Research

FREE-RANGING CATTLE AND BEARS IN SWEDEN: ARE THEY COMPATIBLE?

Jon E. Swenson[1*], Sam M.J.G. Steyaert[2], Christin B. Johnsen[3], Frank Rosell[3], Andreas Zedrosser[3,4]

[1] *Faculty of Environmental Sciences and Natural Resource Management, Norwegian University of Life Sciences and Natural Resource Management, P.O. Box 5003, 1432 Ås, Norway*

[2] *Faculty of Biosciences and Aquaculture, Nord University, N-7715, Steinkjer, Norway*

[3] *Department of Natural Sciences and Environmental Health, University of South-Eastern Norway, N-3800 Bø i Telemark, Norway*

[4] *Institute of Wildlife Biology and Game Management, University of Natural Resources and Life Sciences, Vienna, Gregor-Mendel Str. 33, A-1180 Vienna, Austria*

* *Contact: jon.swenson@nmbu.no*

http://bearproject.info/

1. Introduction

Large carnivores, including brown bears *(Ursus arctos)*, often prey upon livestock throughout their distribution range (Servheen et al., 1999). The resulting conflicts can lead to negative human attitudes towards large carnivores, which can result in the legal or illegal killing of carnivores (Kaczensky, 1999; Linnell et al., 1999). Reducing human–carnivore conflicts is therefore essential for the conservation of large carnivores and for biodiversity in general (Zabel and Holm-Muller, 2007).

Summer pasture farming used to be common in Europe, including in Sweden. Farmers moved their livestock to grazing grounds in forested areas outside villages during spring and summer, because pastures near villages were used to grow hay to feed livestock during winter (Larsson, 2009). Young family members usually accompanied livestock, moving them to suitable grazing areas, protecting them from depredation and typically confining them to pens or barns during the night (Larsson, 2009).

Nowadays, only about 200 summer farms remain in use in Sweden (Anon., 2007); most of them within the brown bear distributional range, which covers the northern two-thirds of the country. In 2018, there were an estimated 2,600–2,900 brown bears in Scandinavia, 95% of which were in Sweden (Bischof et al., 2020). Of these summer farms, 80% have dairy cattle (Elfström, 2005), which commonly range freely and unattended during daytime. However, they are penned overnight, because dairy cattle are milked every day. Beef cattle are also often penned overnight, because Swedish animal welfare laws stipulate that livestock must have daily supervision (Anon., 2010).

In Dalarna Province, southcentral Sweden, genetic-based sampling in 2017 resulted in a population estimate of 322 bears (Bischof et al., 2019), or a population density of ~11 bears per 1000 km². Annual bear-caused cattle mortality accounts for only 0.0007% of free-ranging cattle (calculated from data in Lidberg, 2009). However, 30% of the summer-pasture farmers have claimed that they had experienced disturbances due to the presence of large carnivores (Elfström, 2005; Lidberg, 2009). Predator presence may cause increased stress levels in livestock and may lead to decreased milk production, decreased mass gain or handling difficulties (Murie, 1948; Zimmermann et al., 2003) as well as shifting grazing routines and habitat use (Brown et al., 1999; Kluever et al., 2009). Livestock depredations and potential stress caused by bear presence may therefore lead to loss of income. These arguments, among others, are often used by stakeholders to argue for reducing bear numbers in Sweden (Ericsson et al., 2010), in part to preserve the tradition of summer pasture farming (Sjölander-Lindqvist, 2009).

We conducted two studies to evaluate whether brown bears do, indeed, disturb free-ranging dairy cattle and, if so, to what extent. Sam Steyaert conducted a study of habitat selection by sympatric free-ranging dairy cattle and brown bears using GPS telemetry collars in 2008 (Steyaert, 2009; Steyaert et al., 2011). Christin Beate Johnsen followed this up in 2013 with an experimental study of the effects of exposure to bear scent (faeces) on milk production of pasture-grazing cows (Johnsen, 2017). Here, we provide a summary of the most important findings.

2. Study 1: Do bears influence habitat selection by free-ranging dairy cattle?

2.1 Methods

The first study investigated habitat selection of free-ranging cattle on six summer farms in Dalarna County, Sweden (Fig. 1). These farms kept their cattle inside pens during the night. No disturbance or depredation had been reported on three of these farms, but the other three reported disturbances caused by large carnivores. None of the farms had lost cattle to carnivore depredation, although one cow was injured by a bear in 2006.

