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Marion Lukkari Arnesen

# USE OF EXPERIMENTAL BAIT SITES BY WOLVERINES

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# USE OF EXPERIMENTAL BAIT SITES BY WOLVERINES

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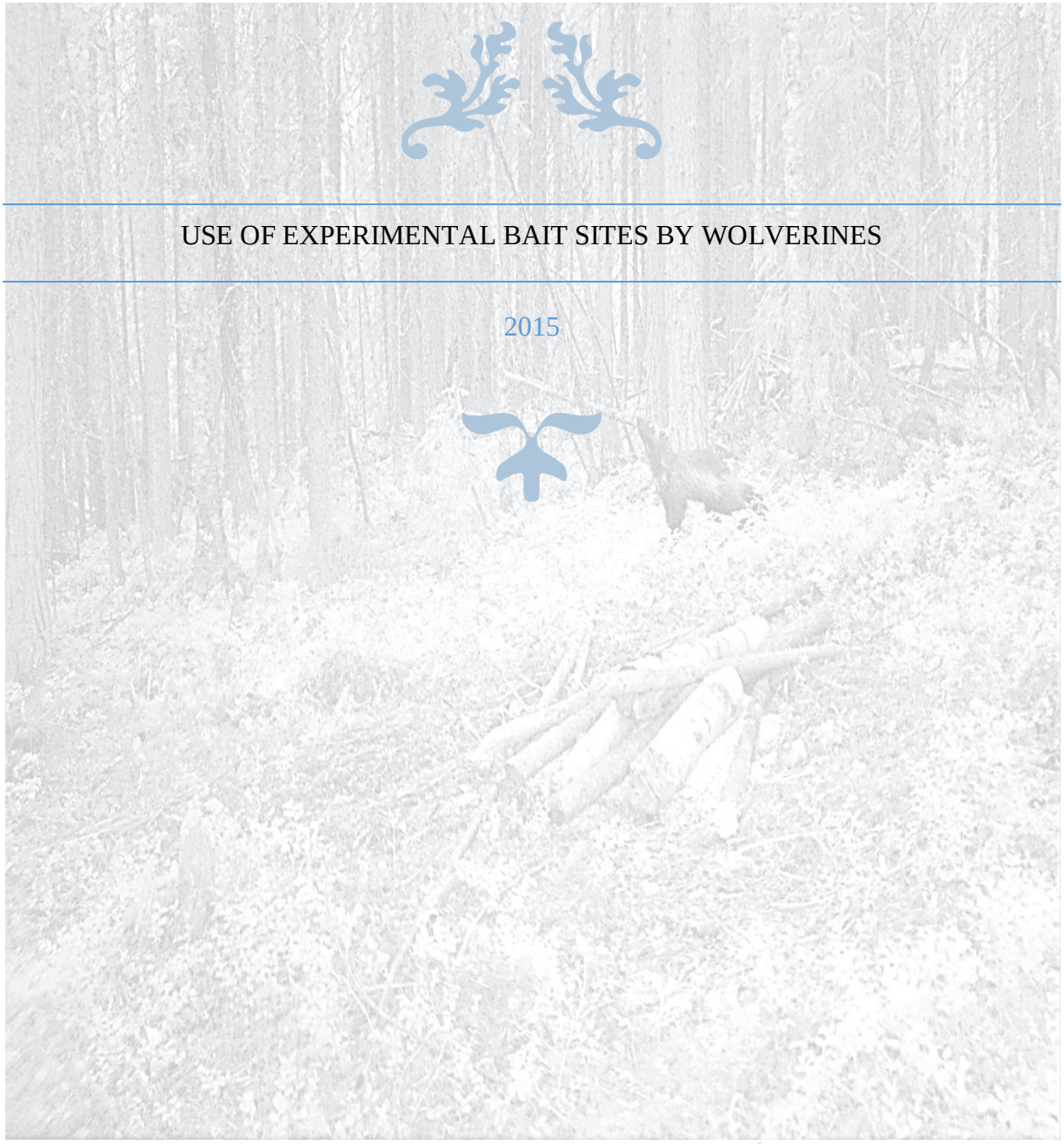


*Marion Lukkari Arnesen*

**Photo on front cover:** A wolverine visiting an experimental bait station in Västerbotten County, Sweden, in 2012. The picture was taken by a remote camera installed by the Scandinavian Brown Bear Research Project.

Marion Lukkari Arnesen
Studentnummer: 106514
Faculty of Arts and Sciences
Department of Environmental and Health Studies
Telemark University College
Hallvard Eikas plass
3800 Bø i Telemark

http://www.hit.no

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## Abstract

This study investigates the visitation frequency and rate of wolverines (*Gulo gulo*) at experimental bait sites originally designed for brown bears (*Ursus arctos*) in Dalarna, Gävleborg, and Västerbotten counties, Sweden, 2008-2012. Bait sites were either permanent, i.e., fixed location that could not be changed throughout the study period, or temporary, i.e., location that could be changed between study years. Bait sites were restocked weekly with bait, i.e., meat (ungulates or fish) and vegetable materials (i.e., corn and beet root). Two remote cameras were installed at each bait site to capture images of visiting animals. The goal of this study was to evaluate the visitation frequency of wolverines at bait sites, their duration of time spent at bait sites, and the time interval between consecutive visits. Further, I also evaluated different behavioral pattern displayed by wolverines during their visits at the bait sites.

Wolverines were the third most common mammal species observed at bait sites, and the second most common mammal observed at the bait sites when considering only the North study area (Västerbotten). Overall, wolverines carried out 74 visits during the study period, and significantly more (~93%) were observed in the North. The average visitation rate for the study period was 3.7 visits per week and did vary significantly between weeks. Visitation frequency did not differ between permanent and temporary bait sites or season (spring/summer and autumn). The highest visitation frequency was observed in 2010. Wolverines are considered a nocturnal species, and I observed significantly more visits during the night hours (68.9%) in comparison to day hours. After the initial establishment of a bait site, it took wolverines an average of 42 days to visit this bait site for the first time. In a Norwegian study, it took wolverines an average of 72 days until the first visit of bait sites at hunting hides. The average time wolverines spent at a bait site was 6.3 minutes, and the majority (77.1%) of visits lasted shorter than 10 minutes. The average time between two consecutive visits at a bait site was 79 hours (~ 3 days) in a given year.

The wolverine is listed as vulnerable (VU) in the red list of endangered species in Sweden, and is protected by several national and international regulations and directives. To manage this elusive carnivore can be demanding, and implementing an adaptive management strategy requires good knowledge of its distribution and population size. The study design applied in this study, with some adaptations, could be useful for population monitoring purposes. The most important adaptation would have to be to restock bait sites also during the winter season. In the course of this study, bait sites were removed when bear denning started in autumn and reestablished in spring after the end of the bear denning period. Population monitoring of

wolverines based on bait sites could provide insight into demographic patterns, conspecific and intra-guild competition, dispersal patterns, and individual wolverines could potentially be identified based on fur coloration and markings.

**Key words:** baiting, experimental bait site, wolverine, *Gulo gulo*, activity pattern, behavior, Sweden, wildlife management

## 1. Introduction

Monitoring of wildlife populations is of crucial importance for management and conservation (Silvy, 2012). However, especially the monitoring of shy or elusive mammals with large home ranges and/or low abundance is challenging, time consuming, and expensive (Linnell et al., 1998; Kindberg et al., 2009; May et al., 2010; Swenson et al., 2011; Gregersen, 2014). Several non-invasive methods have been developed to obtain reliable estimates of absence/presence, distribution and population size of species, such as genetic sampling of hair and/or feces, or the use of remote cameras (Moruzzi et al., 2002; Hedmark et al., 2004; Flagstad et al., 2006; Hedmark and Ellegren, 2007; Brøseth et al., 2010; Flagstad et al., 2010; Andreassen et al., 2012; Long et al., 2012; Silvy, 2012). Common to the use of many of these monitoring techniques is that they often are located at strategic locations (e.g., obligatory wildlife passages, water holes) or the use of some form of attractant (e.g., food, scent lure) to increase the chances of "capturing" an animal(Savidge and Seibert, 1988). For example, hair snagging wires for bears are often placed around food or scents attractive to bears (Karamanlidis et al., 2010; Swenson et al., 2011; Shardlow and Hyatt, 2013; Karamanlidis et al., 2014), or remote cameras have been placed at water holes to obtain pictures of several species (Wolff, 2001; O'Brien et al., 2006). The same practices are also commonly used for the hunting of many species (Bischof et al., 2008; Kilpatrick et al., 2010; Odden et al., 2013). Usually these monitoring or hunting techniques are aimed at one specific species of interest, however, several other species may visit these sites or attractants (O'Brien et al. 2006; Silvy, 2012; personal observation).

Sweden hosts all four European large carnivore species, the brown bear (*Ursus arctos*), wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*), and the wolverine (*Gulo gulo*) (Hedmark, 2006). Large scale genetic monitoring programs are in place for all four species (http://rovdata.no/Nasjonaltoverv%C3%A5kingsprogram/Omoverv%C3%A5kingsprogrammet.aspx;https://www.naturvardsverket.se/Om-Naturvardsverket/Publikationer/ISBN/8700/978-91-620-8709-8/) (assessed on 14.11.2015), however these programs are difficult to organize, time consuming and expensive. Especially in low density areas, the presence/absence of these carnivore species can be difficult to determine. Here I test the functionality of bait sites for brown bears for the monitoring of wolverines.

Historically, wolverines occurred from the south-central to the northern parts of Scandinavia. Since the middle of the19$^{th}$ century, the Scandinavian population decreased dramatically due to human persecution until the Swedish government protected the species in 1969 (Landa et al., 2000b; Walker et al., 2001; Sæther et al., 2005; Hedmark and Ellegren, 2007; Aronsson and

Persson, 2012). The population size of wolverines was estimated at 120 - 150 individuals in Sweden in the 1980s (Bjärvall and Ullström, 1985), to 326 in the period 1998 to 2000 (Landa et al., 2001; Sæther et al., 2005), and between 552 to 790 during the period 2008 - 2010 (Aronsson and Persson, 2012). The Scandinavian population size has increased with a mean of 4.3 % annually from 1998 to 2010 (Persson and Brøseth, 2011; Persson et al., 2011), and since 1996, the number of reproductions registered in Sweden has increased 3.8 % annually (Persson and Brøseth, 2011). Since its protection, the wolverine population has also increased its distribution range from the mountainous areas in northern and western Sweden into the forested areas towards the east and south due to increased dispersal from areas with high wolverine densities (Aronsson and Persson, 2012). A population survey carried out in the winter of 2013/2014 resulted in 138 registered reproductions in Scandinavian, of which 86 were documented in Sweden. Based on this number of reproductions, the overall population size was estimated at 647 (505-867; 95 % CI) individuals in Sweden in 2014 (Naturvårdsverket, 2015).

