Brown bear (Ursus arctos) bed-site selection and behaviour in relation to human settlements

Brunbjørnens (Ursus arctos) valg av hvilesteder og atferd i forhold til bebyggelse

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Abstract

The brown bear *Ursus arctos* has long been a hunted species in Scandinavia, and it has been shown that bears are more vary of humans in areas where they are hunted than in areas where they are not. Concealment provides security for the bears, also at their resting sites.

1. I tested a new method for measuring horizontal concealment, the cover cylinder, and compared it with earlier methods. The new cover cylinder showed the highest correlation when compared to a cardboard profile of a lying bear, and was the most practical device, because it was easy to carry and could be used by a single observer.
2. I used the new cover cylinder, together with a Lemmon's desiometer, to measure concealment at bear beds. Using these concealment values and the distance to the nearest human settlement I found that bears were more concealed at beds when they were closer to people. I also found that day beds were more concealed than night beds, and that night beds were found closer to human settlement. It is likely that bears see humans as predators, and thus, show anti predator behaviour towards them.
3. When bears were found very close to settlements, I found an indication that food items such as carcasses and slaughter remains likely were the reason for the bears to stay there.

Conclusively, brown bears avoid contact with humans at a large, landscape scale, but total avoidance in humanized areas is likely impossible. The results from my study suggest that bears have a behavioural mechanism to deal with potential encounters, by resting further away from human settlements during the day, when humans are active, and hiding in dense cover when resting. The presence of attractive food may explain the cases where bears occurred close to settlements.

Sammendrag

Den skandinaviske brunbjørnen (*Ursus arctos*) har blitt jaktet på i lange tider, og det har blitt vist at bjørner er mer sky i forhold til mennesker i områder de har vært jaktet på enn i områder de ikke har blitt jaktet på. Skjul gir sikkerhet for bjørnene, også ved dag og nattleier.

1. Jeg har testet en ny metode for å måle skjul (vegetasjon og/eller topografi) opp mot tidligere brukte metoder. Den nye "cover cylinder" viste den høyeste korrelasjonen når den ble sammenlignet med en papprofil av en liggende bjørn. Den var også den mest praktiske metoden, da den var lett å bære og kunne opereres av kun én person.
2. Jeg brukte den nye sylinderen sammen med et Lemmons densiometer for å måle henholdsvis vegetasjon på bakken rundt, og over bjørneleier. Jeg sammenlignet disse verdiene for skjul med avstanden til menneskelig bebyggelse og fant ut at bjørnene var mer skjulte da de befant seg nærmere bebyggelse. I tillegg var dagleier mer skulte enn nattleier, og nattleier lå nærmere bebyggelse enn dagleier. Det er trolig at bjørner anser mennesker som predatorer, og derfor viser en anti-predator atferd mot dem.
3. Når bjørner hadde leier nær menneskelig bebyggelse fant jeg en indikasjon på at det var tilgang til matkilder som dyreskrotter og slakteavfall som gjorde at bjørnene opptrådte nære folk.

Resultatene av studien antyder at brunbjørner unngår kontakt med mennesker, men total unngåelse av områder påvirket av mennesker er sannsynligvis umulig. Studien foreslår at bjørner har en atferdsmessig mekanisme for å håndtere potensielle møter med mennesker ved å hvile lenger vekk fra bebyggelse om dagen når mennesker er aktive, og bruke hvilesteder med tett vegetasjon. Tilstedeværelse av attraktive matkilder kan forklare tilfellene der bjørner opptrådte nære bebyggelse.

Introduction

Human activity can affect or alter animal behaviour (Trombulak & Frissell 2000, Frid & Dill 2002, Beale & Monaghan 2004.). The risk of predation is an important factor affecting animal behaviour, i.e. influencing habitat use (Pierce et al. 2004) or movement patterns (Frair et al. 2005). Species that are hunted by humans may consider humans to be a predator, and therefore show anti-predator behaviour towards them (Benhaiem et al. 2008). Species can become wary of humans, and may alter their behaviour so that human encounter becomes less likely, like hiding in dense vegetation, becoming more nocturnal or avoiding areas with high human activity (Boydston et al. 2003). Large carnivores are probably especially sensitive to the growth of human populations (Woodroffe 2000).

In Scandinavia, the brown bear (*Ursus arctos*) has been hunted for a long time, and both Norway and Sweden tried to eliminate the species for hundreds of years (Swenson et al. 1995). Bears were protected in Sweden in 1913, but hunting was allowed again in 1943 and is now legal and has been managed by quotas since 1981 (Swenson et al. 1994). Bears tend to be more wary of humans in areas where they are hunted than in protected areas (Swenson 1999), avoid areas with high human activity levels (e.g. Preatoni et al. 2005, Suring et al. 2006, Nellemann et al. 2007) and become more nocturnal in response to negative experiences with humans (Kaczensky et al. 2006).

