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Do Scandinavian brown bears approach settlements to obtain high-quality food?

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ABSTRACT

Large carnivores that approach human settlements are usually considered a threat to human property and safety. The prevailing paradigm, that such 'problem' animals approach settlements in search of food, ignores their social organization. Based on feces, we compared the diet of individual brown bears (*Ursus arctos*) in Sweden in relation to settlements. Nutritive quality was quantified using near-infrared spectroscopy, and food items were identified using a DNA metabarcoding approach. We analyzed the diet of 21 bears during 36 visits near (<150 m) settlements, and the corresponding diet when the same bears were in remote areas (>600 m from settlements; constituting 95% of bears' habitat use). The food-search hypothesis predicted a different and higher-quality diet when an individual was close to settlements than when in a remote area. Less than 1.9% of the variation in diet was associated with location, giving no support for the food-search hypothesis. However, females with yearlings had 5.1% ± 2.9 (SE) lower fecal protein content than adult males. In addition, females with young (cubs-of-the-year or yearlings) exploited slaughter remains less often than other bears. This suggests that the diet of predation-vulnerable bears may have been affected by despotic behavior of dominant conspecifics. We provide evidence against the paradigm that food search explained the occurrence of brown bears near settlements and suggest that predation-vulnerable bears may use habitation as a human shield without being food conditioned. Management authorities should consider this knowledge when dealing with large carnivores near settlements.

1. Introduction

Several large carnivore species have increased in numbers and range in some areas in recent decades (Linnell et al., 2001). Although they generally avoid human activity and settlements (Woodroffe and Ginsberg, 1998; Frid and Dill, 2002), large carnivores do sometimes occur close to settlements. They are then often considered 'problematic', both because people fear them (Johansson et al., 2012) and because they may damage property or injure humans (Woodroffe and Ginsberg, 1998). In many areas, mesopredators, such as Eurasian badgers (*Meles meles*) and red fox (*Vulpes vulpes*), utilize human-derived foods near settlements (Goszczyński et al., 2000; Bino et al., 2010). Several authors have proposed that also large carnivores, such as brown bears (*Ursus arctos*), approach settlements in search of food, which can result in food conditioning, i.e. associating people with easily accessible and attractive foods (McCullough, 1982; Gunther et al., 2004). Thus, if some bears gain access to high-quality foods near settlements (Hobson et al., 2000), this may explain why these individuals tolerate the disturbance associated with human activity and approach settlements.

The distribution of brown bears in a landscape is affected by food availability, anthropogenic disturbances, and intraspecific interactions, such as aggression or predation from dominant conspecifics (Steyaert et al., 2013a,b). This suggests that the distribution of

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individuals in bear populations follows a despotic pattern, where human settlements may supply food resources and may function as refuges for smaller/subdominant bears that are avoiding interference competition and aggression (Elfström et al., 2014a). Subadults and females with dependent offspring seem to exploit habitats with lower diet quality than adult males (Mattson et al., 1987, 1992; Wielgus and Bunnell, 1994; Ben-David et al., 2004; Steyaert et al., 2013b). Smaller bears have lower nutritional requirements than larger bears (Welch et al., 1997; Rode et al., 2001). Thus, large adult males may require more abundant or higher quality-foods due to their larger size (Robbins et al., 2004). Yet, it is subadults and females with offspring that most often occur near people (Kaczensky et al., 2006; Rode et al., 2006; Schwartz et al., 2006; Hristienko and McDonald 2007; Elfström et al., 2014b). Adult males more often are found in remote areas (Mattson et al., 1987, 1992; Gibeau et al., 2002; Nellemann et al., 2007; Steyaert et al., 2013a). If bears occur near settlements because they are food conditioned, this may be viewed as an 'unnatural' behavior and increase people's fear of bears. However, the type of bears occurring near settlements is better explained by their despotic behavior than searching for food and, thus, food conditioning is not a prerequisite for bear occurrence near settlements (Elfström et al., 2014a).

Avoidance of settlements by predators creates refuges for several prey species, i.e. the human shield theory (Berger, 2007; Barber et al., 2009). Settlements may function as human shields for moose (*Alces alces*) against brown bears and wolves (*Canis lupus*) (Berger, 2007; Rogala et al., 2011), for roe deer (*Capreolus capreolus*) against lynx (*Lynx lynx*) (Basille et al., 2009), and for American black bears (*Ursus americanus*) against brown bears (MacHutchon et al., 1998; Schwartz et al., 2010).

We evaluated brown bear movements in relation to settlements and analyzed their fecal nutritive constituents using near-infrared reflectance spectroscopy (NIRS) (Cen and He, 2007; Steyaert et al., 2012) and diet composition by identifying short fecal DNA sequences, i.e. DNA metabarcoding (Valentini et al., 2009; Taberlet et al., 2012; De Barba et al., 2014). Our objective was to investigate the diet of individual bears feeding near settlements and in remote areas. If bears gain a nutritional advantage by using areas close to settlements, the food-search hypothesis predicts that they would have a different diet and consume foods with higher nutritive value when near settlements than in remote areas (Hobson et al., 2000; Hopkins et al., 2012). Alternatively, if bears use areas close to settlements to avoid intraspecific aggression, or because they are naïve (i.e. lack experience with people), diet composition or quality should be similar near settlements and in remote areas.