The wolverine is currently listed as vulnerable (VU) in the red list of endangered species in Sweden (http://artfakta.artdatabanken.se/taxon/100066) (accessed on 03.09.2015). In addition, the wolverine is also protected by international laws and regulations, such as the Bern Convention, the UNCED-convention (Rio Convention), and Council directive 92/43/EEC on the Conservation of Wild Fauna and Flora in the European Union (ABL L 206, 22.07.1992; Habitats Directive) (Landa et al., 2000a; May, 2007; Schneider, 2009; Naturvårdsverket, 2013; Zedrosser et al., 2014). There is currently no hunting season for wolverines in Sweden. In theory, hunting of wolverines could be authorized by Naturvårdsverket and/or advised by the regional predator councils (Schneider, 2009), in case the population in a given area exceeds its natural carrying capacity, or if conflicts with human interests exceed certain levels and thereby the management goal of coexistence of humans with wolverines is threatened (Persson, 2003; Persson and Forskningsstation, 2007; Aronsson and Persson, 2012) (May, 2007; Silvy, 2012; Naturvårdsverket, 2013). A few wolverines are euthanized annually for management purposes in Sweden, mainly because of conflicts with reindeer herders (Persson, 2003; Schneider, 2009; Rauset, 2013).

The wolverine is a generalist predator, foraging mainly on rodents, birds and carrion in summer (Persson, 2003), and primarily scavenging on ungulate carcasses in winter (Walker et al., 2001; Persson, 2003; Gustavsen, 2006; Van Dijk et al., 2008). However, wolverines frequently also kill reindeer (*Ragifer tarandus*) (Mattisson, 2011) and sheep (*Ovis aries*) (Persson, 2003; Kilström, 2004; Van Dijk, 2008; Wilson et al., 2009; Koskela et al., 2013). Furthermore, food caching is an vital behavior for the wolverine, i.e., they store food among

rocks or underneath snow to consume them later during the winter (Landa et al., 1997; Samelius et al., 2002; Persson, 2003; 2005; Wilson et al., 2009; Inman et al., 2012a).

Wolverines have large home ranges in relation to their body size (Persson, 2003), and adult males and lone adult females have larger territories (200-1.500 $km^2$) than females with dependent young (40-100 $km^2$) (Persson, 2003; Kilström, 2004; May, 2007). Dispersal is male-biased, and sub-adults (Vangen et al., 2001; Persson, 2003) can roam over areas of several thousand square kilometers during this time (May, 2007). Wolverines are strictly territorial, but have intra-sexual territories (Persson et al., 2010), i.e., one male territory usually overlaps with two to three female territories (Copeland, 1996; Persson, 2003; Kilström, 2004; Bevanger, 2012). Scent-marking and olfactory communication are important for the wolverine (Hutchings and White, 2000), and the territory and food resources are marked with anal gland secretions (Wood et al., 2005; Bevanger, 2012).

Population monitoring of large carnivores is challenging (Brøseth et al., 2010; May et al., 2010), and especially so for the elusive wolverine which occurs in large home ranges and at low population densities in Sweden (Persson, 2003; Krebs et al., 2007; Lofroth and Krebs, 2007; Persson et al., 2010). Attracting wolverines to bait sites with either scent lures or food has historically been an important hunting method and is still used in areas where wolverines can be hunted today, such as Norway (Odden et al., 2013). This hunting method is highly successful because it takes advantage of the scavenging and food caching behavior of wolverines (Landa et al., 1997; Samelius et al., 2002; Persson, 2003; 2005; Wilson et al., 2009; Inman et al., 2012a; Odden et al., 2013).

The aim of this study was to evaluate the suitability of experimental bait sites for brown bear hunting (from now on "bait sites") in forested areas in Sweden (Zedrosser et al., 2013; Steyaert et al., 2014) for the monitoring of wolverines. We compared an area in northern Sweden, with an established wolverine population (Schneider, 2012a), with an area at the southern fringe of the wolverine distribution, in south-central Sweden (Aronsson and Persson, 2012). The experimental design of this study was initially aimed at brown bears and contained two types of bait sites (i.e. permanent and temporary) based on a project evaluating the effects of bating for hunting purposes on brown bears and their behavior (Zedrosser et al., 2013; Steyaert et al., 2014). Data collected during this study was used to evaluate the presence, activity and behavior of wolverine at the bait sites.

In the present study I describe the general utilization of bait sites by wolverines, and in addition test some predictions about the use of these bait sites by wolverines. I predict that 1)

the visitation rate of wolverines to bait sites will be higher in the north than in the southern area, due to natural distribution range of wolverines; 2) the visitation rate will increase during the course of a year due to increased familiarity with the food source, and also because availability of alternative food sources (e.g., rodents, juvenile birds and mammals) is assumed to be lower during the latter part of the year (autumn); 3) that the use of permanent bait sites (i.e., bait sites active during the entire snow-free season; see methods) will increase throughout the entire study period, because of increased familiarity with the food source; 4) that permanent bait sites have a higher relative visitation frequency than temporary bait sites (i.e., bait sites active only during autumn; see methods) because of familiarity and higher predictability of these sites for the wolverines;); 5) because wolverines are active mainly at dusk, night and dawn, I predict that visitation frequency will be higher during hours of low human activity (night) than during hours with high human activity (day). Hence, I also predict that 6) duration of visits will be longer during hours of low human activity (night) than during hours of high human activity (day).

## 2. Material and Methods

### 2.1 Study areas

The study was conducted in Dalarna and Gävleborg counties in south-central Sweden (61ºN, 15ºE; from now on referred to as South), and Västerbotten County in northern Sweden (64ºN, 16ºE; from now on referred to as North), (Figure 1). The study period was from 2008 to 2012 (Vestøl, 2012; Zedrosser et al., 2013; Zedrosser et al., 2014). The landscape in the South a consists of hilly terrain with snow cover from approximately October to May, and precipitation averages 600-1000 mm annually (Martin et al., 2013). The North, i.e., Västerbotten, covers 55,000 $km^2$ as the second largest and the second most northerly county in Sweden. The main weather characteristics are cold winters with heavy precipitation and short summers. Forest covers more than 50% of the county (Schneider, 2009).

The vegetation in both study areas is dominated by Scotch pine (*Pinus sylvestris*) and Norway spurce (*Picea abies*) (Vestøl, 2012; Zedrosser et al., 2013) with silver birch (*Betula pendula*), European aspen (*Populus tremula*) and gray alder (*Alnus incana*) as common deciduous trees (Zedrosser et al., 2006). The coniferous species are subjected to intensively large-scale forestry (Dahle and Swenson, 2003; Schneider, 2012b; Zedrosser et al., 2013). The presences of human activity in the study areas is generally highest during summer and fall due to recreational activities, such as hunting, hiking, mushroom and berry picking (Linnell et al., 2000; Ordiz et al., 2011).

The wolverine population size in the South was estimated at 128-236 (95% Confidence Interval (CI)) individuals, and in the North at 120-219 (95% CI) (Karlsson and Eklund, 2014). Reproduction is general observed in the north of Sweden, with 99 % of all litters observed in Norrbotten, Västerbotten, Jämtland and Västernorrland counties, while the counties to the south accounted only for 1% of all litters observed (Naturvårdsverket, 2013).

## 2.2 Bait sites

The bait sites were originally designed to experimentally evaluate the use of bait sites by brown bears (Zedrosser et al., 2013). Two types of bait site were used in this study, i.e.; permanent and temporary bait sites. The establishment of permanent bait sites was as soon as snow and road conditions permitted, in the South usually in the middle of May and in the North usually in the beginning of June (Zedrosser et al., 2013). The bait sites were active (i.e., restocked with bait weekly) until either the onset of bear denning in middle of October (Friebe et al., 2001; Manchi and Swenson, 2005) or the first snowfall, depending on whichever came first. The location of permanent bait sites could not be changed throughout the study period, the location of temporary baits sites could be changed between years. The establishment of temporary bait sites was during the first week of August (usually corresponding to week 31) and were active during the hunting season of brown bear (i.e., from August 21 until October 15), (http://www.naturvardsverket.se/Var-natur/Jakt/Jakt-pa-rovdjur/Bjorn/) (accessed on 15.04.2014), or until the bear hunting quota was filled, the onset of denning, or the first snowfall, whichever came first (Zedrosser et al., 2013). Bait site locations were chosen with local field personnel with good experience as hunters to obtain a hunter's point of view. The locations selected were all in the forest but with a visibility of about 50 meters. In addition, all bait site locations were selected in accordance with regulations proposed by the authorities, i.e., >200m from the nearest road and >2000m from the nearest house or cabin (Schneider, 2011). All bait sites established were approved by the landowners and local hunting teams. Weekly restocking of bait sites was carried out with the same type and amount of baiting material throughout the study period and followed the regulations by the authorities to only use locally harvested/captured game meat or fish. The bait sites were weekly restocked with 5 kilogram (kg) meat or fish, 5 kg of corn (*Zea mais*), 5 kg of beet pulp (*Beta vulgaris*), and five liters of molasses (Vestøl, 2012; Zedrosser et al., 2013; Zedrosser et al., 2014).

## 2.3 Data collection

Remote cameras were set up at every bait site. Two different camera models were used at each bait sites to take pictures from different angles and to have a backup in case of technical

problems. The models used were the STC-DVIR5 Prowler (Prowler) and Scout Guard Infrared Digital scouting camera SG560 Series (Scout). Both models were equipped with remotely-triggered infrared motion sensors and installed at an angle of ~ 90 degree at a distance of ~ 5 m from the bait. When the infrared sensor was triggered by movement, the Prowler model took a burst of three consecutive pictures, followed by a 30 second (sec) interval, after which a new burst of three pictures would be taken in case of continued movement. The Scout model took a burst of nine consecutive pictures with a 60 sec delay until the next burst of nine pictures. Both models were set to the highest image quality. The infrared trigger sensor sensitivity modus was generally set at maximum, but had to be decreased in some instances due to moving vegetation and wind which triggered cameras too easily (Vestøl, 2012; Zedrosser et al., 2013; Zedrosser et al., 2014). Battery change and image downloading from the SD-card was carried out whenever a site was restocked with baiting material (Vestøl, 2012; Zedrosser et al., 2013; Zedrosser et al., 2014).

## 2.4 Data processing

All pictures were uploaded into the software Camera Base Version 1.6 (Tobler, 2014; 2015). The software automatically extracts all metadata (date, time, picture id, etc.) of every picture taken in the field and the raw data are be exported and stored in XML-format. Afterwards, every picture was inspected manually to document if an animal had been photographed and to determine the species. The raw data from the XML-form were then transformed and exported into Excel (Microsoft Office Excel 2013 ®) for further analyses (Vestøl, 2012; Zedrosser et al., 2013; Zedrosser et al., 2014). In case pictures were taken at the same date and time by both cameras at a given bait site, the picture with the poorest quality was removed from the analysis.