Cover is important for animals because it can protect against weather, or it may lower the risk of predation by reducing the chance of detection and hindering attacks (Mysterud and Østbye 1999, Ratikainen et al. 2007). Thus, the availability of cover may be a factor for an animal's choice of habitat (Mysterud and Østbye 1999). Cover is a key habitat factor for many carnivores, such as black bears (*Ursus americanus*) selecting for a mosaic of habitat types that provided security cover in proximity to food resources (Lyons et al. 2003) or badgers' (*Meles meles*) selection of diurnal resting dens (Revilla et al 2001). Spotted hyenas (*Crocuta crocuta*) that are able to persist in areas with increasing livestock pressure rely on dense cover (Boydston et al 2003). The availability of safe cover during daytime is probably the limiting habitat requirement for European lynx (*Lynx lynx*) in areas with human presence (Sunde et al. 1998). Cover has long been shown to be important for habitat use by brown bears (e.g. Zager 1983, Wilson et al. 2006) influencing for example denning site selection throughout the species range, including our study area (e.g. Elfström et al. 2008). Suring et al. (2006) found that brown bears selected resources that lay near cover, and they assumed that cover provides security for the bears.

The ability to measure cover in the field is important to understand a species' habitat requisites, and therefore, important for the preservation of a species. Therefore, I tested different methods for measuring ground cover at bear beds. The goal of these comparisons was to find the most effective device, i.e. easiest to carry and to use in the field, without loosing measurement capacity. To measure ground cover I compared previously used devices including the table board (Nudds 1977), cover pole (Griffith and Youtie 1988) and cover board (Mysterud 1996), with a cover cylinder developed for this study.

Bears select habitat differently when they are resting than if they are foraging (Moe et al. 2007). In this study I visited bed sites of brown bears in Sweden, and measured both the canopy cover above the bed and the horizontal cover surrounding the bed. Horizontal cover means ground concealment, whereas canopy cover reflects what is above the animal, the vertical cover. I analyzed cover in relation to vicinity to human settlements and different times of the day, throughout the non-denning season of the bears. The concealment of bed-sites may be correlated to the chance of encountering humans, and I expected the beds to be more concealed when close to human settlements. I also expected night beds to be less concealed than daybeds, since humans are active during the day, and the chance of an encounter is lower during the night than during daytime.

Bears may be found near people because of available attractive food (Peirce and Van Daele, 2006), but other factors such as age, sex, experience and individual variation could play an important role in the tolerance bears have towards humans. In North America, adult female brown bears have been found to occur closer to human settlement than males, but further away than males to roads and traffic (Gibeau et al. 2002). Nellemann et al. (2007) found a higher proportion of subadults within 10 km of resorts and settlement in their study of the Scandinavian brown bear. Nellemann et al. (2007) also suggested that older adult males are more, or just as, sensitive to disturbance than reproductive females.

Methods

Study area and study individuals

The study took place in 2007, between late April and mid October, in Dalarna and Gävleborg counties in Sweden, near the southernmost distribution of the Scandinavian brown bear population (61ºN, 15ºE, Fig.1). The area is mainly forested, 80% covered by highly managed productive forest basically composed by Scots pine *Pinus sylvestris*, Norway spruce *Picea abies* and birch *Betula* spp. The understory vegetation is dominated by heathers, grasses and berry-producing shrubs (see Elfström et al. 2008 for further details).

Bogs and lakes occupy the remaining area, and the human settlements consist of a few scattered villages and single settlements. In 2007, human density in the counties ranged from 4.1 to 15.1 habitants/km^2 (Statistics Sweden 2008). The study area was close to the minimum density, with 2 to 150 habitants per settlement (S. Brunberg, Scandinavian Brown Bear Research Project, pers. comm.). There is an extensive network of roads in the area, mostly gravelled roads used for forestry, and public roads leading to villages and other settlements. The density of bears in the area has been estimated to 30 bears/1000 km^2 (Bellemain et al. 2005).