As the cattle travelled and grazed together and almost never split up, we equipped one cow in the herd of each farm (herd sizes ranged from four to 28 head of adult cows) with a Global Positioning System (GPS) collar to represent herd movements. Collars were programmed to transmit one position every 30 minutes between 05:00 and 20:30 from

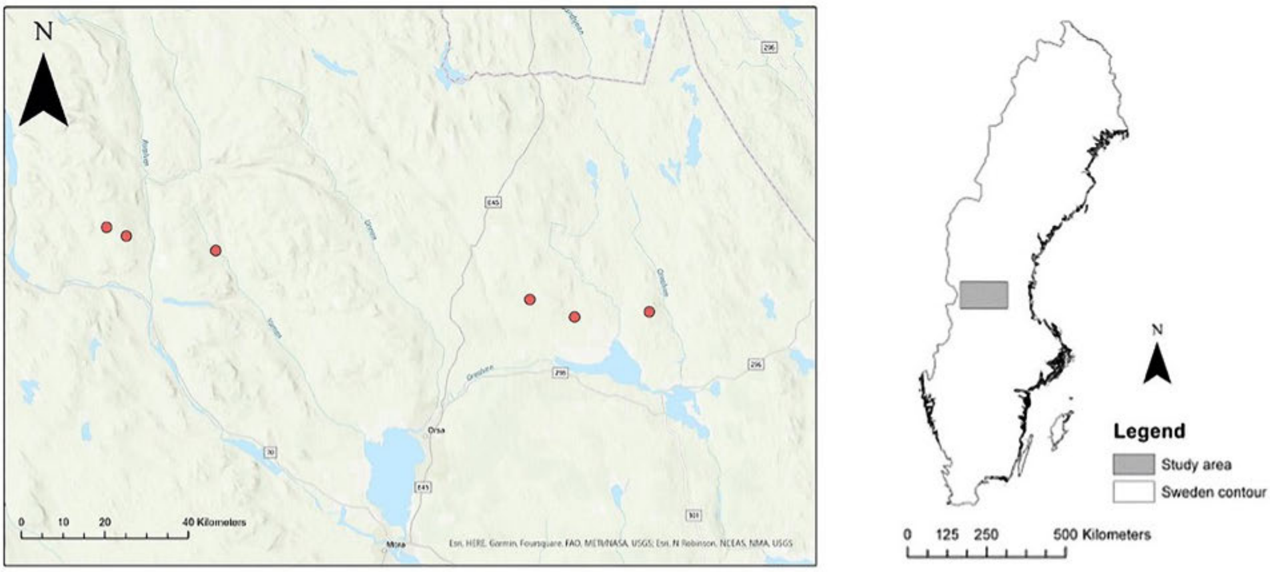


Fig. 1 Overview of the approximate study area in southcentral Sweden (right panel). The operational study area was centered around six cattle summer farms in Dalarna. All farms were located within the Swedish brown bear distribution range.

[1] www.bearproject.info

Overview of the study site at Norwegian University of Life Sciences, Ås, Norway. Dairy cattle were exposed to an experiment to test their reaction to predator scent. A camera mounted on a tripod was used to film the reaction of the cattle in a pasture enclosed by an electric fence (white wires) powered by an external battery (black box). *(All photos: Christin Beate Johnsen)*

14 June to 22 August 2008, i.e. the period when the cattle were ranging free and unattended in forests, forest pastures and roadside verges.

We also captured and equipped nine brown bears ≥3 years old (five males and four females, one of which had three yearling cubs) that frequented the cattle range with GPS collars as part of the Scandinavian Brown Bear Research Project[1]. The distribution range of brown bears overlapped with all studied farms. The GPS collars were programmed to obtain one position every 30 minutes, from 1 June to 31 August 2008. There is a pronounced seasonal shift in bear diet in the study area. Ungulates, forbs and insects dominated the diet during June and July and berries dominated in August-October (Stenset et al., 2016). As this dietary shift affects brown bear behaviour and habitat selection (Dahle & Swenson, 2003), we divided location data for both bears and cattle into two clearly distinct seasons, the pre-berry season (1–30 June) and the berry season (16 July–31 August). We did not include the transition period from 1 to15 July in the analyses.

2.2 Results & Discussion

Our results showed a significant negative relationship between habitat selection by brown bears versus that by cattle, i.e. bears avoided areas that were intensively used by cattle and vice versa. This difference in habitat selection was most likely explained by inverse responses to human habitation-related infrastructure and dense vegetation.