## 2.5 Definitions

### 2.5.1 Definition of a bait site visit

A bait site visit was defined based on one or a series of consecutive picture bursts (with a 30 sec delay for model Prowler and 60 sec delay for the Scout model) that was triggered by a wolverine visiting a bait site. The shortest possible time delay between two nonconsecutive pictures burst was 2 minutes (min). We defined one bait sites visit as a series of picture bursts following by a >10 min delay, because the majority (95%) of time delays between two non-consecutive bursts was <10 min. No marked individuals were present in the study area, which made it difficult to differentiate among individuals (Zedrosser et al., 2014). Therefore, I was not able to ascertain if the same individual carried out two consecutive visits or not.

### 2.5.2 Definition of diurnal patterns and season for a bait site visit

The meteorological information sunrise (day) and sunset (night) was obtained from the webpage www.timeanddate.no (accessed on 14.03.2014). However, due to the long daylight hours during the summer in northern Sweden, the meteorological information may not reflect wolverine patterns in relation to human recreational patterns. I therefore separated wolverine activity patterns into two diurnal classes, i.e., day, lasting from 06:00 to 18:00, and night, lasting from 18:01 to 05:59, based on human activity patterns (Zedrosser et al., 2014). The two seasons spring/summer and autumn were defined based on the hunting season of brown bears in Sweden, which starts on August 21 ; thus spring/summer season was defined the time period from bait establishment until July 31, and the fall season was defined as August 1 until the onset of bear denning. This seasonal division also coincided with the start of temporal bait sites in a given year (i.e., August 1).

### 2.5.3 Definition on behavioral patterns observed at bait sites

I categorized the behaviors observed on pictures taken at bait sites into six different categories (see Figure 2 for examples): A) Investigating: the wolverine investigated the bait with interest, circling around with the nose pointed directly at the bait site; B) Walking/running: walking/running towards or away from the bait site, or walking/running past a bait site with the nose not pointed at the bait site; C) Foraging: collecting/consuming of food from the bait; D) Scent marking: the wolverine assumes a squatting position, sometimes pressing its anal region onto a substrate, thus indicating urination or scent marking with anal glands secretion; E) Vigilance: a still-standing position and sniffing with the nose pointed into the surrounding area, the interest seemingly shifted away from the bait; F) Food caching: food collected at a bait site is carried away to another location (MacNulty et al., 2007; Wilson et al., 2009; Zedrosser et al., 2014).

## 2.6 Statistical analysis

To determine the wolverine visitation frequency and behavior at the bait sites, a series of non-parametric statistical tests were conducted. The frequency data was tested using Chi-square tests and Mann-Whitney U tests. I also tested the observed behavioral differences with Chi-square tests. A Spearman rank correlation test was used to test for relationships between the variables “number of visits” and “duration of a visit at a bait site”. The statistical analysis was carried out with the software R (3.0.2) (http://www.R-project.org/) (accessed on 30.08.2014). P-values $<0.05$ were considered as statistically significant, and p-values $<0.1$ as statistical tendency/trend (Vetter, 2002; Wheater, 2003; Whitlock and Schluter, 2015).

## 3. Results

In total, 54 bait sites were placed at 26 different locations from 2008 to 2012; of which 8 locations were in the North and 18 in the South; 13 of the bait sites were used ≥ 2 years in a row (Table 1). In the North only temporary bait sites were constructed in 2010, but from 2011 to 2012 three of these continued further as permanent bait sites (Zedrosser et al., 2013; Zedrosser et al., 2014).

Overall, 79,239 pictures of wildlife (mammals and birds) were captured at the bait sites (Table 2). The wolverine was the fifth-most common species detected at the bait sites, and the third-most common mammal with 1,297 (1.64%) images, of which 1,234 (95%) images were taken in the North from 2010 – 2012, and 63 (5%) in the South, in 2010 only. The most common mammals at the bait site were the brown bear with 43,338 pictures (54.7 %), and the red fox (*Vulpes vulpes*) with 1,772 (2.2%) pictures in total. The most common bird species was the raven (*Corvus corax*) with 20,517 (25.9%) pictures, and the European jay (*Garrulus glandarius*) with 11,153 (14.1%) pictures in total (Table 2).

### 3.1Visitation frequency and rate

Wolverines visited bait sites 74 times during the study period (Table 3). Of 18 bait locations in the South, only one (5%) was visited, and of eight bait sites in the North three (37.5%) were visited by wolverines (Table 4). The first visit by a wolverine to an experimental bait site in a given year took an average of 42 ± 35 (SD) days after a bait site was established, with a median and range of 32.5 and 15-132 days. During the entire study period, significantly more bait site visits were observed in the North than in the South ($X^2_{6.635}$ = 55.351, DF = 1, $P < 0.001$). The North had 69 (93.3%) visits in total whereas the South had five visits in total (6.7%). No further analyses on differences between South and North were conducted due to the low sample size from the South. Therefore, both study areas were combined in all further analyses.

There were significant difference in visitation frequency between 2012 (13 visits; 17.6%) and 2011 (30 visits; 40.5%) ($X^2_{6.635}$= 6.720, DF = 1, $P < 0.01$), and between 2012 and 2010 (31 visits; 41.9%) ($X^2_{6.635}$= 7.363, DF = 1, $P < 0.01$), but there was no significant differences between 2010 and 2011 ($P > 0.05$). I found no significant differences between the median number of visit per seasons during the entire study period (spring/summer: 2.5; autumn: 3), (Mann-Whitney U-test; $P = 0.557$).

The mean weekly visitation rate to the bait sites was 3.7 ± 3.6 visits, with a median and range of 3 and 0-14. More descriptive statistics are displayed in table 5. The visitation rate per week by wolverines to a bait sites was significantly different between weeks ($X^2_{36.191}$ = 62.756, DF =

19, $P < 0.01$; Figure 3), however, the pattern did not follow a decreasing or increasing trend but rather appears random (Figure 3). There was a significant difference in visitation frequency between permanent bait sites (48 visits; 64.9%) and temporary bait sites (26 visits; 35.1%) ($X^2_{3.841} = 6.540$, DF = 1; $P < 0.05$).

### 3.2 Diurnal visitation rate

The bait sites were visited significantly more often during night hours (51 visits; 68.9 %) than during day hours (23 visits; 31.1 %) ($X^2_{6.635} = 10.594$, DF = 1, $P < 0.01$). The mean number of wolverine visits to the baits within 24 hours was 3.0 ± 2.7 with a median and range of 3 and 0-10 (Table 5). Bait site visits by wolverines were significantly more often carried out during morning and evening hours, and no bait site visit was recorded between 13:00 to 16:00 ($X^2_{36.191} = 52.666$; DF = 19, $P < 0.01$; Figure 4)..

### 3.3 Duration time of bait site visits

The mean time a wolverine spent at a bait site during a visit was 6.3 ± 8.2 min, with median and range of 2.6 and 0.01-33.5 (Table 6)[1]; 24 visits (33.8 %) lasted ≤ 0.5 min; 48 visits (64.9 %) lasted ≤ 5 min, and 57 visits (77.1 %) lasted ≤ 10 min (Figure 5).

The mean duration of a visit to a bait site by wolverine during spring/summer was 5.6 ± 8.8 min, with a median and range of 2.3 and 0.15-33.5 min, and a mean of 6.6 ± 7.9 (SD) during autumn, with a median and range of 3.7 and 0.14-31.2 min (Table 6). There was no significant difference in median duration time between visits in spring/summer and autumn season (Mann-Whitney U-test; $P = 0.638$; Figure 6).

The mean duration of a visit to a bait site by wolverine during a week was 23.2 ± 38.3 min (Table 6). The duration of a visit at bait sites differed significantly between weeks ($X^2_{30.144} = 1185.9$, DF = 19, $P < 0.01$; Figure 7). I found a significant positive correlation between the visitation rate and the duration at a bait site by wolverines ($r_s = 0.938$, $n = 20$, $P < 0.01$; Figure 8).

There was no significant difference in the median duration time of visits between day and night hours in relation to human activity patterns (Mann-Whitney U-test; $P = 0.461$; Figure 9). The mean duration of a visits to a bait sites by wolverines was 4.9 ± 6.5 min during day hours, with a median and range of 2.3 and 0.01-25, and 6.9 ± 8.8 min during the night hours, with median and range of 3.3 and 0.02-33.5 (Table 6). The duration time of visits at bait sites was

[1] Note that negative times are not possible, but the large standard deviation (SD) is statistically correct, caused by the skewedness and kurtosis of the data (see Table 6).

significantly different among different hours of the day ($X^2_{35.172}$ = 540, DF = 23, $P$ < 0.01; Figure 10).

The mean duration of a visit to a temporary bait sites was 5.8 ± 6.8 min, with a median 3.4 and range of 0.01-25, and at permanent bait sites a mean of 6.5 ± 8.9 min, with a median of 2.6 and a range of 0.01-33.5 (Table 6). There was no significant difference in median duration between visits at a temporary and permanent bait sites (Mann-Whitney U-test; $P$ = 0.927; Figure 11).

### 3.4 Duration between bait site visits

The mean duration, in hours (h), between two consecutive visit to a bait site by wolverines during the entire study period was 79 ± 162.4 hours, with a median and range of 2.8 and 0.1-722.5 (Table 7), which is equivalent to a mean of ~3 ± 7 days, with a maximum of ~ 30 days until the next revisit (Figure 12).

Total duration time (h) between two consecutive visits to a bait site by wolverines during spring/summer was a mean of 55.4 ± 188.1 h, with a median and range of 0.5 and 0.2-401.9, and during autumn a mean of 89.8 ± 179.2 h, with a median and range of 4 and 0.1-722.5 (Table 7). There was no significant difference in the median duration time between visits in spring/summer and autumn (Mann-Whitney U-test; $P$ = 0.632; Figure 13).

However, 71.4 % of all the revisits to a given bait site took place within a day (in a 24 hours period). The mean duration time until the next revisit to an experimental bait site within a 24 hour period, was 2.9 ± 5.1 h, with a median and range of 0.5 and 0.1-21.9 (Table 7).

The mean duration time between two consecutive visits to a temporary bait site was a mean of 46.7 ± 133.898 h, with a median and range of 1.1 and 0.2-634.2 and to a permanent bait site a mean of 96.9 ± 175.1 h, with a median and range of 4.1 and 0.2-722.3 (Table 7). There was no significant difference in the median duration time between temporary and permanent bait sites (Mann-Whitney U test; $P$ = 0.429; Figure 14).