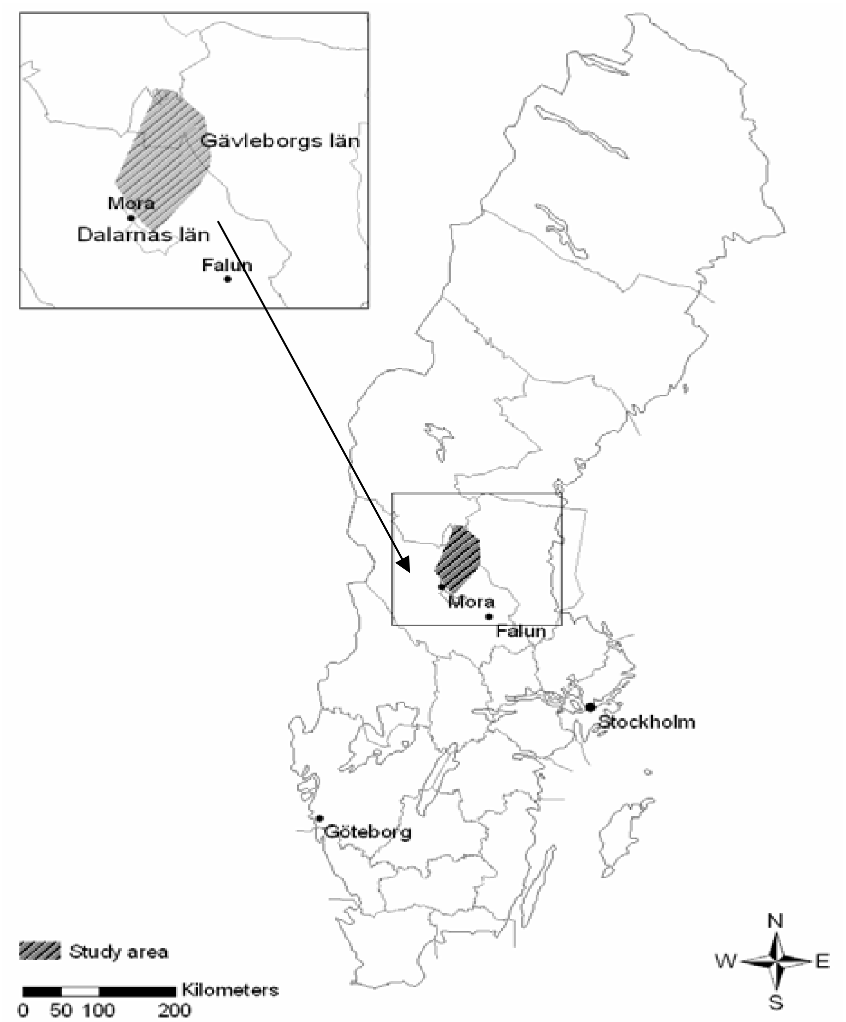

Figure 1. Map of Sweden showing the study area.

For this study I used data from 22 bears equipped by the Scandinavian Brown Bear Research Project with Global Positioning System (GPS)-Global System for Mobile communications (GSM) collars (Vectronic Aerospace GmBh, Berlin, Germany), with collected data being used in a number of different studies. For details on bear capturing and marking, see Arnemo and Fahlman (2007). Of these 22 bears, 17 were females and 5 were males. There were 4 bears considered to be subadults, and 18 were adults.

Selection of resting sites

The GPS-GSM collars were programmed to take a location every half hour during summer time, thus a maximum of 48 locations per day. The coordinates and time were obtained by the NAVSTAR global positioning system (Rodgers et al. 1996). The locations were sent via SMS and downloaded to a 1:50.000 map in the ArcGIS (Geographic Information System) 9.0 software (Environmental Systems Research Institute, Redlands, California, Inc. 2004). A minimum of three locations within a circle of 30 meter radius were defined as a cluster, meaning that the bear had spent at least 1.5 hours there. All times refer to GMT + 2h. I plotted the coordinates into a handheld GPS, and visited those clusters and tried to locate bear beds. To avoid disturbing the bears, I always waited at least 48 hours after the bear had been there before I went to the cluster, and made sure that there were no other marked bears in the area at the time. I chose the bed closest to the centre of the cluster. A site had to contain hairs from the bear to be considered as a bed. When the bed was located and marked, it was considered the centre of the plot. Thirty metres away in each cardinal direction was marked with a plastic bag. This together with the marking of the bed helped the observer orientate him- or herself within the plots, which sometimes were very dense with vegetation. The observer walked circles of 5, 10, 15, 20, 25 and 30 m radius around the bed. This was done to count and register all bear sign.

Comparison of methods for measuring concealment

To measure the horizontal concealment of the bed we used a cover cylinder (fig. 2). Because this cylinder was our own invention and had not been used in fieldwork before, we performed a comparison of methods for measuring concealment in the first beds we visited. The following devices were used to measure ground cover in a total of 42 beds:

1. Table board (Nudds 1977), 1 m high, divided in two 50 cm high and 30 cm wide sections, white down and red up. 5 kg (fig. 3).