In general, cattle habitat selection was higher in proximity to human habitation-related variables (settlements, buildings, forest roads and trails) and in the habitat type 'other open', which comprised mostly forest pastures. Cattle avoided older forest and young dense forest, i.e. habitats generally more selected by bears. Young open forest and bogs did not contribute significantly to habitat selection by cattle, probably because these habitat types do not provide sufficient suitable food for them. Cattle are preferential grazers (Putman, 1986), which explains the selection for the habitat class 'other open', as well as their preferred proximity to forest roads and trails. Putman (1986) showed that roadside verges were the most preferred habitat type for cattle in the New Forest, England. Roadside verges are also considered important grazing areas in forested parts of Scandinavia, because few other habitats with high-quality foods are available and the area of forest meadows and pastures has declined (Anon., 2009).

Many studies have reported avoidance of human-related infrastructure by brown bears (e.g., Kaczensky et al., 2003). Our results were consistent with these findings. Brown bears generally avoided human-related infrastructure, such as forest roads, trails, settlements, and buildings. This avoidance was especially prevalent during the berry season in summer and autumn, when the forest is also more intensively used by humans for hunting, fishing, and berry and mushroom picking (Nellemann et al., 2007).

Brown bears in our study area are mainly active during crepuscular and night-time hours and tend to rest most of the day (Moe et al., 2007). Because the husbandry system only allows cattle to range free during daytime, there is a mismatch between the two species' activity patterns, which likely reduces the relative probability of an encounter between them. Our results suggest that, with the current dairy cattle husbandry system, direct interactions between bears and dairy cattle are low, which is also reflected in the low reported depredation rate. Therefore, our results do not support the claim that a reduction of the bear population would help support the summer farming system.

Our study had some limitations. The ultimate causes (e.g., predator avoidance, activity budgets, and intrinsic behaviour) of the observed differences in habitat selection between the two species remain unknown. Thus, we cannot rule out that cattle avoid bears, resulting in a trade-off between safety and optimal habitat selection, which may reduce the cattle's fitness. With our approach in this study, we could not evaluate indirect effects by bears on dairy cattle. However, this aspect was addressed in the following study.

3. Study 2: Does bear odour reduce milk production in dairy cattle?

3.1 Background

Besides direct effects, predators can also have indirect, nonlethal effects on prey caused by fear (Altendorf et al., 2001), resulting in changes in habitat use, vigilance, foraging, or physiological stress that may affect the individual fitness of prey by reducing growth, survival or reproduction (Creel & Christianson, 2008). On a population level, predator-induced fear may cause effects in prey that can be more substantial than the direct effect of predation (Altendorf et al., 2001).

All mammals, predators included, leave behind urine, faeces, and glandular secretions (Hegab et al., 2015). Prey species can detect and respond to predator odour (Parsons and Blumstein, 2010), which may induce stress (Hegab et al., 2015). Predator stimuli often elicit similar responses in domestic and wild mammals (Kluever et al., 2009; Welp et al., 2004). For instance, Pfister et al. (1990) found that domestic cattle avoided feed bins contaminated with faecal odour from red fox *(Vulpes vulpes)*, coyote *(Canis latrans)*, mountain lion *(Puma concolor)* and American black bear *(Ursus americanus)*.

Brown bear fecal sample in a petri dish in a box presented to dairy cattle to test their reaction to predator scent at the Norwegian University of Life Sciences, Ås, Norway.

Fig. 2 Cow participating in an experiment to test the reaction of dairy cattle to predator scent at the Norwegian University of Life Sciences, Ås, Norway. The red box contains a brown bear fecal sample in a petri dish.

Dairy cattle farmers in Sweden sometimes argue that bears are not just problematic due to the threat of direct depredation, but that there may be severe indirect effects on cattle due to increased stress levels caused by the mere presence of bears in the same area, even in the absence of direct encounters (Steyaert et al., 2011). Farmers have claimed that the presence of bears, advertised by odour from bear faeces, urine or tracks, causes behavioural changes and lowers both the quality and quantity of milk in dairy cattle (Zimmermann et al., 2003). Reduced milk production in dairy cattle, due to such indirect effects of bear presence, could lead to loss of income for famers (Steyaert et al., 2011). Physiologically, such a stress response of cattle to a predator would be caused by the release of stress hormones via the blood stream into the mammary glands, reducing milk production (Jouan, 2006).