### 3.5 Behaviors observed at bait sites

The frequencies of behaviors observed at the bait sites were significantly different between each of the six defined behavior (see methods) ($X^2_{15.086}$= 2157.046, DF = 5, $P$ < 0.01). Investigating was the most frequent behavior wolverines displayed during visits (64%), followed by walking/running (14%), and vigilance/sniffing (9%). Food caching was the least frequently observed behavior (1%) (Figure 15).

The frequencies of behaviors observed during day and during night visits differed significantly ($X^2_{6.635}$= 39.5199, DF = 1, $P$ < 0.001; Figure 16). All of the observed behaviors were recorded more frequently during the night than during the day, with the exception of foraging behavior, which was more commonly observed during the day than during the night (Figure 16).

## 4. Discussion

My results suggest that bait sites in combination with remote cameras in general are useful for the monitoring of wolverines in Scandinavia, also if the bait sites are aimed at other carnivorous species. The use of camera technology is deeply rooted in wildlife research and management (Silvy, 2012), and the study design originally aimed at brown bears illustrate its usefulness also for wolverines.

Observations at the experimental baits sites show a species-specific pattern with almost 55 % of all pictures of wildlife displaying bears. Wolverine bait site visits were almost exclusively restricted to the North. In comparison to other mammals observed at the bait sites, wolverine visitation rate was relatively high, especially in the North. Wolverines were the second most frequent mammal, behind bears, observed in the North, and the third most-frequent mammal, behind bears and red fox, in the South. These results correspond well with the general distribution pattern of wolverines in Sweden, with higher concentration of individuals in the northern parts of the country and only few individuals in the southern parts (Schneider, 2009; Persson and Brøseth, 2011; Persson et al., 2011; Aronsson and Persson, 2012). The results also correspond well with the foraging behavior of wolverines, i.e., as scavengers and their use of carcasses (Wilson et al., 2009; Inman et al., 2012b; Inman et al., 2013).

It took a wolverine an average of 42 days to find an experimental bait site designed for bears in my study. In comparison, it took wolverines an average of 72 days to find bait sites at hunting hides specifically designed for wolverines in Norway (Mattisson et al., 2013) , while it took an average of 7.1 days for the wolverine to find reindeer or sheep killed by predators and 10.3 days to find slaughter remains at hunting hides. This can indicate that wolverines discover the bait sites established in this study for bears rather randomly. In addition, the bait sites were stopped at the onset of winter in my study design, which may be the most effective time to bait wolverines (Mattisson et al., 2013; Odden et al., 2013). Moreover, the study design was focused at lower elevation forest areas with higher bear densities in both the South and the North (Schneider, 2009; Schneider, 2012a; Zedrosser et al., 2013). Wolverines overlap their distributional range with brown bears in Scandinavia (Schneider, 2009), however, wolverines

generally prefer terrain at higher elevations (May et al., 2008), whereas bears prefers forested areas at lower elevations (Martin et al., 2010). The wolverine are currently expanding their distribution range into lower elevations and forested areas (Persson et al., 2011; Aronsson and Persson, 2012), and prefer lower elevation increasingly throughout the summer and nightly hours (May et al., 2010).

I observed the highest visitation frequency in the first year of the study (2010) and the annual visitation rate was significantly lower in 2012, i.e., the last year of the study, suggesting that that the assumption of baiting (Steyaert et al., 2014; Zedrosser et al., 2014) does not fully hold for wolverines during our overall study period. This result therefore contradicts with my prediction that wolverine visitation rate will increase throughout the entire study period. Wolverines' use of their home range can vary between seasons (Persson, 2003), but I did not observe a significant variation in visitation frequency between spring/summer and autumn seasons. My findings are similar to the study of Mattisson et al. (2013), which found that re-visitation probability to a given bait site by wolverines decreased over time.

The mean weekly visitation rate of wolverines to bait sites was 3.7 visits per week, and differed significantly between the weeks throughout the study period. The highest observed visitation rate was in the last week of study (in the middle of October) with 14 visits. Wolverines shift their diet in relations to seasonal patterns, with more facultative scavenging towards and during the winter season due to higher mortality among ungulates and snow conditions (Persson, 2003; Gustavsen, 2006; Persson et al., 2006; Copeland et al., 2010; Koskela et al., 2013). The experimental design used in this study was aimed at brown bears, which usually start hibernation in the middle of October in Sweden. For the population monitoring of wolverines it would have been advantageous to maintain the bait sites also during the winter months (Friebe et al., 2001; Manchi and Swenson, 2005; Zedrosser et al., 2013; Zedrosser et al., 2014).

The bait study of wolverines conducted by Mattisson et al. (2013) in Norway observed an average of 3.2 visits to bait sites at hunting hides (in Swedish: åtelkoja"), and observed the highest visitation rates at bait sites stocked with carcasses of reindeer, sheep and moose carcasses that died of natural causes as well as with slaughter remains. Bait sites with prey killed by a wolverine had the highest observed frequency of visitation (Mattisson et al., 2013). However, wolverines readily use ungulate carcasses killed by other predators, such as lynx and wolfs (van Dijk et al., 2008a; Van Dijk et al., 2008b; Wilson et al., 2009; Mattisson, 2011; Mattisson et al., 2011a). There is little information in the literature of wolverines utilizing bear

kills. This may be related to the fact the main predation of bears on ungulates is on calves in the spring, which are usually consumed entirely within a short timer period (Dahle et al., 2013). In addition, bears hibernate during the winter months (Sahlén et al., 2011), when the scavenging behavior of wolverines is at its peak (Inman et al., 2012a). I did not observe wolverines visiting a given bait site on the same day as a bear visited the same bait site. This spatial and temporal avoidance could be due to asymmetrical intra-guild predation and competition, which is common among carnivores (van Dijk et al., 2008a; Mattisson et al., 2011b).

The underlying assumption of baiting and bait sites is that a given species would increase its probability to visit a more stable and predictable (in space and time) food source rather than a temporary and/or unpredictable food source (Zedrosser et al., 2014). In general, wolverines used both temporary and permanent bait sites, but a significantly higher visitation frequency was recorded at permanent bait sites. Wolverines visited temporary bait sites only during one year (2010) in the North, but three of the originally temporary bait site in the North were used as permanent bait sites in 2011 and 2012.

The wolverine is generally considered a nocturnal species (Beauvais and Johnson, 2004; May et al., 2008), which has also been suggested in the similar bait study by wolverines in Norway (Beauvais and Johnson, 2004; May et al., 2008; Mattisson et al., 2013). This nocturnal behavior of wolverines was also visible in this study, as wolverines visited bait sites significantly more often during the night than day hours. I did not observe any visitation by wolverine around midday (from 13:00 to 16:00). Most of the visits lasted under 10 minutes (~ 77%). I found no differences between time wolverine spent at the bait site in relation to seasons, but the time wolverine spent at a bait site differed significantly between the weeks of study. There was a positive relationship between the number of consecutive visits per week and time spent at a bait site, suggesting that wolverines may become more familiar with a food source and thus spend more time during consecutive visits. The general pattern of time spent at the bait site differs significantly between the hours of a day, showing that wolverines are more active during crepuscular hours (Stephens, 2008), however this pattern was not significant in relation to typical human activity patterns.

I observed that the majority (71%) of the re-visits to a given bait site occurred within 24 hours, with a mean of ~3 hours between two consecutive visits. The maximum time between two visits was 30 days. The visitation frequency by wolverines to bait sites observed in this study can thus be described as temporally and spatially clustered, i.e., several visits at one bait site within a short period of time are followed by a long time period until the next cluster of

visits (May et al., 2010; Zedrosser et al., 2014). Based on the behavior of wolverine, i.e. strict territoriality, with low population density (May, 2007; Persson et al., 2010; Mattison et al., 2011; Inman et al., 2012b), it is likely that two consecutive visits were made by the same individual, however due to the lack of marked individuals in this study I was not able to ascertain this pattern.

The most frequent behavior (Silvy, 2012) observed at experimental bait sites was investigation of the site, which can be explained by the wolverines role in the ecosystem as a scavenger (Walker et al., 2001; Persson, 2003; van Dijk et al., 2008a; Wilson et al., 2009). Investigation of the food source may also give a wolverine important information to avoid intra-guild predation (Linnell and Strand, 2000; May et al., 2008; van Dijk et al., 2008a) and intraspecific predation (Persson et al., 2003). This may also explain why I observed vigilance and sniffing as the third most common behavior observed at the bait sites. Walking or running was the second most observed behavior of wolverines. This activity is a vital behavior for the wolverine, as a facultative scavenger (Pereira et al., 2014), predator, and territorial species (Wolff and Peterson, 1998; Vangen et al., 2001; Persson, 2003; Persson et al., 2003; Wilson et al., 2009; Persson et al., 2010; Andrén et al., 2011; Mattisson et al., 2011b), and wolverines can travel up to 30 km a day (Wilson et al., 2009). The fourth, fifth and sixth most frequent behaviors captured on pictures was foraging on site, scent marking, and food caching, in this order. One of the cameras was accidentally switched on recording video clips instead of still pictures (Zedrosser et al., 2014), and less frequent observed behavior as food caching and scent marking was more noticeable. This indicates that, when the goal is to detect wolverine behavior with the use of remote cameras, video clips may be useful to capture rare behaviors. Scent marking the bait area likely indicates communication between conspecifics and ownership of a food sources (Wilson et al., 2009). Food caching is a well-known behavior that wolverine use to store food throughout the winter (Inman et al., 2012a).

Supplementary feeding sites and bait sites can provide useful tools for the management of large carnivores (Steyaert et al., 2014). Besides information collected with the use of remote cameras, these sites can serve as collection locations for non-invasive molecular information, such as feces, urine, and hair samples for DNA analysis (Hedmark et al., 2004; Flagstad et al., 2006; Flagstad et al., 2010) (Magoun et al., 2011; Aronsson et al., 2015). This study shows that bait sites can be used for the absence/presence monitoring of wolverines, and in combination with individual identification from remote cameras and/or genetic samples, also could give insights into the spatiotemporal activity patterns, demographic characteristics, dispersal, and

geographically distribution of wolverines (Sæther et al., 2005; van Dijk et al., 2008a; Wilson et al., 2009; May et al., 2010; Persson et al., 2010; Vangen et al., 2001).

