bear visits to permanent and temporary bait sites; 2) when during the day do bears visit bait sites; 3) what affects the number of weekly bait site visits; 4) is there a difference between the number of bait site visits between the spring/summer season and the hunting season in the fall and 5) do subadult brown bears use bait sites more commonly and more often during the day than adult bears?

2. Methods

2.1 Study areas

The study was conducted in Dalarna and Gävleborg counties in south-central Sweden (61°N, 15°E, see Figure 1), and Västerbotten County in northern Sweden (64 °N, 16°E, see Figure 1), in 2010 and 2011. Both study areas consist of gently rolling hills with forests, rivers, and only few agricultural areas. The forested areas are dominated by coniferous tree species, such as Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), and are intensively used by large-scale forestry (Dahle and Swenson, 2003a, Schneider, 2009). The bear population density in 2001; 286 (range: 251-337) in Dalarna and 264 (range: 232-311) in Gävleborg counties (from now on referred to as south) and 2004; 309 (range: 265-401) in Västerbotten County (from now on referred to as north) (Kindberg et al., 2011). Bears are

hunted in both study areas. The start of the hunting season was on 21 August in both areas throughout the study period.

2.2 Bait sites

Two types of bait sites were used in this study, permanent bait sites and temporary bait sites. Permanent bait sites were established annually as soon as snow and road conditions permitted, usually in the middle of May in the south and the beginning of June in the north, and were active, i.e. re-stocked weekly with bait, until either the onset of denning (usually the middle of October (Friebe et al., 2001, Manchi and Swenson, 2005) or the first arrival of snow in the autumn (whichever came first). The location of permanent bait sites was not changed throughout the study period. Temporary bait sites were established annually during the first week of August, prior to the start of the bear hunting season, and were active until the bear hunting quota was filled, the onset of denning, or the first arrival of snow (whichever came first). The location of temporary sites could be changed from year to year. The locations of all bait sites were chosen with local field personnel (all of them experienced hunters) from a hunter's point of view, i.e. a location open enough that a hunter could view the site from ~50 m but vegetated enough that bears would approach, as well as in accordance with regulations proposed by the authorities, i.e. >200 m from the nearest road and >2000 m from the nearest house/cabin (Schneider, 2011). All bait sites were established with the approval of the land owners.

Every bait site was equipped with two remote-controlled infrared cameras set up at an angle of ~90 degrees at a distance of ~5 m from the bait, to ensure that one camera always was working in case of technical problems. Two different camera models were used at each bait site, one STC-DVIR5 Prowler (her after model Prowler) and one ScoutGuard Infrared Digital scouting camera SG560 Series (her after model Scout). After the infra-red sensor on a camera was triggered by a movement, the model Prowler took a series of 3 consecutive pictures, delayed for 30 seconds, and took a new 3-picture burst. The model Scout took a series of 9 consecutive pictures, delayed for 60 seconds, and took a new 9-picture burst. All cameras were set to take maximum image quality. The sensitivity of the infra-red trigger sensor was always set at maximum, however it had to be decreased in some instances, when vegetation was moved by wind and triggered the camera too easily.

Every bait site was restocked weekly with the same amount and same type of baiting material throughout the course of the study, 5 kg of locally harvested/captured game meat or

fish, 5 kg of corn (*Zea mais*), and 5 liter of molasses. Every bait site was visited once a week to restock bait material, as well as to change batteries and download pictures from the remote cameras. Every bait visit by field personnel was registered on a standardized form sheet (see Appendix I).

2.3 Data processing

All bait site pictures were uploaded into the software Camera Base 1.5 (http://www.atrium-biodiversity.org/tools/camerabase/). This software automatically extracts all electronic information (e.g. date, time, picture id, etc.) connected to a picture taken in the field and stores it in a data base in XML-format. I viewed every picture manually to document if an animal had been photographed and to which species it belonged. These data were then transformed from XML-format to the software Excel (Microsoft ® Office Excel 2007®) for further analyses.

2.4 Definition of a bait site visit and of legal hunting hours

A bait site visit was defined based on the assumption that consecutive picture bursts (during a 30-second interval for model Prowler or a 1 minute interval for model Scout) were triggered by the same bear during the same bait visit. I used all pictures taken of bears at all bait sites to calculate the time gaps ≥2 minutes between picture bursts (i.e. the shortest possible time gap between two nonconsecutive picture bursts). Because >90% of these time gaps were <10 minutes. I defined a bait site visit as a series of picture bursts followed by a >10-minute time gap.

2.5 Definition of beginning and end of the daily legal hunting time

According to the Swedish hunting regulations, bear hunting is only legal from one hour after the meteorological sunrise to two hours before the meteorological sunset (Ordiz et al., 2012). I used the median date of all hunter-killed bears in the north and in the south from 2007-2011 to estimate the median time of sunrise and sunset during the hunting season. These median times were used to divide a 24-hour period into a period when hunting was legal (termed day) and a period when hunting was not legal (termed night). In the estimation of sunrise and sunset in the spring/summer period I used the median day in every month.

2.6 Differentiation of adult and subadult bears based on pictures

Although the differentiation between age classes (i.e. adult vs. subadult) of brown bears is not straight forward, indications of a bears' age class can be gained from the general body size

(adults are larger), but also from the head shape and size (more massive in adult bears), as well as the relationship of eyes to head size (adult bears seem to have smaller eyes in relation to head size), and ear size (subadult bears seem to have larger ears in relation to head size than adult bears) (see illustrative examples in Fig. 2). Known-age individuals (recognizable due to their radio-collars and ear tags) were used for comparison with unknown bears. In addition, personnel of the Scandinavian Brown Bear Research Project were consulted in some cases to aid in age-differentiation.

2.7 Statistical analysis

Nonparametric statistics (Mann-Whitney U tests, Chi-square tests) were used to analyze whether there was a difference in the number and frequency of bait visits among different age, sex, or reproductive classes, and to test the differences between number and frequency of visits at different bait sites and differences in the number and frequency of visits among years. I used generalized linear models (GLM) with Poisson distribution corrected for overdispersion (i.e. quasi-Poisson) (Zuur et al., 2009) to determine which factors affected the length of a visit (in minutes) at a bait site during the spring/summer season and during the hunting season separately. The variables used in the analyses were study area (as binomial variable; south, north), reproductive class (adult, subadult, female with cubs of the year accompanying the mother to the bait site), and time of day (as binomial variable; night: outside the legal hunting hours; day: inside the legal hunting hours), as well as the interaction reproductive class*time of day.

