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Behavioral reactions of brown bears to approaching humans in Fennoscandia

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Summary

Human disturbance causes behavioral responses in wildlife, including large carnivores. Previous research in Scandinavia has documented that brown bears (*Ursus arctos*) show a variety of behavioral reactions to different human activities. We investigated how proximity to human settlements and roads, as proxies of human influence, affected brown bears' reactions to encountering humans. We analyzed experimental approaches to GPS collared bears, 18 males and 23 single females, in Sweden (n = 148 approaches) and Finland (n = 33), conducted between 2004 and 2012. The bears in Finland inhabited areas with higher human density compared to Sweden. However, the proportion of bears staying or moving when approached and the flight initiation distances were similar in both countries. In Sweden, the flight responses were not dependent on human densities or roads inside the bears' home ranges or the distances from the bears to roads and settlements. Brown bears in Fennoscandia live in areas with relatively low human population densities, but in many areas with high forestry road densities. Our results show that bears' flight reactions were consistent between areas, which is an important message for management, reinforcing previous studies that have documented human avoidance by bears at very different spatial and temporal scales.

Keywords: experimental human disturbance, Finland, flight initiation distance, flight responses, human density, road density, Sweden

Introduction

Wildlife generally react to and avoid human activities. However, behavioral responses vary in relation to factors such as the individuals' previous experience, physical condition, age, degree of gregariousness, antipredator strategies, type of disturbance, and time of day when it occurs (e.g., Whittaker and Knight 1998, Beale and Monaghan 2004a, Stankowich 2008,

Vincze et al. 2016, Tablado and Jenni 2017). Human disturbance can have short- and long-term effects, such as changes in distribution and activity patterns, and reduced breeding success (Beale and Monaghan 2004b, Stankowich 2008 and references therein).

Moving away from or avoiding areas with human activity is indeed an antipredator response, with disturbance perceived as predation risk by the responding animal (e.g., Gill et al. 1996, Lima 1998, Frid and Dill 2002). Antipredator responses reduce risk and are therefore crucial in modulating animal behavior (e.g., Deecke et al. 2002). Nevertheless, risk avoidance implies costs, which animals try to minimize while maximizing survival (e.g., Gill et al. 1996, Lima 1998).

Mammalian carnivores can be especially vulnerable to human disturbance (e.g., George and Crooks 2006). Large carnivores, such as brown bears (*Ursus arctos*), show spatial and temporal reactions to a variety of human activities across their wide distribution range in North America (e.g., Gibeau et al. 2002, Nielsen et al. 2004, Rode et al. 2006) and Europe (e.g., Naves et al. 2003, Nellemann et al. 2007, Ordiz et al. 2017). In Scandinavia, as elsewhere, most brown bear mortality is caused by humans (Sahlén et al. 2006, Bischof et al. 2009) and mortality risk is higher closer to villages and roads (Steyaert et al. 2016). Not surprisingly, brown bears generally select for rugged areas far from people (Nellemann et al. 2007). Bears' resting sites are concealed by denser vegetation when bears are closer to villages and during daytime compared to nighttime, suggesting that bears perceive and react to proximity to people, especially in summer-autumn, when human activities outdoors are most common (Ordiz et al. 2011). Bears' stress levels are also higher when they are closer to humans (Støen et al. 2015).

Brown bears have been expanding in Scandinavia in the last century following a severe population decline, from approximately 130 bears around 1930 to ~3,000 bears in recent times (Swenson et al. 1995, Swenson et al. 2017), and some people express concern about

human safety in the forest. Similarly, in Finland there were only about 150 bears by the 1960's (Pulliainen 1983), and the population reached 1,150-1,950 bears in 2009 (Wikman 2010, Kopatz et al. 2014). Therefore, to better understand bear behavior and to inform management agencies and the public about the reactions of bears to casual encounters with outdoor users (hikers, berry or mushroom pickers, hunters, etc.), we have conducted several studies in Sweden that included experimental approaches to radio-collared bears. Most bears react by moving away, which holds for both single bears (Moen et al. 2012) and females with cubs (Sahlén et al. 2015). After the encounters, bears become more nocturnal (Ordiz et al. 2013), as they do when bear hunting seasons start (Ordiz et al. 2012), and when they live in areas with higher road densities (Ordiz et al. 2014). That is, the behavioral reaction of the bears goes beyond their initial flight after encountering a person, which can change bears' daily activity patterns for several days (Ordiz et al. 2013).

Whereas the research summarized above shows a solid pattern of bears' avoidance of people, it was conducted in areas with low human densities. There is a need for research on bear reactions to humans also in areas with higher human densities, because the range of brown bears has been expanding in Fennoscandia, with bears moving into more human-dominated landscapes (Swenson et al. 1998, Kojola and Heikkinen 2006). It is possible that bears relax their behavioral responses if they encounter humans more often and eventually habituate to their proximity. This could in turn make encounters with bears more dangerous, if they do not move away as consistently as we have documented so far (Moen et al. 2012, Sahlén et al. 2015).

In this study, we have conducted experimental approaches of radio-collared bears in Sweden and Finland to assess whether bears' behavioral responses, i.e., flight reactions, change in relation to the level of human activity. We used distance to roads and human settlements from the bears' initial sites and the densities of human population and roads in

bears' home ranges as proxies for human activity. We also controlled for variables that influence the bears' flight reactions, i.e., bear behavior (if it was active or passive when approached), vegetation concealment, season of the year, and individual characteristics of the bears (Moen et al. 2012, Ordiz et al. 2013, Sahlén et al. 2015). As previous studies show that brown bears in Scandinavia avoid humans on different scales, we did not expect to see a reduced behavioral response of bears encountered by people due to living in areas with higher human or road densities, but a consistent pattern of human avoidance by the bears.