Monitoring of the wolverines distribution, abundance, and life history becomes increasingly important as their Nordic ecosystem is changing due to climatic change (Walther et al., 2002) The wolverine is adapted to artic and sub-arctic climate (Wilson et al., 2009; Inman et al., 2012b; Inman et al., 2013), and as a top-down predator, may be especially vulnerability to environmental changes (Brodie and Post, 2010; McKelvey et al., 2011; Inman et al., 2012a). Snow cover is especially important during the reproductive denning period of wolverines (Magoun and Copeland, 1998; Persson et al., 2006; Aubry et al., 2007; Copeland et al., 2010; McKelvey et al., 2011). Further studies based on baiting methods should consider large-scale analyses to evaluate population responses to climate change (Brodie and Post, 2010). Stocking the bait sites with reindeer, moose or other natural food sources that wolverine utilize in that specific habitat and season (Mattisson et al., 2013) may increase visitation frequency and may also provide clues in relation to intra-guild competition (van Dijk et al., 2008a; Mattisson et al., 2011a). Bait sites specifically aimed at wolverines should be active all year around, and especially during the winter, because wolverines shift their foraging behavior toward scavenging in winter months (Walker et al., 2001; Persson, 2003).

## 5. Conclusions

I observed that wolverines were attracted to experimental bait sites originally designed for brown bears, and observed more frequent visitation in the North and at permanent bait sites. The wolverine was the third most common mammal observed at bait sites, even though the location of the bait sites was suboptimal for wolverines, i.e., at lower elevation boreal forest, with high densities of bears. The wolverine was the second most common observed mammal in the North, which corresponds well with its established population in Västerbotten County. Therefore, it seems reasonable that the prevalence of visits to bait sties can be viewed as a proxy of the wolverines' abundance throughout the study areas and Sweden.

I observed a total of 74 visits by wolverine to an experimental bait site throughout this three years study period, however, I could not identify the individuals. However, observations based on fur patterns and body size indicate that only a few individuals visited the majority of the bait sites. Observation also indicates that males and lone female wolverines visited the bait sites, because I never observed any family groups. Wolverine visited the bait sites at crepuscular hours, and I did not observe wolverines at experimental bait site during midday.

The average duration time of one visit at a bait site lasted ~ 6 minutes, and most of the visits lasted less than 10 minutes (~77%). The average time between two consecutive visits was ~79 hours, which is equivalent to ~3 days. I observed that most of the re-visits to a bait sites took place within 24 hours, with a long period of time until the next visit.

The most frequent behavior observed at the bait sites was investigating, and behavior did differ between day and night. The study design was not optimal toward attracting wolverines to visit an experimental bait site, and should be modified to be more specie-specific. Bait sites should be maintained throughout the winter months, when wolverines' diet shift, showing more scavenging behavior. Interestingly, when comparing my results with Mattisson et al. (2013), there was similarity in the visitation frequency, suggesting that bait sites aimed at other species could function as a method to attract wolverines.

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**Tables**

**Table 1:** The number of different experimental bait sites established per year in Dalarna/Gävleborg counties and Västerbotten County in Sweden from 2008 to 2012.

| | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | perm | temp | perm | temp | perm | temp | perm | temp | perm | temp |
| Dalarna/Gävleborg | 0 | 8 | 2 | 8 | 2 | 4 | 2 | 4 | 2 | 4 |
| Västerbotten | - | - | - | - | - | 6 | 3 | 3 | 3 | 3 |

**Table 2:** Absolute number of pictures taken of large mammals and selected bird species at experimental bait sites in Dalarna/Gävleborg counties (2008-2012)* and Västerbotten County (2010 to 2012).

| Species | | Västerbotten | Dalarna | Total | Proportion |
|---|---|---|---|---|---|
| Brown bear | *Ursus arctos* | 16731 | 26607 | 43338 | 54.69 |
| Raven | *Corvus corax* | 8950 | 11567 | 20517 | 25.89 |
| Eurasian jay | *Garrulus glandarius* | 10860 | 293 | 11153 | 14.08 |
| Red fox | *Vulpes vulpes* | 216 | 1556 | 1772 | 2.24 |
| Wolverine | *Gulo gulo* | 1234 | 63 | 1297 | 1.64 |
| Dog | *Canis lupus f.* | 117 | 128 | 245 | 0.31 |
| Badger | *Meles meles* | 240 | 0 | 240 | 0.30 |
| European pine marten | *Martes martes* | 221 | 3 | 224 | 0.28 |
| Moose | *Alces alces* | 102 | 51 | 153 | 0.19 |
| Golden eagle | *Aquilla chrysaethos* | 18 | 120 | 138 | 0.17 |
| Capercaillie | *Tetrao urogallus* | 48 | 0 | 48 | 0.06 |
| Roe deer | *Capreolus capreolus* | 9 | 39 | 48 | 0.06 |
| Mountain hare | *Lepus timidus* | 36 | 6 | 42 | 0.05 |
| Eurasian lynx | *Lynx lynx* | 18 | 6 | 24 | 0.03 |
| Total | | 38800 | 40439 | 79239 | |

*****Note that pictures of wolverines was observed only in year 2010 from areas in Dalarna/Gävleborg counties.

**Table 3:** The frequency of wolverine visits (N=74) per year to experimental bait sites in Dalarna/Gävleborg counties and Västerbotten County, Sweden. Dalarna and Gävleborg had 18 bait sites from 2008 to 2012 and Västerbotten had eight bait sites from 2010 to 2012 (Table 1).

| Bait site type | | 2008** | 2009** | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Permanent | | | | | | |
| | Dalarna | 0 | 0 | 5 | 0 | 0 |
| | Västerbotten | - | - | 0 | 30 | 13 |
| Temporary | | | | | | |
| | Dalarna | 0 | 0 | 0 | 0 | 0 |
| | Västerbotten | - | - | 26 | 0 | 0 |

**No experimental bait sites in Västerbotten County" (Zedrosser et al. 2013).

**Table 4:** The absolute number of wolverine visits (N=74) at each experimental bait sites with at least one visit, in relation to type of bait sites (temporary, permanent) and years in Dalarna/Gävleborg counties, south-central Sweden and Västerbotten County, northern Sweden from 2008-2012.

| Location | Bait site type | County | Year of study | Frequency of visits |
|---|---|---|---|---|
| Djupdalsberget | Temporary | Västerbotten | 2010 | 23 |
| Skallvattenberget | Temporary | Västerbotten | 2010 | 1 |
| Svartberget-östra | Temporary | Västerbotten | 2010 | 2 |
| Lannaberget | Permanent | Dalarna/Gävleborg | 2010 | 5 |
| Skallvattenberget | Permanent | Västerbotten | 2011 | 25 |
| Svartberget-östra | Permanent | Västerbotten | 2011 | 5 |
| Djupdalsberget | Permanent | Västerbotten | 2012 | 5 |
| Skallvattenberget | Permanent | Västerbotten | 2012 | 5 |
| Svartberget-östra | Permanent | Västerbotten | 2012 | 3 |

**Table 5:** Visitation rate by wolverine (N=74) per week and throughout a day summarized for both study areas and all years combined, to experimental bait sites in Dalarna/Gävleborg counties, south-central Sweden and Västerbotten County, northern Sweden from 2008-2012.

| Descriptive statistics | Week | 24-hour period |
|---|---|---|
| Mean | 3.7 | 3 |
| Median | 3 | 3 |
| Mode | 1 | 3 |
| Standard Deviation | 3.6 | 2.7 |
| Kurtosis | 2.7 | 0.8 |
| Skewness | 1.5 | 1 |
| Variance | 12.2 | 6.9 |
| Range | 14 | 10 |

**Table 6:** Wolverines' duration time, calculated minutes (min), for each visit (N=74) summarized with variables; season (spring/summer and autumn), week, time of day (day and night), 24-hour period and bait site type (permanent and temporary).

| Statistic | Total duration | Spring/summer | Autumn | Week | Day | Night | 24 hour period | Temporary | Permanent |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 6.3 | 5.6 | 6.6 | 23.2 | 4.9 | 6.9 | 19.2 | 5.8 | 6.5 |
| Median | 2.6 | 2.3 | 3.7 | 4.2 | 2.3 | 3.3 | 12.4 | 3.4 | 2.6 |
| Mode | 0.02 | 0.13 | 0.02 | 0 | 0.01 | 0.02 | 0 | 0.03 | 0.02 |
| SD | 8.2 | 8.8 | 7.9 | 38.3 | 6.5 | 8.8 | 21.2 | 6.8 | 8.9 |
| Kurtosis | 2.1 | 4.1 | 1.4 | 2.6 | 3.1 | 1.6 | 1.8 | 1.3 | 2 |
| Skewness | 1.6 | 2.1 | 1.4 | 1.8 | 1.8 | 1.5 | 1.5 | 1.3 | 1.7 |
| Variance | 66.8 | 78 | 62 | 1472.8 | 42 | 78 | 450.8 | 46 | 79 |
| Range | 33.5 | 33.5 | 31.2 | 133.2 | 25 | 33.5 | 77.5 | 25 | 33.5 |

**Table 7:** Wolverines' duration time between two consecutive visits at experimental bait sites summarized with variables; season (spring/summer and autumn), 24-hour period and bait site type (permanent and temporary), for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

| Statistic | Total duration (h) | Spring/summer | Autumn | 24-hour period | Temporary | Permanent |
|---|---|---|---|---|---|---|
| Mean | 79 | 55.4 | 89.8 | 2.9 | 46.7 | 96.9 |
| Median | 2.8 | 0.5 | 4.0 | 0.5 | 1.1 | 4.1 |
| Mode | 0.6 | 0.3 | 0.6 | 0.6 | 0.4 | 0.3 |
| SD | 162.4 | 188.1 | 179.2 | 5.1 | 133.9 | 175.1 |
| Kurtosis | 5.4 | 2.9 | 4.6 | 5.1 | 16.7 | 3.5 |
| Skewness | 2.4 | 2.0 | 2.3 | 2.4 | 3.9 | 2.0 |
| Variance | 26370.7 | 13946.5 | 32103.9 | 26.2 | 17928.8 | 30653.4 |
| Range | 722.5 | 401.9 | 722.5 | 21.9 | 634.2 | 722.3 |

## Figures

**Figure 1:** Map of the study areas in Dalarna/Gävleborg counties, south-central Sweden from 2008-2012, in left panel, and Västerbotten County, northern Sweden from 2010-2012, in right panel. Both study areas had permanent and temporary bait sites. Permanent bait sites were established annually as soon as the weather conditions permitted and stayed active until the first snowfall. Temporary bait sites were also established annually during the first week of August and stayed active until the bear hunting quota was filled, bear denning onset or the first snowfall (Zedrosser et al., 2013).