I used GLMs with Poisson distribution corrected for overdispersion to determine which factors affected the length of time between bait visits during the spring/summer and during the hunting season separately. The variables used in the analyzes were study area (as binomial variable; south, north), reproductive class (adult, subadult, female with cubs of the year), and time of day (as binomial variable; night: outside the legal hunting hours; day: during the legal hunting hours), as well as the interaction reproductive class*time of day.

I used a generalized linear mixed model (GLMM) to analyze the factors affecting the average number of bear visits per week at bait sites during the hunting season. The variables used in the analysis were study area (as binomial variable; south, north), week, type of bait (as binomial variable; permanent, temporary), year (as binomial variable; 2010, 2011), as well as the interaction study area*year.

I used a GLMM to analyze if the number of bait visits by subadult bears within a given week was affected by the number of visits of adult bears. The variables used in the analysis were study area (as binomial variable; south, north), week, type of bait (as binomial variable; permanent, temporary), year (as binomial variable; 2010, 2011), the number of visits by adult bears within a given week, as well as the interaction study area*year.

All models were fitted using the stepwise backwards elimination procedure, by successively removing the least significant variable until the model contained only significant or suggestive variables (Zuur et al. 2009). A T-value of $p \leq 0.05$ was considered as statistically significant, and T-values $0.05 < p < 0.1$ were considered as statistically suggestive. All analyses were carried out in R 2.14.2.

3. Results

Overall 150,756 pictures were taken during the study period, of which 18,727 were taken of bears. Other pictures showed other species (e.g., moose (*Alces alces*), wolverine (*Gulo gulo*), Eurasian lynx (*Lynx lynx*), roe deer (*Capreolus capreolus*), European badger (*Meles meles*), red fox (*Vulpes vulpes*), marten (*Martes martes*), mountain hare (*Lepus timidus*) and various bird species), were triggered by the field crew, or for reasons unknown (likely moving vegetation). Based on number of bear pictures taken, I estimated an overall of 1,275 bait visits by bears; at permanent baits 546 visits during the spring/summer and 236 visits during the hunting season, and at temporary baits 493 visits during the hunting season (Table 1).

Significantly more visits in the south than in the north (Chi-square test: $\chi^2 = 251.382$, $df = 2$, $p \leq 0.001$) (south: 1006 visits, north: 269 visits) (Figure 3). Significantly more visits at permanent bait sites during the spring/summer season than during the hunting season (Chi-square test: $\chi^2 = 19.876$, $df = 2$, $p \leq 0.001$)(spring/summer: 546 visits, hunting season: 236 visits). Significantly more visits at temporary bait sites in comparison to permanent bait sites during the hunting season (Chi-square test: $\chi^2 = 17.625$, $df = 2$, $p \leq 0.001$) (permanent: 236 visits, temporary: 493 visits).

Adult bears (N=904) were observed at bait sites significantly more often per week than subadult bears (N=325) (Mann Whitney U test: $W = 35386$, $p < 0.001$) and significantly more often than females w/cubs (N=46) ($W = 39405.5$, $p < 0.001$) (Figure 4). Subadult bears were observed bait sites significantly more often per week than females w/cubs (N=46) ($W = 31388$, $p < 0.001$) (Figure 4). The overall mean number of bear observed at bait sites per week

was 7.3±9.3 observations for the entire year, 7.3± 9.1 observations during spring/summer, and 4.9 ± 9.4 observations during the hunting season (Table 2). The overall mean length of a bait site visit was 14.7 ± 25.0 min in both study areas, and 13.7 ± 9.3 during the spring/summer and 15.4 ± 16.6 minutes during the hunting season (Table 3).

The distribution of visits at bait sites within a 24-hour period general showed a bimodal pattern, with most visits recorded during the early morning and early evening hours and the fewest visits recorded during the middle of the day at both permanent and temporary bait sites and both study areas (Figure 5). This pattern was generally similar for all reproductive classes of bears (Figure 6), both types of bait sites (Figures 7 and 8), and in both areas during the hunting season (i.e., the most relevant time period for hunters) (Figure 9).

The results of a GLM evaluating which factors affected the length of a bait site visit during the spring/summer showed that bait site visits were significantly shorter in the north, and that adult bears spent significantly more time at a bait site than subadults, and tended to spend more time at a bait site than females w/cubs (Table 4). The following variables were removed as non-significant from the model: study area, time of day, as well as the interaction reproductive class*time of day.

The results of a GLM evaluating which factors affected the length of a bait site visit during the hunting season showed that adult bears spent significantly more time at a bait site compared to subadults, but not compared to female w/cubs (Table 5). The following variables were removed as non-significant from the model: study area, time of day, as well as the interaction reproductive class*time of day.

The results of a GLM evaluating which factors affected the length of time between consecutive bait visits during the hunting season showed that the time between visits was significantly longer in the north, and there was å significantly longer time between consecutive visits of adults in comparison to subadults, but that there was no significant difference in the time in between consecutive visits between adults and females w/cubs (Table 6). The following variables were removed as non-significant from the model: time of day, and the interactions reproductive class*time of day.

The results of a GLMM evaluating which factors affected the number of bait site visits per week during the hunting season showed that there was a tendency for the number of visits to increase over time and a tendency to be higher at temporary bait sites compared to permanent

bait sites. Significantly more bait site visits were recorded in 2011 than in 2010 (Table 7). The following variables were removed as non-significant from the model: study area and the interaction study area*year.

The result of a GLMM evaluating which factors affected the weekly number of subadult bears visiting bait sites during the hunting period showed that subadults bears visited significantly more temporary bait sites than permanent bait sites, and that significantly more subadults visits were recorded in 2011than in 2010 (Table 8). The following variables were removed as non-significant from the model: study area, weeks, number of visits by adult bears within a given week, and the interaction study area*year.

4. Discussion

The results showed that bears visit both types of bait sites, permanent as well as temporary, on a regular basis. Surprisingly, temporary bait sites were visited more often than permanent bait sites during the hunting season. Although results based on age determination must be interpreted carefully, lone adult bears seemed to visit bait sites more often than other subadults or family groups. The temporal pattern of bait site visits within 24 hours showed in general a bimodal distribution, with most visits recorded during the early morning and early evening hours and the fewest visits recorded during the middle of the day at both permanent and temporary bait sites in both study areas. The bimodal pattern was similar for all reproductive classes of bears, both types of bait sites, and in both areas during the hunting season (i.e., the most relevant time period for hunters).