2. Material and methods

2.1. Study area

Our ~12,000 km^2 study area was situated in south-central Sweden (~61°N, 15°E) (Dahle and Swenson, 2003). More than 80% of the area consists of intensively managed boreal forest, dominated by Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*); the remaining area is mainly covered by bogs or lakes (Moe et al., 2007). The forest floor is dominated by lichens, heather (*Calluna vulgaris*), bilberry (*Vaccinium myrtillus*), cowberry (*V. vitis-idaea*) and crowberry (*Empetrum hermaphroditum*) (Swenson et al., 1999). Elevations range between 200 and 1000 m a.s.l., and 90% of the area lies below the timberline (~750 m) (Dahle and Swenson, 2003). The area is sparsely populated, with few settlements and isolated houses (Martin et al., 2010). There are six towns, ranging from 3000 to 11,000 inhabitants, and two large tourist resorts with cabins (Nellemann et al., 2007). Human presence is most pronounced during summer and fall, and mainly related to hunting and berry picking (Ordiz et al., 2011). Brown bear population density is about 30 individuals per 1000 km^2 (Bellemain et al., 2005) and the population is intensively hunted from 21 August until 15 October (Bischof et al., 2009).

2.2. Study design

We studied brown bear diet using fecal remains found at GPS-collar locations between 1 May and 1 October 2010 in three areas defined in relation to distance to human settlements. We monitored 49 bears equipped with GPS/GSM-collars scheduled to obtain locations at 10- or 30-min intervals (VECTRONIC Aerospace GmbH, Berlin, Germany). All capture and handling of bears were approved by the appropriate Swedish Ethical Committee (Uppsala Djurförsöksetiska Nämnd). See Arnemo et al., (2011) for details about capturing and handling of bears. Bears were categorized according to their sex, age, and reproductive status. Males $\geqslant$ 5 years of age were defined as adult males and males $\leqslant$ 4 years and nulliparous females as subadults. After having given birth, females were categorized as lone parous females, females with cubs-of-the-year, or females with dependent 1-2-year old offspring (Dahle and Swenson, 2003; Zedrosser et al., 2007).

We used ArcGIS 9.2 (Environmental Systems Research Institute, Inc., Redlands, California) for spatial analyses. We defined settlements as inhabited building(s) with registered garbage collection. Bear-proof garbage bins are not used in this area. The County Administrative Boards of Dalarna and Gävleborg provided digital maps (GSD Fastighetskartan) of buildings (D nr 501-6993-09 and 09910-2009). Registers of garbage collection were provided by the municipalities of Ljusdal, Mora, Orsa, Ovanåker, Rättvik and Älvdalen, and four garbage disposal companies. We defined three areas in relation to bear movements: a settlement visit, a remote area and prior to a settlement visit.

A settlement visit (SV) was defined as a bear occurring within a 150-m radius of a settlement for a minimum of two consecutive relocations. Minimum SV duration was the time elapsed between the first and last location <150 m from a settlement. The 150-m cut-off around settlements likely excluded unknown bear movements between consecutive locations exceeding the maximum recommended distance of 450 m between garbage bins and residential houses, based on decisions by the Swedish Environmental Supreme Court (cases M 7725-05 and M 583-06). Bears in our study area have an upper range of movement, i.e. 3rd quartile, of 600 m per 30 min when active (Moe et al., 2007), thus the maximum distance from a settlement and back between two consecutive GPS locations separated by a maximum of 30 min corresponds to ~300 m. We collected SV samples from all bed sites starting $\geqslant$1 h after the first GPS location <150 m from a settlement, and until 24 h after the first GPS location >150 m from the settlement. Thus, we sampled feces deposited during a minimum of 24 h after a bear entered a settlement, which overlaps reported gut retention times of 6 and 14.5 h for captive Scandinavian brown bears on berry and meat diets, respectively (Elfström et al., 2013), i.e. diets with different fiber content and digestibility (Pritchard and Robbins, 1990).

A remote area (RA) was defined as >600 m from any settlements, and corresponded to 95% of the habitat used by GPS-collared bears in our study area during 2006–2009. We randomly selected two bed sites from the same individual to sample RA fecal remains >48 h after a bear visited a settlement, and only after all GPS locations had been in RAs for >24 h.

We analyzed fecal samples defecated in the 24-h period prior to a settlement visit (PSV). The PSV samples were collected from two randomly selected bed sites only when the bear had not been located <150 m from a settlement for >48 h before SV occurred and independently of bear use in RA.