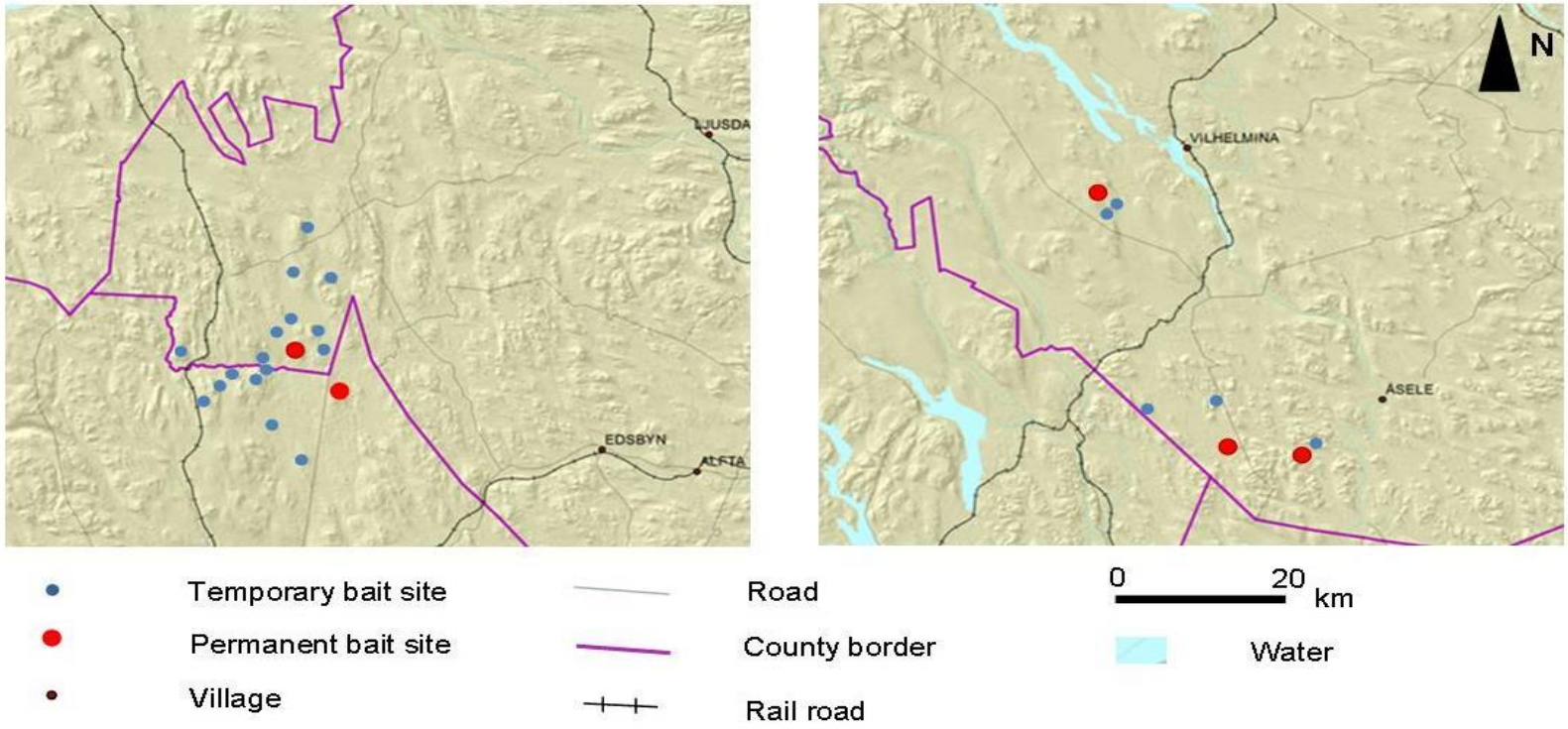

**Figure 2:** Examples of wolverine behavior at experimental bait sites in Dalarna and Gävleborg counties, south-central Sweden, and Västerbotten County, northern Sweden, 2008-2012. ): A) Investigating: the wolverine investigated the bait with interest, circling around with the nose pointed directly at the bait site; B) Walking/running: walking/running towards or away from the bait site, or walking/running past a bait site with the nose not pointed at the bait site; C) Foraging: collecting/consuming of food from the bait; D) Scent marking: the wolverine assumes a squatting position, sometimes pressing its anal region onto a substrate, thus indicating urination or scent marking with anal glands secretion; E) Vigilance: a still-standing position and sniffing with the nose pointed into the surrounding area, the interest seemingly shifted away from the bait; F) Food caching: food collected at a bait site is carried away to another location.

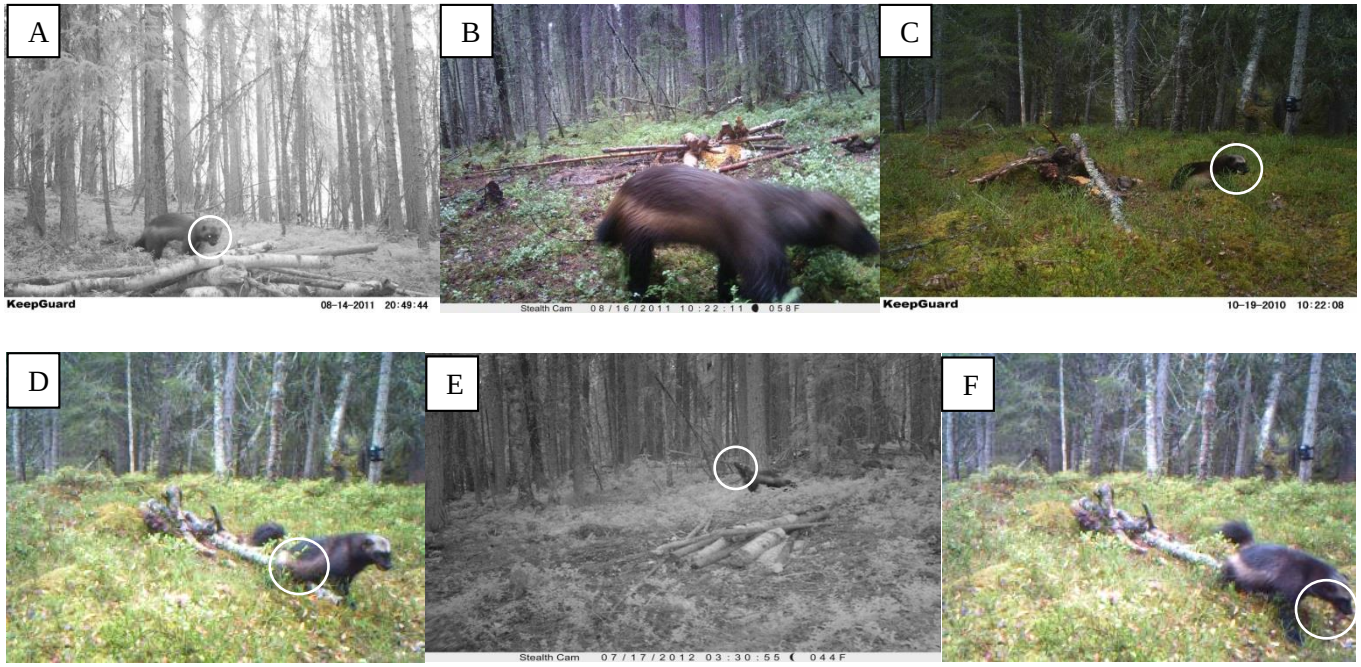

**Figure 3:** Frequency distribution of visits per week by wolverines to experimental bait sites (N=74) in Dalarna/Gävleborg counties (n=5), south-central Sweden and Västerbotten County (n=69), northern Sweden from 2008-2012. Week 23 is usually in the beginning of June, week 31 usually the first week of August and week 42 usually in the middle of October. Week 31 represent the establishment of temporary bait site. Temporary bait sites could move to another location from year to year, but permanent bait sites were established at the same place annually.

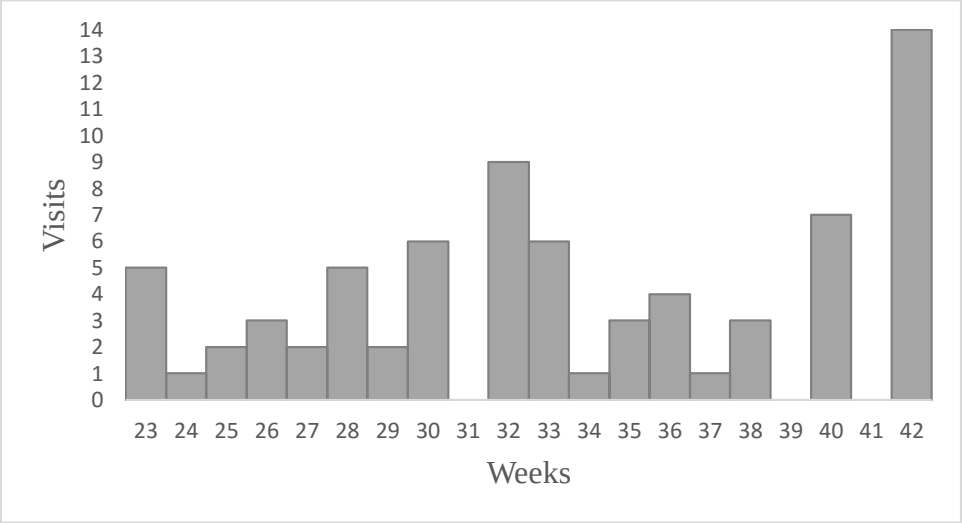

**Figure 4:** Frequency distribution of visits by wolverines within 24 hours to the experimental bait sites (N=74) in Dalarna/Gävleborg counties (n=5), south-central Sweden and Västerbotten County (n=69), northern Sweden from 2008-2012.