3.2 Methods

We tested the hypothesis that milk production in naïve dairy cattle would be affected when experimentally exposed to brown bear odour (faeces). We included odour (faeces) from another species (red deer *Cervus elaphus*) in the experiment to check if cattle responded to any novel odour rather than specifically to the odour of a predator, as well as a blank control (no odour) (Christensen et al., 2005). Because milk yield in cattle is highly affected by food intake and age (Grant and Albright, 2001), we also controlled for these variables in the analyses. Specifically, we predicted that: (i) milk yield would be lower when cattle were exposed to bear odour than when exposed to nonpredator odour (red deer) or no odour (blank); and (ii) milk yield would be lower during experimental periods, when cattle were exposed to odour treatments, in comparison to before or after experimental periods.

We used 37 lactating and pregnant individuals of the Norwegian Red Cattle breed, with a mean age of 3.7 ± 1.5 years (SD), located at the Norwegian University of Life Sciences, Ås, in southeastern Norway, which is outside the distribution range of brown bears. The cattle had no experience with the odour of bears or red deer prior to the experiment and were naïve to depredation events by carnivores. They were milked by milking machines in a barn twice per day, at approximately 06:30 and 15:30. Milk yield was recorded automatically via ID chips worn by all cattle.

The cattle were provided individual amounts of grain feed from an automatic feed dispenser and had access to silage hay in the waiting area before milking. The experiment was conducted in four one-week study periods during June–August 2013 in two 25 × 25 m enclosures with electric fencing on a large (> 5 ha) pasture. The enclosures were spatially separated by at least 150 m to decrease odour transfer. Due to grass depletion inside the enclosures, new experimental enclosures were established every day.

Four experimental cycles of four days each were divided into two periods of two days each. For each period, we randomly selected one group of ten cows and divided them into two subgroups. After morning milking, these subgroups were placed in the two experimental enclosures in the morning of day 1 and morning of day 2. Each subgroup was then randomly assigned one of three possible odour treatments: bear faeces, red deer faeces or control (blank, i.e. no odour). The only non-random requirement was that at least one of the subgroups on either day 1 or day 2 had to be exposed to bear faeces.

Odour samples were placed on sterile petri dishes and an empty petri dish was used for the control treatment. For presentation in the enclosures, petri dishes were placed in a small container that allowed odours to evaporate (Fig. 2). The containers were cleaned with chlorinated water every morning before use. The container with the odour treatment was placed randomly in the enclosure. Random placement was achieved by dividing the enclosure into a grid of 16 cells. The odour treatment was placed in the middle of a selected cell in the morning, where it remained until the cattle were collected for milking the next morning. Production of milk was measured four times during each 2-day experimental period: in the evening of day 1, in the morning and evening of day 2 and in the morning the day after the experimental period.

3.3 Results

A total of 236 measurements of individual milk yields were made on the 37 cows in the study under the three treatment regimes. No difference in

Dairy cattle participating in an experiment to test their reaction to predator scent at the Norwegian University of Life Sciences, Ås, Norway. The cattle are just on their way to the milking facility.

Dairy cattle participating in an experiment to test their reaction to predator scent at the Norwegian University of Life Sciences, Ås, Norway. A camera mounted on a tripod (visible in the background) was used to film the reaction of the cattle in a pasture enclosed by an electric fence (white wires) powered by an external battery.

milk yield was found among odour treatments. Cattle yielded on average 24.8 ± 4.4 L of milk when presented bear odour, 24.2 ± 4.6 L when presented odour from red deer and 24.4 ± 5.1 L when presented the blank (no odour) control. The cows produced significantly less milk before an experimental period (average = 22.8 ± 5.1 L) compared to during (24.5 ± 4.6 L) or after (24.6 ± 4.9 L).

The results did not support our main hypothesis that milk production in naïve dairy cows would be affected when experimentally exposed to brown bear odour, but rather suggested that bear faecal odour as a predator cue was not a strong enough stressor to elicit a physiological response affecting milk production. Our first prediction was therefore rejected, as milk yield did not differ significantly among odour treatments (i.e. bear, red deer, or blank). Moreover, our second prediction was also rejected, because milk yield was significantly lower before an experimental period, and not significantly different when comparing during an experimental period to after an experimental period.