Two cameras were used at each bait site, set up at an angle of 90 degrees to cover most area at a given bait site. However it is still possible that not all bear visits to bait sites were detected, due to possible “blind spots” not covered by the cameras. It is unlikely that bears feeding on the bait material were missed, but bears not completely approaching a bait site may have been missed, because in some pictures a bear was only visible in the far background (i.e. it is not clear if it was the bear that has triggered the camera). A hunter waiting at a bait site would very likely spot those bears. In addition, the chosen definition of a bait site visit (i.e. a series of picture bursts followed by a >10-minutes time gap) may result in fewer visits recorded by cameras than if an observer would have been present at a bait site. Also, in a hunting situation, a hunter will rarely use 10 minutes to decide whether to shot or not. Therefore the definition of a bait visit may not be fully applicable to a hunting situation.

It is difficult to assess the age of a bear based on a picture taken at a bait site. Several of the individuals visiting the bait sites were known-aged bears captured previously as part of the research by the Scandinavian Brown Bear Research Project, and were thus easily recognizable due to radio collars or ear tags. It was more difficult to assess the age class (i.e., subadult or adult) on unmarked bears. Although it is relatively obvious to differentiate a large old bear from a lone yearling bear based on pictures, the differentiation of older subadults from middle-aged bears can be difficult or sometimes even impossible. Bears for which it was impossible to estimate the age class were not included into the analyses including age. In general, all results in relation to age have to be interpreted carefully and conservatively.

In general, the bait sites were very species-specific, i.e., most pictures taken were of bears, and relatively few of other mammals. The only other group of animals that used the bait sites on a regular basis were birds, mainly corvids, such as ravens (*Corvus corax*) and European jays (*Garrulus glandularius*). I found more bait site visits of bears in the southern study area in comparison to the northern study area. This area difference is likely related to the larger population size as well as the higher density of bears in the south (Kindberg et al., 2009, Schneider, 2011)

During the hunting season, bears visited temporary bait sites more often than permanent bait sites. This result is surprising, however it may be related to dominance hierarchies developing around stable, long-term food supplies, such as for example shown in Yellowstone National Park, USA (Craighead et al., 1995). Garbage sites in the park were regularly visited by bears, and subadult brown bears avoided using the garbage sites during times when large adult males were present (Craighead et al., 1995). A similar situation may have developed around permanent bait sites in our study area during the study period. However, temporary bait sites are not available until late summer, and therefore a large individual may not be able to establish dominance around a temporary bait site within the short time period.

The distribution of visits at bait sites within a 24-hour period followed the general behavioral pattern of bears, with most visits during the early mornings and early evening hours, and the fewest visits registered during the middle of the day at both permanent and temporary bait sites in both study areas. Moe et al. (2007) showed the same 24-hour pattern, with low activity during the daylight hours and high activity during the crepuscular and nocturnal hours. This behavioral pattern was similar for all classes of bears, both types of bait site, and in both areas during the hunting season. Swedish bear hunting regulations include

time restrictions where hunting is not allowed until 1 hour before sunrise and has to be stopped 2 hours before sunset. Due to these restrictions, relatively few bears visit bait sites during legal hunting hours, and the most effective hunting times are early morning and late evening.

There were on average 7 bear visits per week to bait sites during the spring/summer season in both study areas, regardless of bait type. In comparison, there were on average 5 bear visits per week at bait site during the hunting season in both areas, regardless of bait type. This drop in visits is likely related to the beginning of the berry season. During this time of the year, bears have better access to food and thus use the bait sites less often. However, there may also be an alternative explanation for the decreased use of bait sites during the hunting season. Ortiz et al. (2012) showed that the temporal behavior of brown bears shifted dramatically at the beginning of the hunting season. Because days are shorter during late fall, bears were expected to become more active during the day, however, bears became more night-active and increased their movements during the dark hours after hunting start, losing their nocturnal rest, probably to compensate for decreased day-time activity. Ordiz et al. (2012) attributed this abrupt shift in behavior to the beginning of the hunting season.

In general, more bait site visits were recorded at permanent bait sites during spring/summer in comparison to the hunting season. Brown bears show a strong seasonality in their diet (Dahle et al., 1998, McLellan and Hovey, 1995). Bears forage mainly on moose carcasses (*Alces alces*) (Johansen, 1997) and mound-building ants (*Formica* spp.) during spring season in Sweden (Swenson et al., 1999). During summer a pronounced dietary shift occurs and bears forage mainly on berries until denning in October or November (Johansen, 1997, Friebe et al., 2001). In late summer and fall, which corresponds with the hunting season, bears have access to large amounts of berries, which they rely on to add adipose fat tissue for hibernation. Therefore bears may use less time to look for alternative food sources, i.e. bait material.

A bear spent on average 15 minutes at a bait site during a visit during the entire study period. However, the visitation time was on average longer during the hunting season compared to the spring/summer season. The mating season of brown bears occurs during May, June, and early July (Steyaert et al., 2012). During this time brown bears of both sexes increase their home range in the search of reproductive partners, which results in an increase of their home range (Dahle and Swenson, 2003a, Dahle and Swenson, 2003b). In comparison,

during late summer and fall the main goal of a bear is to convert protein-rich food and food high in lipids or carbohydrates into fat stores for the coming winter (Hilderbrand et al., 1999). This behavioral difference may explain why bears use on average less time at a bait site during spring/summer than during the hunting season in fall.

Also the behavior of a bear at a bait site may be affected by its age or reproductive category. Based on observations from pictures taken at bait sites, adult bears seem to be calmer at a bait site and seem "to have the situation under control". Subadults, on the other hand, seem to be more vigilant at bait sites and seem to pay more attention to the surroundings. Family groups, i.e. females with cubs, were the age and reproductive class visiting bait sites the least. It may be that females with cubs visit bait only when no other bear had been visiting the bait site previously, i.e. the only visits of a bait site by a female with cub was in early spring. After the first visit of an adult bear, the female with her cubs did not come back to the bait site. Females with cubs avoid areas that may involve meeting adult male bears to minimize the risk of infanticide (Gunther et al., 2004, Ben-David et al., 2004).

The results showed that adult bears visited bait sites more often than subadults and family groups. This may be explained by subadult bears and family groups avoiding areas with higher chances of meeting especially adult males, who may be aggressive towards them, especially when defending a food source. Only one recorded was registered where an adult and a subadult bear were observed together at a bait site, and (Støen et al., 2006) visits where two adult bears were observed together at bait sites. These cases may be explained by two related individuals, likely females, visiting a bait site together (Støen et al., 2006); in other cases two adults, based on size and appearance judged to be an adult female accompanied by an adult male, were observed together at bait sites during the spring/summer season, which suggests mating activities (Steyaert et al., 2012). In 2011 a larger bear was observed at the bait while a seemingly smaller and younger individual was visible in the far background of the pictures. These cases may be related to the larger individual dominating the bait site and the smaller individual therefore not taking the risk of fully approaching the bait site.