2. Cover pole (Griffith & Youtie 1988), 2.5 cm wide and 1 m high, divided into ten 10 cm bands painted black and white. 1 kg (fig. 3).
3. Cover board (Mysterud 1996), 30x40 cm with 40 6x5 cm grid cells (fig. 3).
4. Cardboard profile of a bedded bear, live size (fig. 3).
5. Cover cylinder, 60 cm high, divided in two 30 cm sections, white down and red up. 700 g (fig. 2).

Figure 2. Collapsible, self-supporting cover cylinder used to measure concealment. From side, top and folded.

When a bed was located, all the devices were placed consecutively inside it. The measurements were taken 10 m away from the device in the four cardinal directions. The observer estimated how much of every device that was visible (Table 1). Then the next device was placed in the bed, and the procedure was repeated until the cover was measured with all the devices. Only one observer took all the measurements at each location to avoid individual biases. We used a fixed distance of 10m to compare all methods exactly in the same circumstances. Mysterud and Østbye (1999) suggested using sighting distance (D), i.e., the distance that the observer must walk away from the device for it to be completely hidden by vegetation or topography. This provides a continuous variable that is better for statistical analysis. I used it for the measuring of concealment of the beds, but for the comparison of methods we chose to use 10m as a fixed distance (Griffith and Youtie 1988, Nudds 1977) to avoid possible sources of variation not related itself to the set of devices under evaluation. For all devices except the cover board, we used the same scale (Table 1). For the table board, cover pole and cylinder there were taken values from both sections of the device. The cover pole had two sections with five bands for comparison with the table board. For the cover board we counted squares not covered at all by vegetation (Mysterud 1996).

a)

b)

c)

d)

Figure 3. The different devices (table board (a), cover pole (b), cardboard profile of a bedded bear (c) and cover board (d)) used in the comparison of methods for measuring concealment.

Table 1. Scale used to quantify the observed section of the device

Value assigned to each of the sections of the device	% observed
1	< 25
2	26 – 50
3	51 – 75
4	> 75

Concealment at bed sites

I used the cover cylinder to measure D in the four cardinal directions around each bed. I used the average value to describe the concealment of the bed. In addition, to compare bed site concealment with the surrounding habitat I measured D in a random direction at every bed, and sat the cylinder at a randomly selected point, 50 m away from the bed, and measured D in a random direction.

The canopy cover can be measured with angular or vertical methods. The vertical methods are only influenced by the horizontal plane of interception, whereas the angular methods also measure interception from the sides of the crown, which is more interesting for ecological studies. Nuttle (1997) argued that it is the general cover that gives an animal its perception of cover. This involves light interception not only directly from above, but with an angular direction. Thus, I used a densiometer (Lemmon 1956) to measure canopy cover (fig. 4). The densiometer consists of 24x4 squares, 96 in total, and those not covered at all by vegetation are to be counted (Lemmon 1956), giving a percentage of canopy openness (CO). This was done in the middle of the bed, at 60 cm height (on top of the cylinder), in each of the four cardinal directions. By putting the number of counted open squares from each direction into the formula, $100-((N+E+S+W)/4)*1.04166$, we got a value of openness. CO was also measured at the random point.

An effect of temperature on the selection of bed sites might be expected. We installed 6 temperature loggers (Easy Log OM-EL-USB1, Omega Engineering, Manchester, England Inc.) in 6 permanent plots during the field season, which recorded a temperature value every half an hour. The loggers covered the main habitat types present in the study area, i.e. clear cut, tree-rich bog, young forest, intermediate-age forest, swamp forest, and mature forest (from Karlsson and Westman 1991).

Figure 4. Lemmon's densiometer for measuring canopy cover.

Behaviour close to human settlements

The behaviour (feeding or resting), presence of food items, age and sex were considered to be possible factors affecting how close the bears got to human settlements. I counted feeding sign such as ground scratches (digging for insects), fresh anthills (foraged on by the bear), turned stones, carcasses (including slaughter remains left by people) and other food, like dug out wasp nests. The amount of ripe berries within the plot was also registered. I noted if there were food items such as carcasses, slaughter remains and other human-derived food in/by the resting site. By identifying bear feeding sign, I determined whether the site was only a resting site or if it was also a feeding site. I divided all the bed-sites into two classes of behaviour, feeding or resting. If there were any sign of foraging it was classified as feeding behaviour.

Statistical analysis

For the comparison of methods we got a value for ground cover for every single device at every bed by adding the values from the four cardinal directions taken at that bed, and got the observed percentage of the maximum possible. I ran a correlation between pairs of devices, comparing all of them.