Methods

Study areas

The experimental approaches were conducted in Sweden and Finland. The study area in southcentral Sweden (61.5°N 15° E, Gävleborg and Dalarna counties) consists of bogs and heavily managed coniferous forest of mainly Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*). There are few main roads in the area, but a dense network of gravel roads (1.0 ± 0.8 km/km², mean $\pm$ SD) (Road map: Swedish National Land Survey). The human population in the area is low, 3.6 - 6.2 inhabitants/km² in the four municipalities where the study was conducted (Statistics Sweden). The whole study area is located below the timberline, which is at approximately 750 m a.s.l. (Dahle and Swenson 2003). Temperatures in the study area average -7° C in January and 15° C in July (Swedish Meteorological and Hydrological Institute 2017a, b). The density of bears in the study area was estimated to ~30 bears/1000 km² (Solberg et al. 2006).

The study area in central and southeastern Finland (62.5°N 27°E) also consists of bogs and managed coniferous forest of Scots pine and Norway spruce. Altitudes range from 75 to 200 m a.s.l., all below the timberline. Temperatures average -8° C in January and 17° C in July (Finnish Meteorological Institute). There is a dense network of roads in the area (1.5 ± 1.1

km/km²) (National Land Survey of Finland), and the average human population is higher than in the Swedish study area (11.3 - 16.2 inhabitants/km²) (Statistics Finland 2008). An estimate of the bear density in the study area is ≥ 6 bears/1000 km² (Wikman 2010). The bears are hunted in the fall in both areas, with hunting quotas averaging about 10% of the estimated populations in recent years, i.e., ~300 bears are annually harvested in Sweden (National Veterinary Institute 2017) and ~100 in Finland (The Finnish Wildlife Agency 2017).

Bears and the experimental approaches

We analyzed 148 experimental approaches between humans and adult solitary brown bears (9 males and 21 females) conducted in Sweden from 2006 to 2009, and 33 approaches on solitary bears (9 males and 2 females) carried out in the Finnish study area from 2004 to 2012. The bears were either followed from birth, being captured with previously known mothers, or their age was determined through cross-section of the premolar roots (Matson et al. 1993). Bears were from four to twenty years old in Sweden, and three to eleven years old in Finland. In Sweden, we approached the bears between one and six times per season, with a minimum of 13 days and maximum of 92 days between each approach. Most of the bears in Sweden were approached during one season (n = 18), although some were approached during two (n = 10) or three seasons (n = 2). We approached the bears in Finland with a minimum of seven days and maximum of 50 days between the approaches. The bears in Finland were approached between one and six times per season, during one (n = 9) or three (n = 2) seasons.

The bears were captured and equipped with GPS Plus-3 or GPS Pro-4 neck collars (VECTRONIC Aerospace GmbH, Berlin, Germany) and a VHF transmitter implant (IMP 400L) (Telonics, USA) in Sweden, and Tracker GSM/GPS without VHF (Tracker Inc., Oulunsalo, Finland) in Finland (see Sundell et al. (2006) and Arnemo et al. (2007) for details). The females in Finland were equipped with the same collar as the Swedish bears. Handling was approved by the Swedish Ethical Committee on Animal Research and the Swedish

Environmental Protection Agency in Sweden, and the National Animal Experiment Board and the Finnish Ministry of Agriculture and Forestry in Finland.

On the day of the approach in Sweden, the bears' GPS collars were scheduled to send positions every minute for three hours; one hour before the approach started and two hours after. The position data in Sweden was collected into the Wireless Remote Animal Monitoring (Dettki et al. 2013) database system for data validation and management. In Finland, the collars were scheduled to send positions every 25 seconds at the start of the approach, resulting in a poorer determination of pre-encounter behavior than in Sweden, and the interval of positions was gradually increased to 24 hours after the bear was passed by the observers. The females' collars were scheduled to send positions every minute. The approaches in Sweden were conducted between 10:00 and 16:00 local time, when most bears usually rest (Moe et al. 2007). The approaches in Finland were conducted between 08:00 and 19:00 local time. Prior to the approaches, the bears in Sweden were located based on triangulation of the VHF-signals from the neck collars and the implant. In Finland, bears' locations before the approach were obtained from GPS positions in real time. The approaches were conducted by one to six people (1.9 ± 0.7 observers), hereafter referred to as the observers, who mimicked hikers and talked to each other during the encounters. If only one observer conducted the approach, this person talked to him- or herself during the approach. The observers started the approaches 841 ± 336 m from the bear in Sweden and 952 ± 455 m in Finland, walked towards it, passing the initial sites at 57 ± 67 m in Sweden and 52 ± 21 m in Finland (the goal was passing the bears at approximately 50 m). During the approaches, the bear's location and movement were monitored using VHF-tracking equipment in Sweden and by observing the GPS positions on a computer by another observer who was in telephone contact with the observers in the field in Finland. After passing the bear, the observers continued walking away (approximately 500 m), keeping a distance to the bear to avoid

disturbing it a second time. The track of the observers in Sweden was registered with