4.1 Conclusions

Stokke et al. (2012) found that brown bears are more often shot in the extremities than in the vital organs in contrast to moose. Comparatively few hunters have shot bears in Scandinavia, and compared to moose hunting, brown bear hunting is not as common and may

even be a stressful experience for the hunter (Stokke et al., 2012). One of the commonly mentioned advantages of bait hunting is that a hunter may have better time to make a lethal shot. The time that an average bait site visits lasts may support such this claim, however, no studies comparing shooting performance at bait sites in comparison to e.g. dog hunting or drive hunting exist. In addition, bears that have been stressed by the presence of hunting dogs may become aggressive towards the hunter (shooter), if the shot is not lethal (Stokke et al., 2012). Hunting towers or similar installations, which can be installed at a bait site, are likely a good measure to increase hunter safety and may increase the probability of a steady shot due to better support options for the rifle. In addition, such installations may provide hunters with more time for assessing the age or reproductive status of a bear, because the hunter may spot an approaching bear from a larger distance.

It is illegal to shoot a female with dependent offspring in Sweden. A commonly mentioned argument, i.e. against bait hunting is that a female with dependent offspring may leave the cubs behind and visit the bait site by herself, this has not been tested with scientific methods. It was not possible to test this assumption based on pictures taken at bait sites, however a technique tested in Canada may potentially help hunters in Sweden to determine the reproductive status of a bear at a bait site. Obbard et al. (Obbard et al., 2008) tested if it was possible to determine the sex of American black bears (*Ursus americanus*) with the use of a suspended bait and thereby forcing a bear to raise on the hind legs. Bags of bait were placed 2-3 m over ground, and when on the hind legs the bears was visually investigated for enlarged nipples, presence or absence of penis and, if female, whether it is lactating (Obbard et al. 2012). It is unknown if this technique could be applied in Sweden, however new regulations may force hunters using bait sites to come up with innovative methods to determine the sex and/or reproductive status of bears. For example, Dalarna County implemented new guidelines regarding the maximum number of harvested female bears within the annual quota in 2012.

In general, bait hunting of bears may provide some of the advantages commonly mentioned by hunters, for example better time to place a well-aimed shot at a bear, and thereby decreasing the number of wounded bears and the number of dangerous searches for wounded bears. In addition, it may present hunters with the opportunity to be more selective in terms of age and sex of bears. However, the results also suggest that hunting at bait sites with the current set of temporal restrictions to hunting will likely result in few bears killed at bait sites, simply because the daily time window for the legally defined hunting period is

relatively short in fall, and most bear visits occur before the start or after the stop of the hunting time.

5. Acknowledgments

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Table 1: Summary of visits to bait sites by brown bears in two study areas in Sweden, 2010-2011, based on picture records from remote cameras. Visit were classified according to season (spring/summer: from establishment of bait site in May/June (snow-dependent)-July 31; hunting season: August 1-until onset of denning (snow-dependent)), bait site type (permanent: established annually as soon as snow and road conditions permitted, until either the onset of denning or first arrival of snow in the autumn; temporary: established annually during the first week of August, until the bear hunting quota was filled), study area (south: Dalarna/Gävelborg counties; north: Västerbotten county), and age/reproductive class of bears (adults, subadult, female with dependent offspring).

Season	Reproductive class	Permanent bait		Temporary bait		Overall
		South	North	South	North	
Spring/summer		441	105	-	-	546
	Adult	347	13	-	-	360
	Subadult	52	92	-	-	144
	Female w/cubs	42	-	-	-	42
Hunting		209	27	356	137	729
	Adult	174	14	276	81	545
	Subadult	34	11	79	56	180
	Female w/cubs	1	2	1	-	4

Table 2: Mean standard deviation (SD), median, and range of the number of weekly visits at bait sites by brown bear in two study areas in Sweden, 2010-2011. Visit were classified according to season (entire year: from establishment until the removal of bait sites; spring/summer: from establishment of bait site in May/June (snow-dependent)-July 31; hunting season: August 1-until onset of denning (snow-dependent)), and age/reproductive class of bears (adults, subadult, female with dependent offspring).

	Mean	SD	Median	Range
All bear classes				
Entire year	5.658	9.328	1	1-166
Spring/summer	7.297	9.110	4	1-143
Hunting season	4.9	9.358	1	1-166
Adult				
Entire year	3.888	7.808	0	1-166
Spring/summer	4.756	8.098	1	1-143
Hunting	3.487	7.663	0	1-166
Subadult				
Entire year	1.555	5.065	0	1-144
Spring/summer	1.959	4.903	0	1-123
Hunting	1.368	4.142	0	1-144
Female with cubs of the year				
Entire year	0.196	1.271	0	1-112
Spring/summer	0.581	2.208	0	1-112
Hunting	0.018	0.176	0	1-12

Table 3: Mean, standard deviation (SD), median, and range of time (in minutes) spend by a visiting bear at a bait site in two study areas (south: Dalarna/Gävleborg; north: Västerbotten), separately as well as combined, in Sweden, 2010-2011. Visit were classified according to season (entire year: from establishment until the removal of bait sites; spring/summer: from establishment of bait site in May/June (snow-dependent)-July 31; hunting season: August 1-until onset of denning (snow-dependent)).

		South	North	North/South
Entire year	Mean	15.1	13.3	14.7
	SD	25.8	21.9	25.0
	Median	5	5	5
	Range	1-287	1-169	1-287
Spring/summer season	Mean	14.8	9.3	13.7
	SD	23.3	16.6	22.7
	Median	5	1	4
	Range	1-189	1-93	1-189
Hunting season	Mean	15.2	16.0	15.4
	SD	27.6	24.5	26.9
	Median	5	8	5
	Range	1-287	1-169	1-287

Table 4: Result of a generalized linear model explaining the time brown bears spent at experimental permanent bait sites during the spring/summer season (May-July) in Dalarna/Gävleborg and Västerbotten counties in Sweden 2010-2011 (N=546). A permanent bait site was established in spring as soon as the road conditions allowed it and terminated in fall as soon as hibernation started or snow arrived. The variables available were study area (north, south), reproductive class (adult, subadult, female with cubs of the year), time (night, day). β is the parameter estimate, SD is the standard error, t denotes the t-value, and P denotes the significance level.