I used linear models to evaluate the effect of the following variables on D, the measure of horizontal cover, and on CO, the measure of canopy cover, respectively:

1. Day/Night beds. The core resting periods previously defined for this bear population ranged from 00:00 to 03:30 and from 09:00 to 18:00 (Moe et al. 2007). I defined day-beds to be resting sites which the bear used during the time of day that humans are active (07:00 to 19:00), and night-beds when humans rest (22:00 to 06:00).

2. Distance to the closest human settlement (HS) in straight line, obtained with ArcGIS.

3. Temperature: the daily average value of the 6 temp loggers, for the values recorded between 01:00-02:00 for night beds, and between 13:00-14:00 for day beds, as reference values to be compared with the concealment of every bear bed.

4. Daylight length: the minutes of daylight for every single day within the study period (data from Astronomical Applications Dept, U.S. Naval Observatory Washington, DC 20392-5420).

5. Sex: male or female.

6. Age: adult (>4 years) or subadult (<4 years).

Our most general models included all of the above variables and meaningful two-way interactions among them. Every model was run separately for D and CO and for bed sites and random sites 50 m away. We used linear mixed models because of the different number of beds available from every animal. Model selection was based on the Akaike Information Criterion (AIC; Akaike, 1974) using backward removal of model terms until the model with the lowest AIC value was reached. We used non-parametric tests to compare concealment and distances to settlements between day and night (Mann-Whitney test), and concealment at bed sites vs. paired random sites (Wilcoxon test).

To examine why bears occurred close to people, I used a mixed linear model (see above) with distance to HS as response variable. The effect of the variables sex, age, behaviour (feeding or resting) and presence/absence of food items were evaluated. In addition, I also looked only at beds that were within 150 m from HS. I used the same method as above with the variables food items and behaviour. I also calculated which proportion of the food items found were within 150 m.

P values lower than 0.05 were considered statistically significant. I used the statistical package R 2.8.0 (R Development Core Team, http://www.R-project.org) in all statistical analyses, except for the correlations comparing methods, which was done in Microsoft® Office Excel (Microsoft Corporation 2003).

Results

Comparison of methods

The cylinder developed for this study showed a high correlation with all the devices (r range = 0.67 – 0.87; Table 2). A high correlation was obtained when comparing the cylinder and the lying bear (r = 0.86; Fig. 5), which represented the most accurate shape of a resting bear.

Table 2. Correlation coefficients (r) between pairs of devices (upper sections) tested to measure ground cover at a fixed distance of 10 m.

Devices	n	r
Cover cylinder vs. Lying Bear	31	0.86
Cover cylinder vs. Cover Pole	42	0.82
Cover cylinder vs. Table Board	42	0.87
Cover cylinder vs. Cover Board	42	0.67
Lying Bear vs. Cover Pole	31	0.73
Lying Bear vs. Table Board	31	0.70
Lying Bear vs. Cover Board	31	0.76
Cover Pole vs. Table Board	43	0.89
Cover Pole vs. Cover Board	43	0.58
Table Board vs. Cover Board	43	0.49