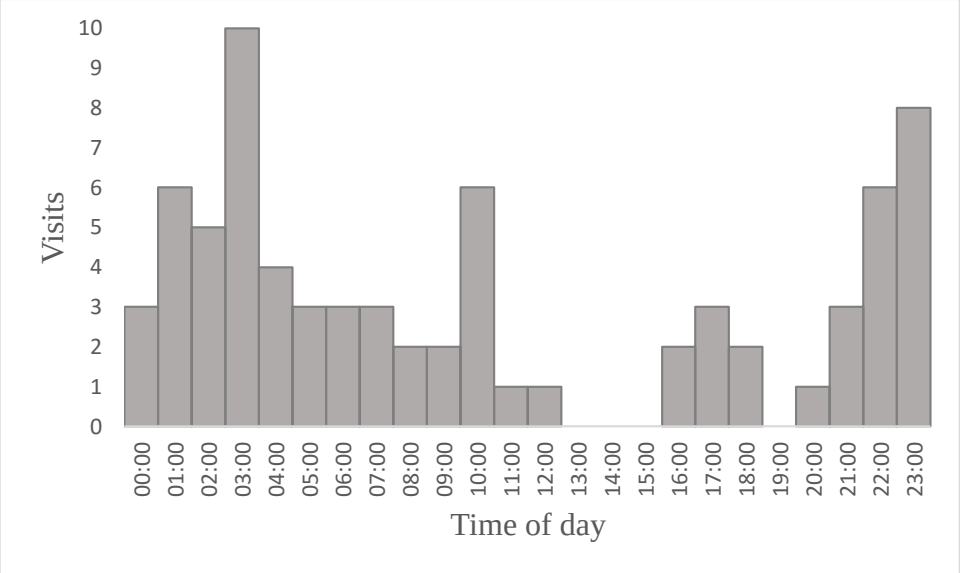

**Figure 5:** Frequency distribution of the duration time (in minutes) of visits (N=74) by wolverines at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

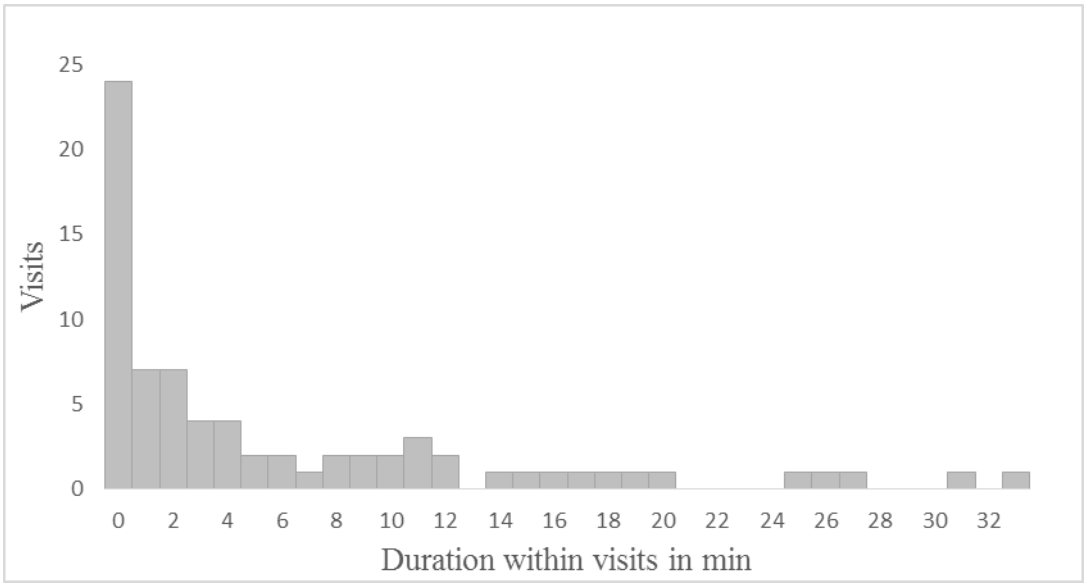

**Figure 6:** Boxplot of duration time (in minutes) of visits (N=74) by wolverines in relation to season, i.e., spring/summer (n=26) and autumn (n=48), at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

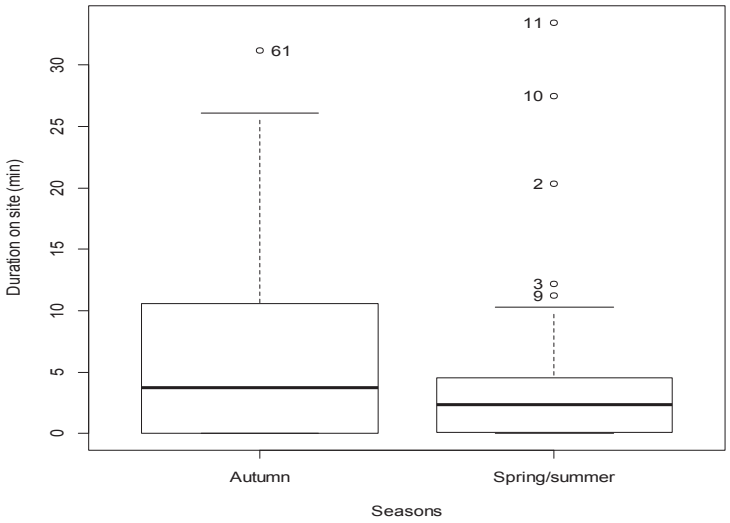

**Figure 7:** Frequency distribution of duration time (in minutes) of visits by wolverines in relation to weeks to experimental bait sites (N=74) in Dalarna/Gävleborg counties (n=5), south-central Sweden and Västerbotten County (n=69), northern Sweden from 2008-2012. Week 23 is usually at the beginning of June, week 31 usually the first week of August, and week 42 usually in the middle of October. Week 31 represent the establishment of temporary bait site. Temporary bait sites could move to another location from year to year, but permanent bait sites were established at the same place annually.

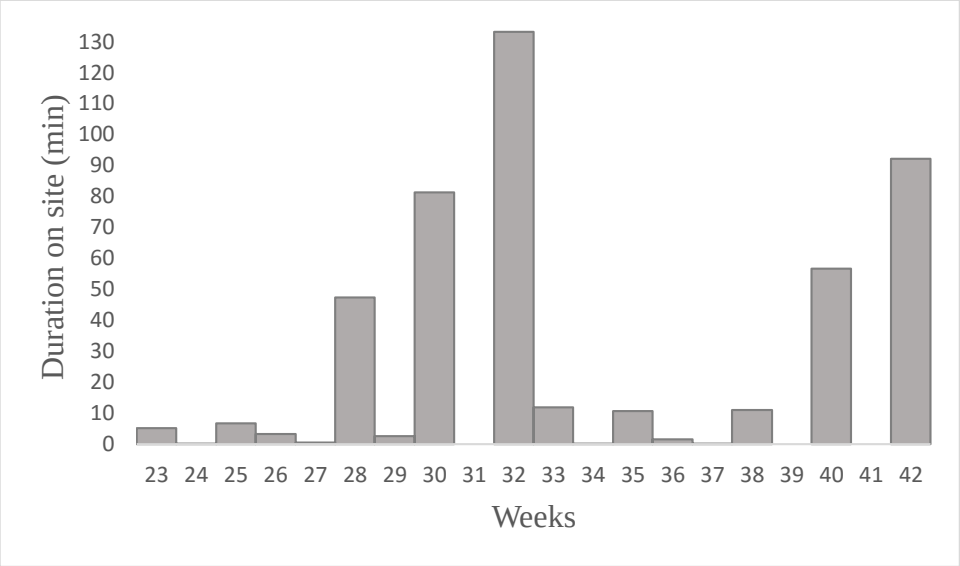

**Figure 8:** Scatter plot and correlation (Spearman's rank correlation $r_s = 0.938$, $n = 20$, $P < 0.01$) between visitation rate (visits per week) and duration at bait site (in minutes) of wolverines at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

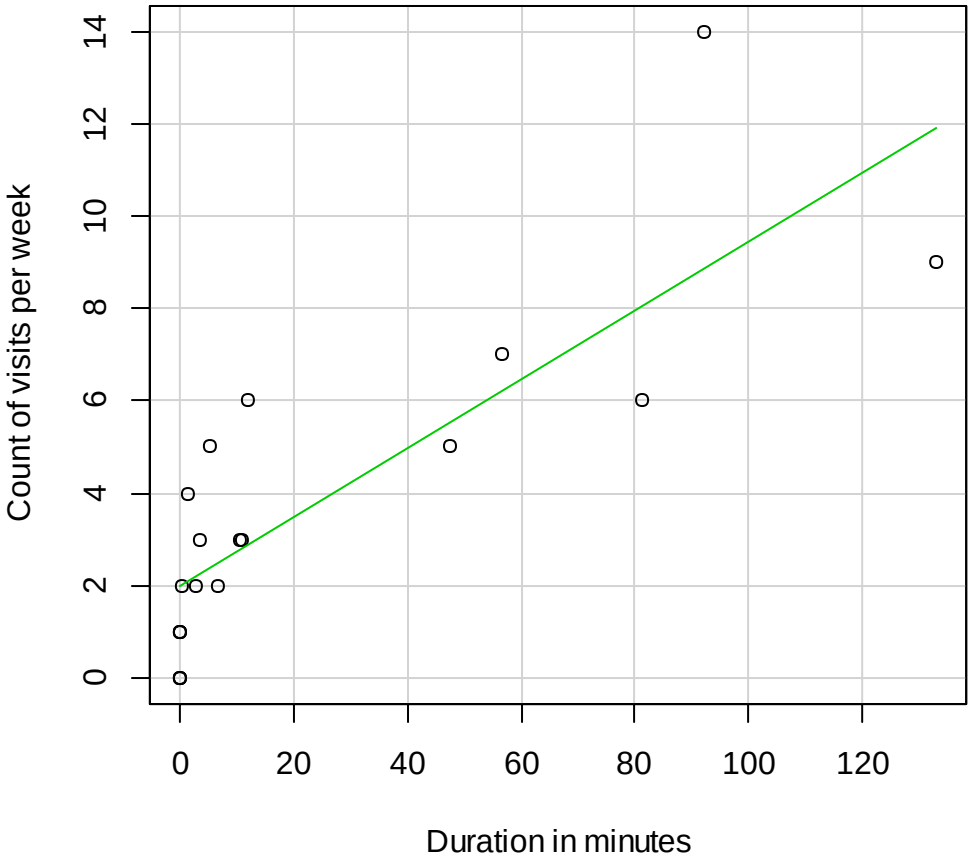

**Figure 9:** Boxplot of duration time of visits (N=74) by wolverines during day (lasting from 06:00 to 18:00) and night (lasting from 18:01 to 05:59) hours, based on human activity patterns, at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

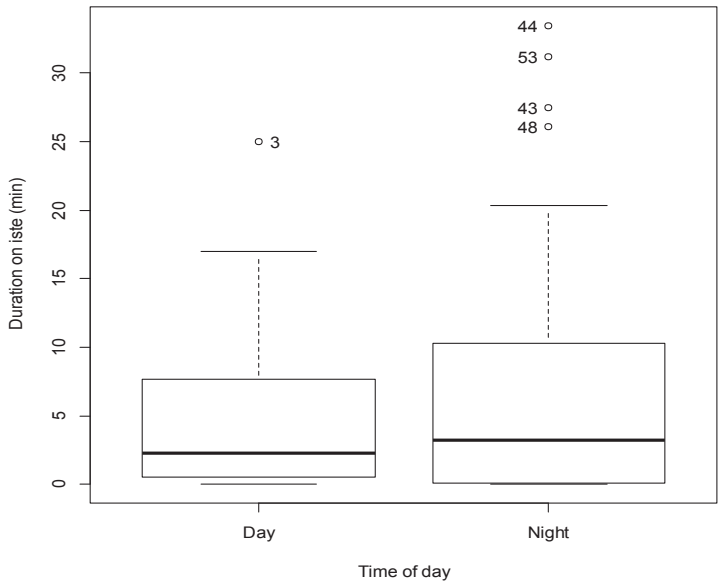

**Figure 10:** Frequency distribution of time spent (in minutes) by wolverines (N = 74 visits) at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