Explanatory variables	β	S.E.	t	p
Intercept	2.549	0.087	29.064	< 0.001
Study area			-3.882	< 0.001
North	0	0		
South	-0.921	0.237		
Reproductive class				
Adult	0	0		
Subadult	0.670	0.179	3.735	< 0.001
Female w/cub	0.392	0.226	1.732	0.0838

Table 5: Result of a generalized linear model explaining the time brown bears spent at experimental bait sites during the hunting season (August-snow) in Dalarna/Gävleborg and Västerbotten counties in Sweden 2010-2011 (N=727). A permanent bait site was established in spring as soon as the road conditions allowed it and terminated in fall as soon as hibernation started or snow arrived. Temporary bait sites were established in august when hunting regulations allowed it. The variables available were study area (north, south), reproductive class (adult, subadult, female with cubs of the year), time (night, day). β is the parameter estimate, SD is the standard error, t denotes the t-value, and P denotes the significance level.

Explanatory variables	β	S.E.	t	p
Intercept	2.808	0.070	39.850	< 0.001
Reproductive class				
Adult	0	0		
Subadult	-0.321	0.160	-2.011	0.044
Female w/cub	-0.793	1.222	-0.649	0.516

Table 6: Result of a generalized linear model explaining the time between visits during the hunting season (August-snow) in Dalarna/Gävleborg and Västerbotten counties in Sweden 2010-2011 (N=727). A permanent bait site was established in spring as soon as the road conditions allowed it and terminated in fall as soon as hibernation started or snow arrived. Temporary bait sites were established in August when hunting regulations allowed it. The variables available were study area (north, south), reproductive class (adult, subadult, female with cubs of the year), and time (night, day). β is the parameter estimate, SD is the standard error, t denotes the t-value, and P denotes the significance level.

Explanatory variables	β	S.E.	t	p
Intercept	7.007	0.160	43.730	< 0.001
Study area			2.481	0.013
South	0	0		
North	0.6894	0.277		
Reproductive class				
Adult	0	0		
Subadult	-1.132	0.417	-2.712	0.006
Female w/cub	0.688	1.017	0.977	0.498

Table 7: Result of a generalized linear mixed model explaining the number of visits made by brown bears per week during the hunting season (August-snow) at experimental baits in two study areas in Sweden 2010-2011. The variables available were area (north-south), week, type (permanent-temporary), year (2010-2011) and year compared to area were used in the base model. A permanent bait site was established in spring as soon as the road conditions allowed it and terminated in fall as soon as hibernation started or snow arrived. Temporary bait sites were established in August when hunting regulations allowed it. β is the parameter estimate, SD is the standard error, df denotes the degrees of freedom, t denotes the t-value, and P denotes the significance level. Number of observations 160 and number of groups 11.

Explanatory variables	β	SD	df	t	P
Intercept	-14.769	9.241	146	-1.598	0.112
Week	0.445	0.247	146	1.796	0.074
Type of bait site			146	1.853	0.065
Permanent	0	0			
Temporary	3.959	2.136			
Year			146	2.258	0.025
2010	0	0			
2011	3.405	1.508			

Table 8: Result of a generalized linear mixed model explaining the number of visits by subadult brown bears per week during the hunting season at experimental baits in two study areas in Sweden, 2010-2011. The variables available were area (north-south), week, type (permanent-temporary), year (2010-2011) and year compared to area were used in the base model. A permanent bait site was established in spring as soon as the road conditions allowed it and terminated in fall as soon as hibernation started or snow arrived. Temporary bait sites were established in August when hunting regulations allowed it. β is the parameter estimate, SD is the standard error, df denotes the degrees of freedom, t denotes the t-value, and P denotes the significance level. Number of observations 160 and number of groups 11.

Explanatory variables	β	SD	df	t	P
Intercept	-1.684	1.178	147	-1.428	0.155
Type of bait site				2.157	0.032
Permanent	0	0			
Temporary	2.458	1.139	147		
Year				3.428	0.0008
2010	0	0			
2011	2.807	0.818	147		

Figure 1: Location of the study areas used for the experimental bait study in relation to the general study areas of the Scandinavian Brown Bear Research Project (SBBRP; www.bearproject.info). The study areas of the SBBRP are the red areas in the south and the north of Sweden, the red lines indicate where bears marked as part of the activities of the SBBRP have dispersed to. The arrows indicate the location of the experimental bait site study areas in the southern study area of the SBBRP in Dalarna and Gävleborg counties, as well as in Västerbotten County in north-central Sweden.

Figure 2: Illustrative examples of different age classes of brown bears at bait sites in Dalarna/Gävleborg and Västerbotten counties, Sweden. Upper panel: adult bears; lower panel: subadult bears.

Figure 3: Number of visits to bait sites by brown bears in two study areas (south: gray line, N=1004 visits; north: black line, N=272 bait site visits) in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. The dashed line indicates the start of bear hunting season.

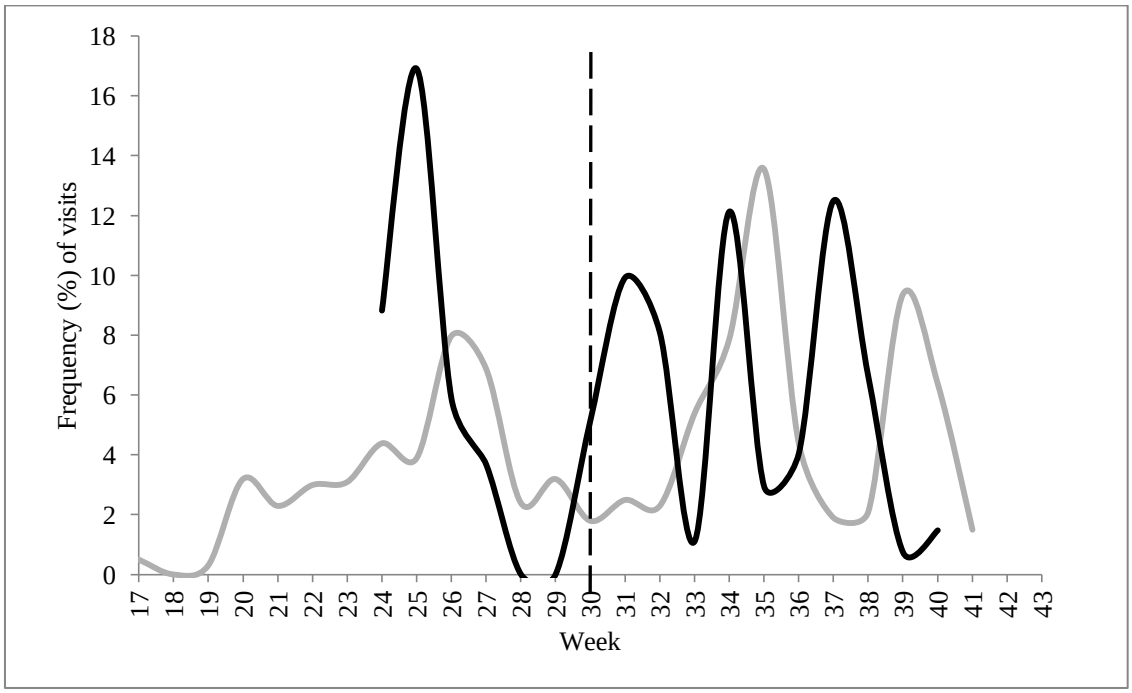


Figure 4: Weekly frequency of brown bear visits to bait sites by different age and reproductive classes in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. The dashed line shows start of hunting period. Adults (N=914 visits): black line; subadults (N=316 visits): dotted line; female with dependent offspring (N=46 visits): gray line with points.