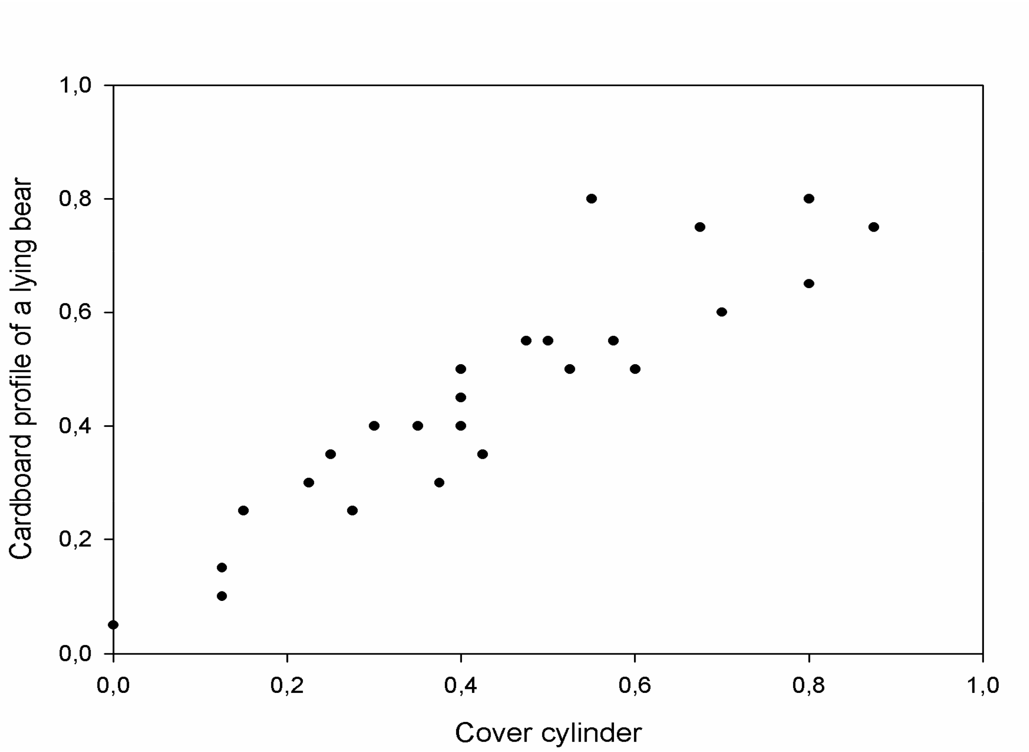

Figure 5. Correlation between the cylinder and the cardboard profile of a lying bear.

Concealment at bear beds

We found beds in 441 clusters; 221 were classified as daybeds and 220 as night beds. Individual bears provided 20 ± 13.6 beds. The mean distance to HS was larger for daybeds (2410 ± 2114 m) than for night beds (1888 ± 1804 m; U = 20329, p = 0.003). Still, D was shorter (U = 14009.5, p = 1.39e-14) at daybeds (17.6 ± 8.4 m) than at night beds (24.8 ± 11.8 m) (fig.6). Likewise, CO was lower (U = 10284.5, p < 2.2e-16) at daybeds (9.1 ± 16.6) than at night beds (27.6 ± 29.7) (fig. 6). D at bed sites was shorter than at random sites (V = 29397.5, p = 2.680e-09). D at beds was larger in the nights and increased further away from HS, and decreased with larger daylight length (Table 3). D at random sites was larger during the nights and increased with higher temperatures, and decreased with larger daylight length (Table 3). CO at beds was lower than at random sites (V = 17281.5, p < 2.2e-16). CO at beds increased further away from HS, decreased with larger daylight length and decreased during the day hours with higher temperature. CO at random sites was larger in the nights and increased further away from HS, and decreased with larger daylight length (Table 3).

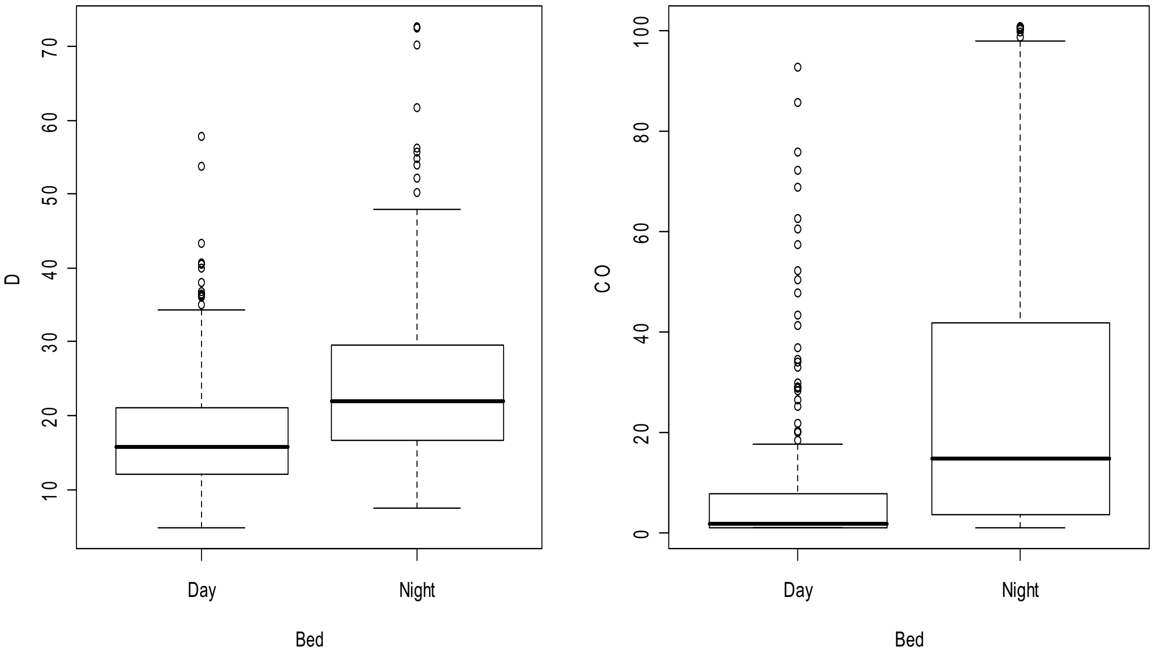

Figure 6. Sighting distance (D) in metres (left) and percentage of canopy openness (CO) (right) at day beds and night beds.