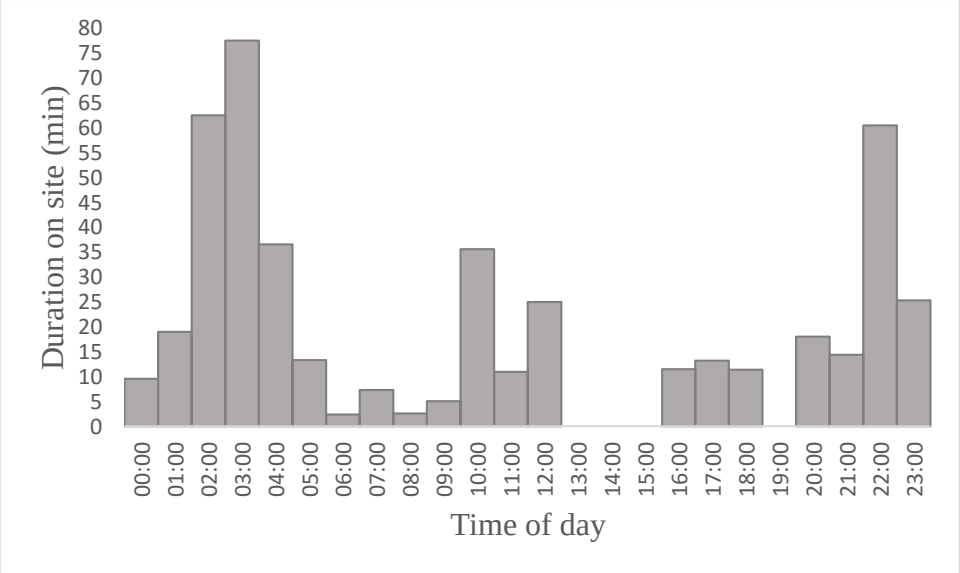

**Figure 11:** Boxplot of time (minutes) wolverines spent at permanent and temporary experimental bait sites (N=74 visits) for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

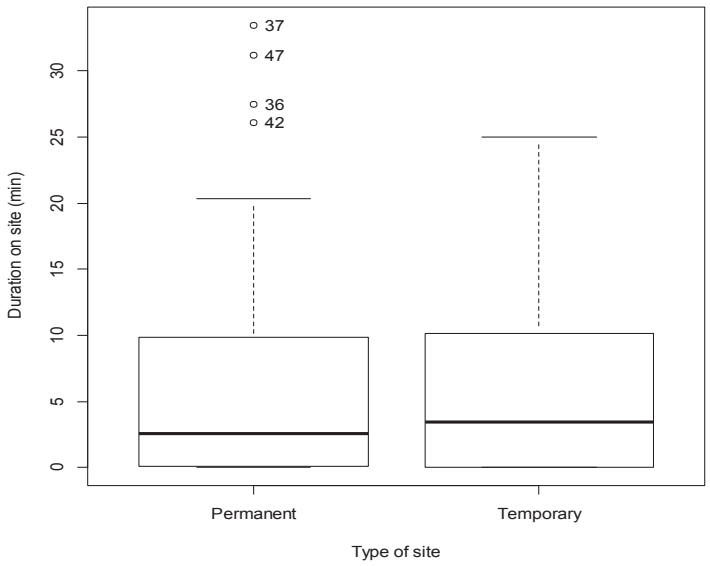

**Figure 12:** Frequency of wolverine duration time between each visits (N=70), calculated in days at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

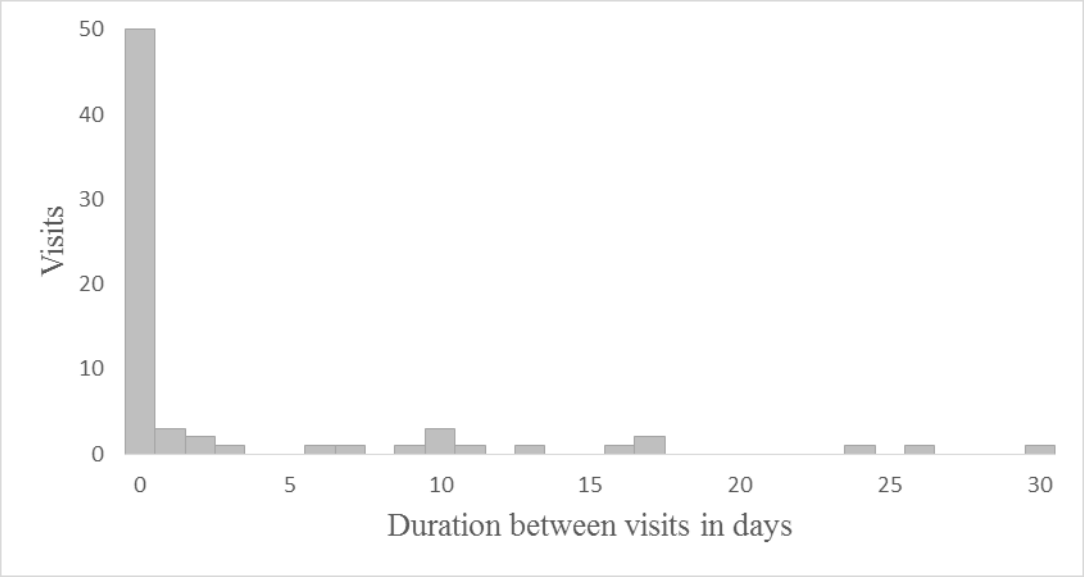

**Figure 13:** Boxplot of time (in hours) between visits (N=70) of wolverines in relation to season, i.e., spring/summer (n=22) and autumn (n=48), bait sites at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

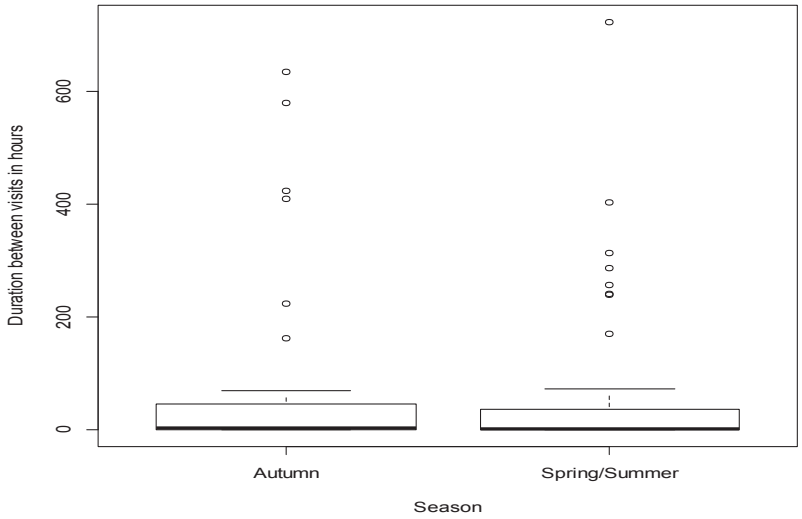

**Figure 14:** Boxplot of time (in hours) between visits (N=70) by wolverines at permanent (n=45) and temporary (n=25) bait sites at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012.

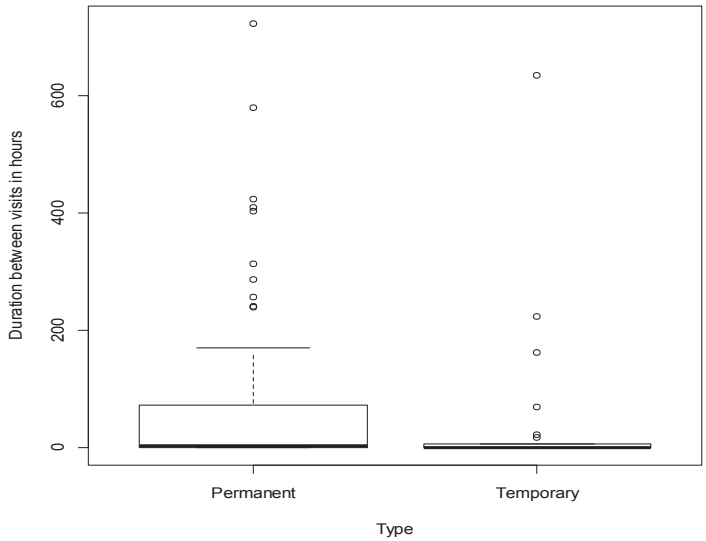

**Figure 15:** Pie chart of the frequencies of different behaviors displayed by wolverine at the experimental bait sites in Dalarna and Gävleborg counties in south-central Sweden and Västerbotten County in northern Sweden from 2008 to 2012.

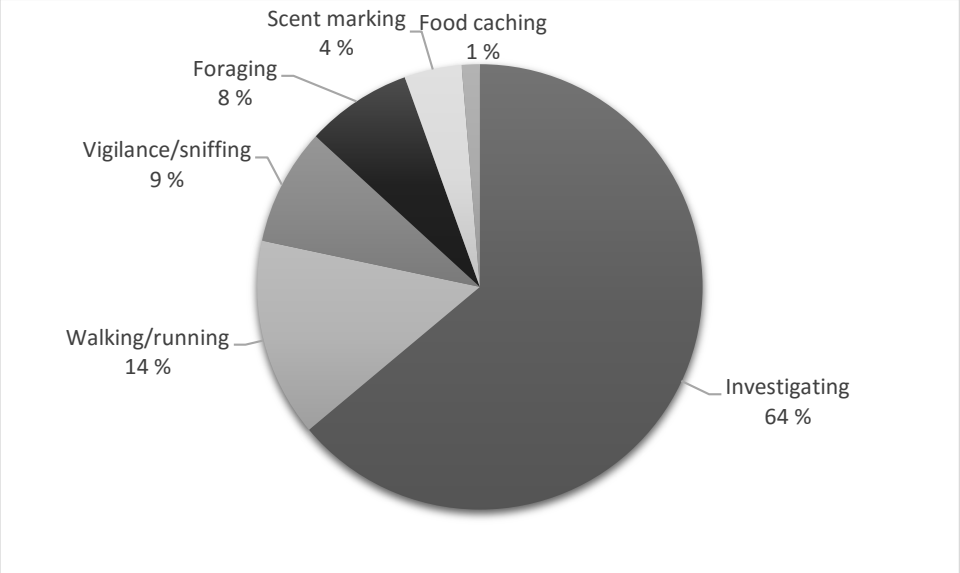

**Figure 16:** Bar chart and frequencies of different behaviors of wolverines displayed between day and night time visits at experimental bait sites for brown bears in Dalarna/Gävleborg and Västerbotten counties in Sweden, 2008-2012. The dark gray bars show the number of pictures displaying a given behavior during the night (lasting from 18:01 to 05:59), and light gray bars during the daytime (lasting from 06:00 to 18:00), based on human activity patterns.