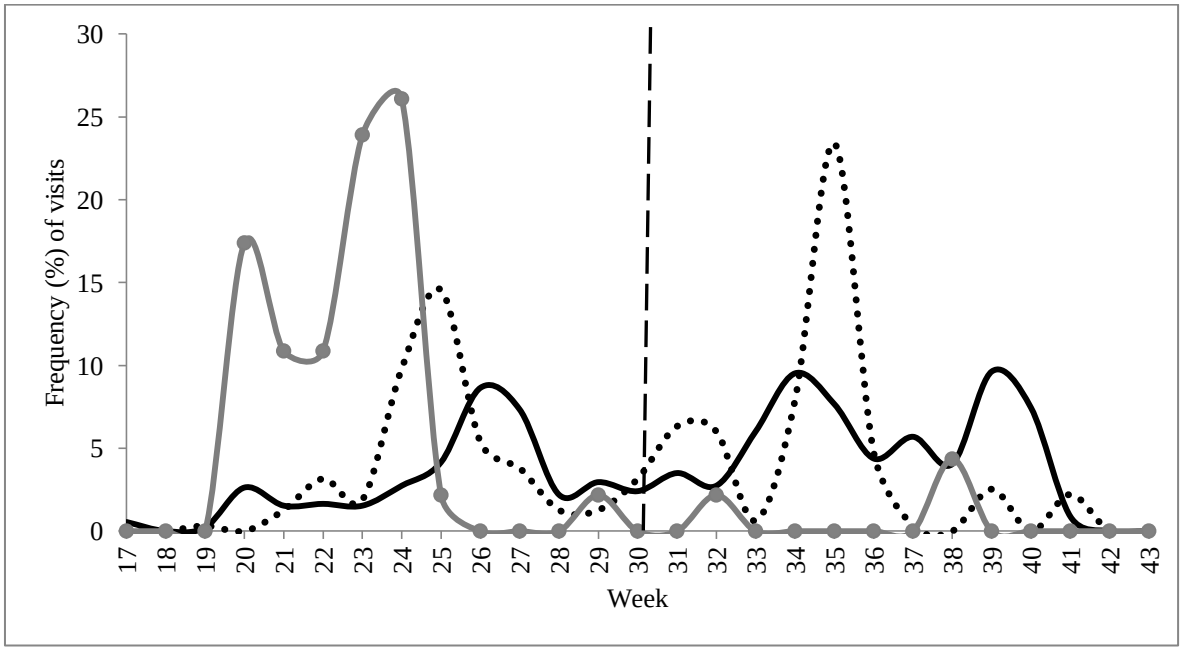


Figure 5: Frequency distribution of visits to bait sites by brown bears within a 24-hour period in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. The black lines summarizes all visits in the course of the study period (N=1275).

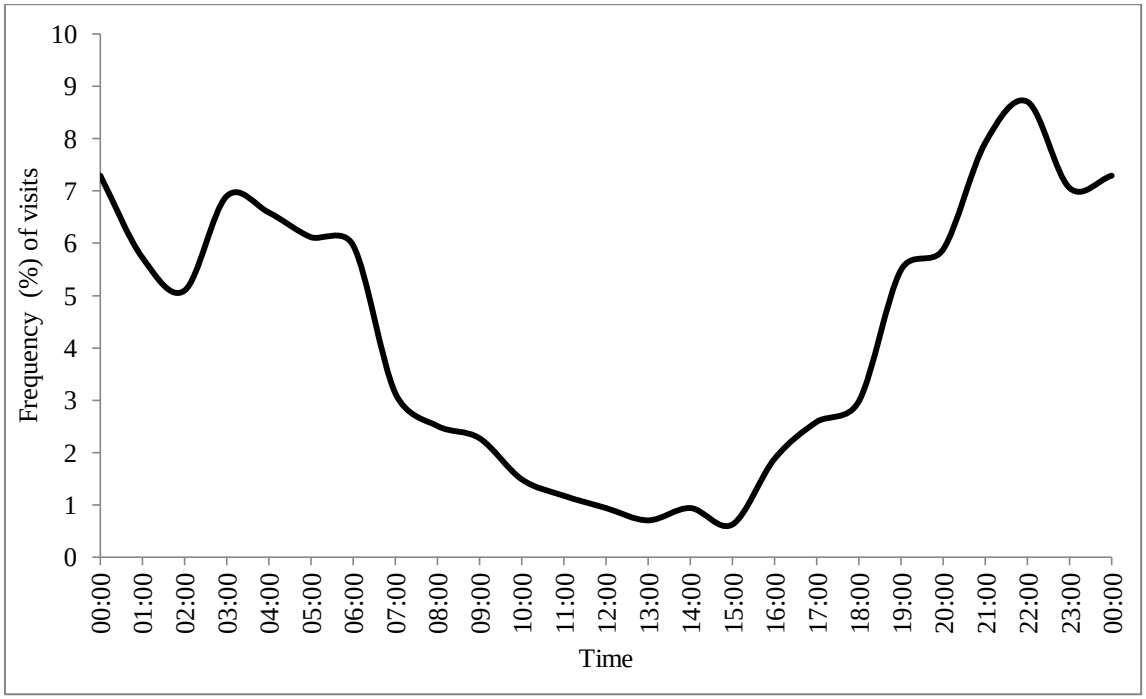


Figure 6: Frequency distribution of visits to bait sites entire year by brown bears of different age and reproductive classes within a 24-hour period in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. Adults (N=914 visits): black line; subadults (N=316 visits): dotted line; female with dependent offspring (N=46 visits): gray line with points.