Behaviour close to human settlement

When looking at the all 441 beds, none of the variables (i.e. sex, age, behaviour and food items) were explanatory on distance to HS. However, when I only looked at the 25 beds that were within 150 m, I found an indication that food items occurred more frequently the closer to HS the bears were ($t = -1.69$, $p = 0.1095$). Of all food items found, 24.1 % were at the plots within 150 m from houses, and 77.8 % of the food items found at beds within 1 km to HS were at the beds within 150 m from HS. Food items found within 150 m were mainly carcasses and slaughter remains, but we also found bee hives destroyed by a bear.

Table 3. Models with the variables affecting horizontal cover (sighting distance) and vertical cover (canopy openness) both at beds and at random sites 50 m away.

Model	ß	SE	t-statistic	P-value
Sighting distance at beds				
(Intercept)	2.667	0.2052	12.9978	0.0000
Day/Night	0.3365	0.0409	8.2207	0.0000
Log (Distance to HS)	0.0503	0.0193	2.6030	0.0096
Daylight length	-0.0003	0.0001	2.0802	0.0381
Sighting distance at random 50m sites				
(Intercept)	3.1553	0.2314	13.6343	0.0000
Day/Night	0.4157	0.1089	3.8185	0.0002
Temperature	0.0230	0.0091	2.5256	0.0121
Daylight length	-0.0006	0.0003	-2.1930	0.0291
Canopy openness at beds				
(Intercept)	3.0804	0.7716	3.9923	0.0001
Day/Night	0.3798	0.4598	0.8259	0.4096
Log (Distance to HS)	0.2715	0.0719	3.7789	0.0002
Temperature	-0.0386	0.0232	-1.6620	0.0977
Daylight length	-0.0034	0.0006	-5.3627	0.0000
Day/Night:Temp	0.0881	0.0330	2.668	0.0081
Canopy openness at random 50m sites				
(Intercept)	1.7580	0.6783	2.5915	0.0101
D.NN	0.5617	0.1425	3.9434	0.0001
Log (Distances to HS)	0.3274	0.0681	4.8070	0.0000
Daylight length	-0.0017	0.0005	-3.3818	0.0008

Discussion

Comparison of methods to measure horizontal concealment

I tried to find the most effective device to measure ground cover in the field, without loosing measuring capacity, and the results suggested that the new cover cylinder was the most advisable device. Most of the previously used devices were difficult to use for a single observer. The table board was in addition heavy and unnecessary high compared to a lying bear. The cover pole, was easier to carry, but did not stand by itself on hard soils. It was also very narrow. Griffith and Youtie (1988) argued that the width of the device was not important in estimating concealment by vegetation, but in our case bear beds were often next to a tree, resulting in the cover pole becoming completely hidden.

Thus, I found several reasons for using the cover cylinder. First of all, the cover cylinder was light and collapsible, which made it easy to carry. One person could handle it without difficulty because it was self-supporting. Because of their circular structure, both the cover cylinder and the cover pole could be observed from different observation points without having to turn them around. Finally, the cover cylinder showed the highest correlation value with the lying bear (Table 2). After the comparison of methods that I performed in the first 42 beds, I decided to use the cover cylinder to measure horizontal cover in beds and random sites.

Concealment at bear beds

As hypothesised, day beds were more concealed, both horizontally and vertically, than night beds. This was probably a response to the fact that humans are active during daytime hours, and bears will choose resting sites that give better protection during this time. A study on activity patterns of bears in Slovenia and Croatia (Kaczensky et al. 2006) have also described day beds as being more inaccessible than night beds due to high cover or being located in steep slopes. The beds were more concealed than the random positions, suggesting a strong bear selection, given that beds and random sites were only 50m away. Night beds were less concealed than daybeds. It might give the bears an opportunity to discover danger, through smell and sight from a longer distance than if they were more concealed. Infanticide occurs in the Scandinavian brown bear (Swenson et al. 1997, Bellemain et al. 2006), and the risk of intraspecific predation may be another factor influencing the choice of bed sites. Cover can also obstruct flight (Mysterud & Østbye 1999), and good flight options might be more important as an anti predator strategy against other bears than against humans, and thus, more important during the night, when humans are inactive.