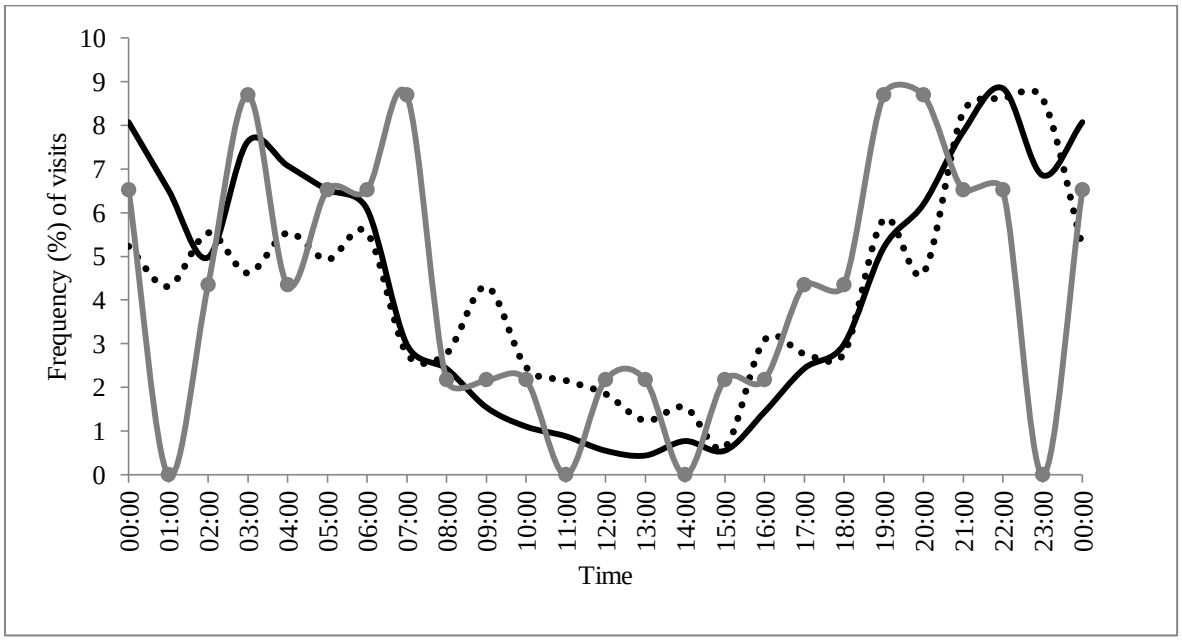


Figure 7: Frequency distribution of visits to permanent (May-October) bait sites by brown bears of different age and reproductive classes within a 24-hour period in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. Adults (N=548 visits): black line; subadults (N=189 visits): dotted line; female with dependent offspring (N=45 visits): gray line with points.

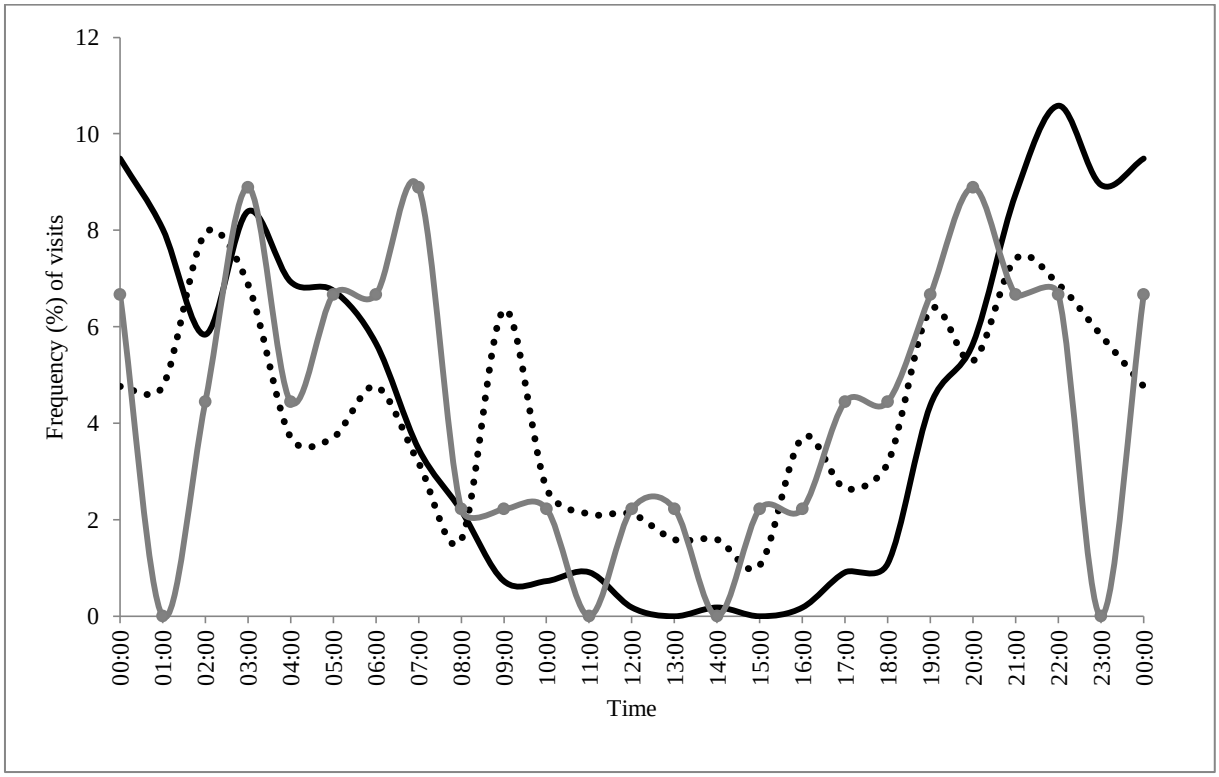


Figure 8: Frequency distribution of visits to temporary bait sites during the hunting season by brown bears of different age and reproductive classes within a 24-hour period in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2010-2011. Adults (N=357 visits): black line; subadults (N=153 visits): dotted line. Females with dependent offspring were not included into this graph, because the sample size was too low (N=1).

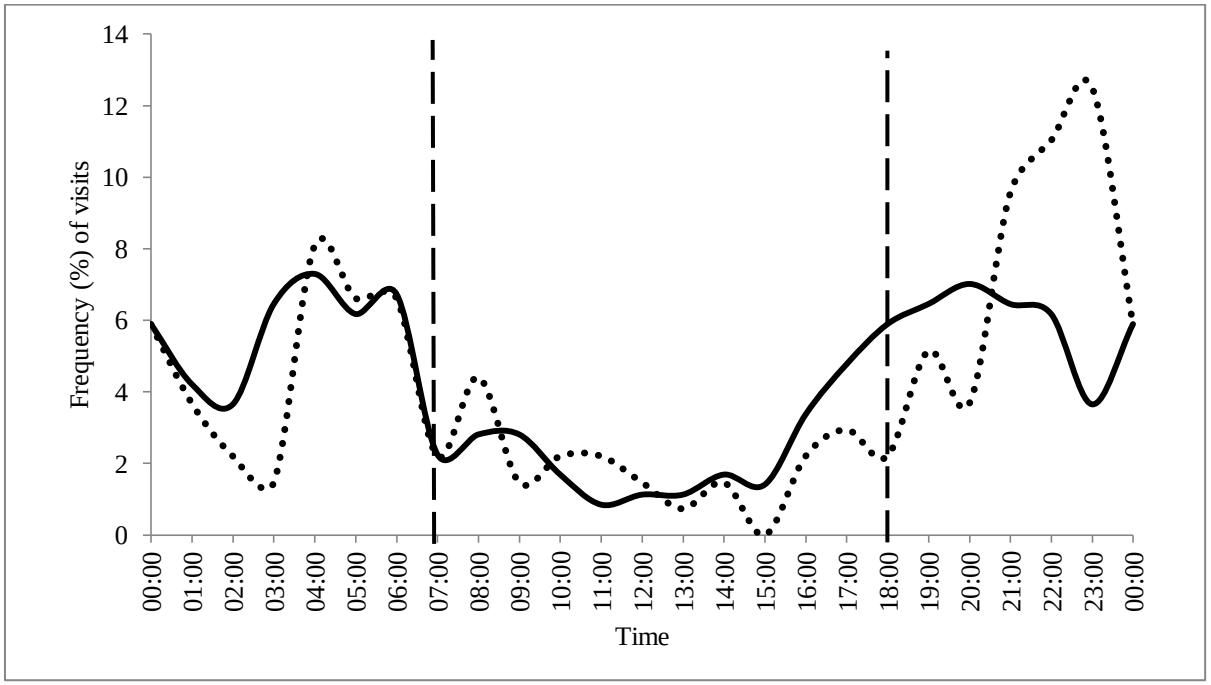
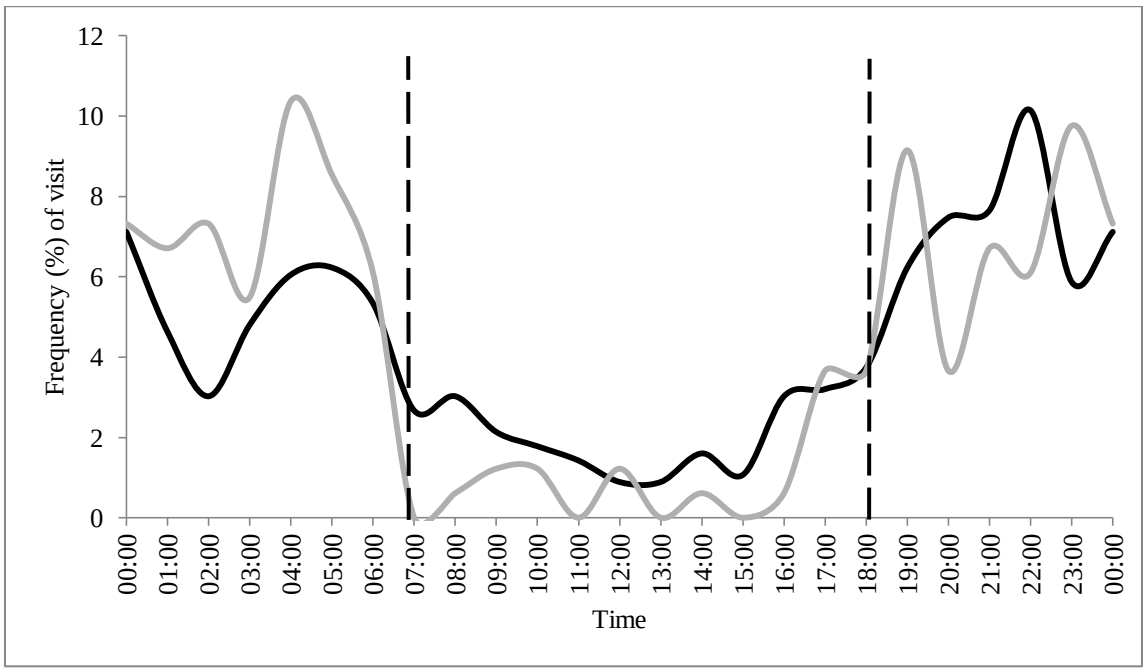


Figure 9: Frequency distribution of visits to bait sites during the hunting season by brown bears within a 24-hour period in Dalarna/Gävleborg (south study area: black line, N=562) and Västerbotten (north study area: gray line, N=164) counties in Sweden, 2010-2011. The dashed lines indicated the beginning and the end of the legal hunting hours, i.e., one hour after sunrise and two hours before sunset. Due to the different geographic location of the study areas, the indicators of the beginning and end of the legal hunting period were based on the timing of sunset and sunrise of the median date of all bears harvested in Dalarna/Gävleborg and Västerbotten counties from 2007-2011.



Appendix 1: Bait site protocol

Fältprotokoll åtelprojektet

2011

Besöksinformation

Kontrollant:	Datum:	Ankomst:	Avgång:
Åtel nr:	Åtelnamn:		Besök nr:

Mängd utlagt foder (kg eller l)

Betfor:	Foto:	Ja	Nej	Slaktavfall:	Foto	Ja	Nej
Majs:	Foto:	Ja	Nej	Fisk:	Foto	Ja	Nej
Melass:	Foto:	Ja	Nej				

Foderåtgång (mängd försvunnen)

Betfor:	100%	>50%	<50%	Slaktavfall:	100%	>50%	<50%
Majs:	100%	>50%	<50%	Fisk:	100%	>50%	<50%

Genetiska prover

Hårprov träd 1:	(kuvert)	Träd 1 rengjort:	Ja	Nej	Melass:	Ja	Nej
Hårprov träd 2:	(kuvert)	Träd 2 rengjort:	Ja	Nej	Melass:	Ja	Nej
Spillningsprov:	(rör)						

Kamera 1

Nr:		Antal kort/sekv:	3		9
Time Out:		Bildkvalité:	low	medium	high
Antal tagna bilder:		Batterinivå (%):			
Minneskortsbyte:	Ja Nej	Battribyte:		Ja Nej	
Sparade i mapp:					

Kamera 2

Nr:		Antal kort/sekv:	3		9
Time Out:		Bildkvalité:	low	medium	high
Antal tagna bilder:		Batterinivå (%):			
Minneskortsbyte:	Ja Nej	Battribyte:		Ja Nej	
Sparade i mapp:					

Kommentar/övrigt