Brown bears rested further away from humans in the day, whereas night beds were found closer to human settlements. In addition, both night and day beds were found to be more concealed when closer to human settlement. These findings, together with the fact that day beds were more concealed than night beds, supported the hypothesis that bears consider humans to be a predator, and thus, show anti predator behaviour towards them. To my knowledge, similar studies on brown bear bed-site selection have not been conducted. However, human settlements have been shown to have a negative effect on the bed-site selection in other species. Human disturbance, and especially villages, had a strong negative effect on moving, foraging and bed-site selection in red deer (*Cervus elaphus xanthopygus*) in China (Jiang et al. 2007). The study population is a hunted one, and hunted populations are more vary of humans than non-hunted populations (Swenson et al. 1999). In response to human disturbance, bears have been known to alter their behaviour (Suring et al. 2006). Humans have been found to drive bears to be more nocturnal (Kaczensky et al. 2006), so it is not unlikely that humans also drive bears to be more concealed, and rest further away to humans during the day than during the night.

Increased canopy cover and a denser habitat probably gave the bears more shading and thus, cooling on warm days, because increasing temperature corresponded with increasing canopy cover. Both canopy cover and ground cover increased with increasing daylight length. This could have climatic explanations, when more sunlight may cause more heating and, thus more need for shading. Canopy cover can shelter against temperature and solar radiation (Mysterud 1996). However, for ground cover, the most likely explanation is probably that humans are active longer when daylight hours increase, because temperature had no significant effect on the horizontal cover at beds. I argue that it was the risk of encountering humans that was the most important factor when it came to brown bears' choice of bed-sites, but that more canopy cover also gave lower temperature on days with longer daylight.

Behaviour close to people

In spite of the general behaviour of avoiding people, in some occasions bears stayed near human settlements. Despite a lack of significant results clearly explaining such situations, food items may partially explain that proximity.

Human activity appeared to be the main factor why bears concealed themselves and rested further away in the day when humans are active. The interesting question was then why they occurred very close to human settlements. Contrary to earlier findings (see introduction), the results did not find evidence that the age or sex of the bears affected the distance to human settlements. However, only 4 of the study individuals were subadults, and this could have affected the result. The availability of habitat is probably not a limiting factor in the study area. There were 8 different bears occurring within 150 m from houses, and all of them had access to areas far from human settlements within their home range. In fact, all of our study animals had access to areas close and far away from human settlements. I did not find evidence that feeding behaviour or food items were correlated with vicinity to human settlements when I looked at all 441 beds. I did, however, find an indication ($p = 0.1095$) that presence of food items was an important factor when bears occurred very close to human settlements. Food is probably what drives the bears to get close to human settlements and risk the chance of predation.

When bears are frequently exposed to human food they can become food conditioned (Smith et al. 2005). Wilson et al. (2006) found that most conflicts between grizzly bears and humans were associated with concentrated attractants. For black bears it has been shown that foraging on human food is a socially learned behaviour, being transmitted from sows to cubs (Mazur and Seher 2008). This may also be the case for brown bears. There might have been a difference in the tolerance each individual study animal had towards humans, and that this effected how close they got to settlements. Individual distinctiveness has been documented in brown bears (Fagen and Fagen 1996), and this could turn some bears in to so-called “problem individuals” (Linnell et al. 1999).

Management implications

Suring et al. (2006) assumed that cover provides security for bears, and state that the availability of cover is important in how human activities influence brown bears. Suring et al. (2006) also argue that availability of cover is most important in areas where bears and humans congregate. This study supported this, and showed how bears actively used cover as a behavioural mechanism to deal with human presence. Thus, I argue that the availability of cover is important for the Scandinavian brown bears in areas where humans are present. Cover is probably not a limiting factor when it comes to managing the brown bear in Sweden. However, the results of my study could be used as a guideline to how people should behave in areas where bears are present. I suggest that people should try to avoid areas with dense vegetation when moving (i.e. hiking, berry picking) in the forest. Avoiding such areas is probably a good way both to 1) avoid disturbing the bears and 2) to avoid potential encounters, which is important for the security of both bears and humans.

There are many different food items that could attract a bear, carcasses and slaughter remains being the most obvious. Other food such as bee hives (Genov and Wanev 1992, Wilson et al. 2006), garbage (Peirce and Van Daele, 2006) and apples (Naves et al. 2006) can also be food sources for bears, and they all occur close to human settlements. Food items such as slaughter remains should not be placed close to human settlements to reduce the chance of encounter between bears and humans. Other food should be kept inside or made inaccessible so that the bears do not become food conditioned. Electric fencing, bear-proof containers or penalizing violators are possible measures to prevent access (Huber et al. 2008). Wilson et al. (2006) stated that electric fencing of beehives deters grizzly bears. Conditioned food aversion have been proven effective against black bears damaging bee hives (Smith et al. 2000), but there are issues concerning the development of effective chemical components (see Baker et al. 2008). In areas where bears are present, people may have to accept that most food sources (i.e. dog food, bird seeds, compost) can not be left outside.

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