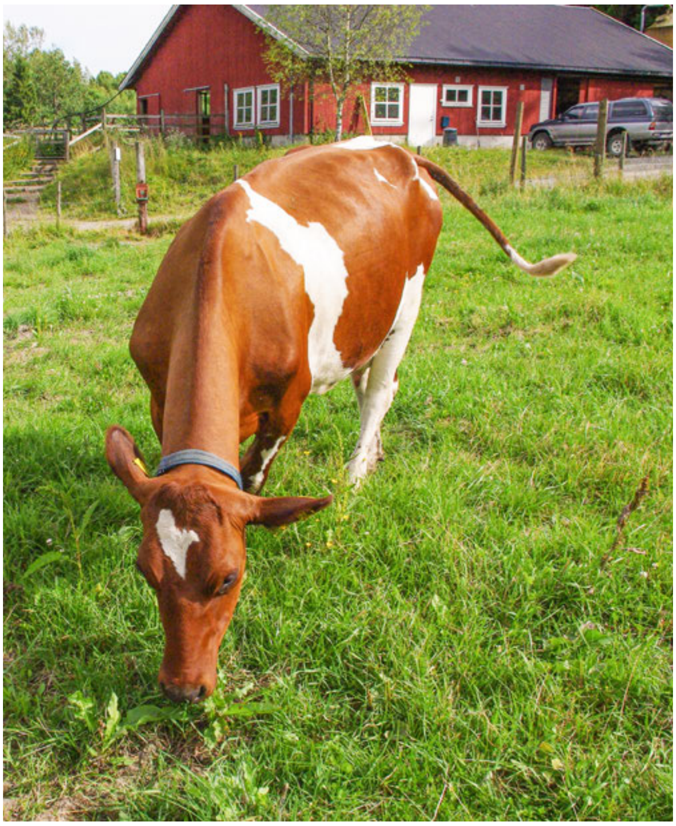
3.4 Synthesis and implications

The results of our first study suggest that, with the current dairy cattle husbandry system, direct interactions between bears and dairy cattle are low. In our second study, cows exposed to bear odour did not respond with reduced milk production. Thus, our findings do not support the claim that a reduction of the bear population would help support the summer farming system.

The dairy cattle in our experiment were naïve to predators. Cattle may need stronger negative cues and experiences in relation to the presence of a predator, such as direct visual observation, fur-derived odours or even direct attacks, to evoke responses (Sarno et al., 2008; Sahlén et al., 2016). Although some studies have shown an innate recognition and response toward predator odours (Blumstein et al., 2002; Apfelbach et al., 2005), recognition may generally have to be learned (Blumstein et al., 2002). For example, North American moose *(Alces alces)* that were naïve to grey wolves *(Canis lupus)* failed to respond to wolf olfactory cues after the two species had been separated for over 80 years, whereas bear-experienced moose showed increased vigilance in response to bear olfactory cues (Berger et al., 2001). Free-ranging dairy cattle in Sweden are potentially exposed to a variety of predator stimuli and could therefore elicit different responses than seen in our experiment. However, the mismatch in activity patterns and habitat selection between the two species, as well as the very low depredation rates on cattle by bears in Sweden, suggest a very low probability of free-ranging cattle learning to fear bears by experience and direct encounters. The income loss for farmers caused by the presence of bears can therefore likely be considered as low.

4. Conclusion

The conflict between free-ranging dairy cattle husbandry and brown bears in Sweden is apparently more imagined than real. In general, our results showed no support for the dairy farmers' concerns that the presence of bears negatively effects the traditional system of free-ranging dairy cattle. Thus, we conclude that these concerns are not substantiated and should not be a basis for a reduction in the bear population in areas with this traditional dairy system.



Cow participating in an experiment to test the reaction of dairy cattle to predator scent at the Norwegian University of Life Sciences, Ås, Norway. The red building in the background is the milking facility.

References

Altendorf KB, Laundré JW, González CAL, Brown JS (2001) Assessing effects of predation risk on foraging behavior of mule deer. Journal of Mammalogy 82(2), 430–439.

Anonymous (2007) Rovdjuren och deras förvaltning. SOU 2007: 89, 680 p. (In Swedish).

Anonymous (2009) Analys av väglandskapet i Dalarnas län – med prioriterade områden för drift och underhåll. Vägverket Region Mitt, 2009:93, 72 p. (In Swedish).

Anonymous (2010) Statens jordbruksverks föreskrifter och allmänna råd om djurhållning inom lantbruket m.m. SJVFS 2010:15, 15 p. (In Swedish).

Apfelbach R, Blanchard CD, Blanchard RJ, et al. (2005) The effects of predator odors in mammalian prey species: a review of field and laboratory studies. Neuroscience & Biobehavioral Reviews 29(8), 1123–1144.

Berger J, Swenson JE, Persson IL (2001) Recolonizing carnivores and naive prey: conservation lessons from Pleistocene extinctions. Science 291(5506), 1036–1039.

Bischof R, Milleret C, Dupont P, et al. (2019) RovQuant: Estimating density, abundance and population dynamics of bears, wolverines and wolves in Scandinavia. Norwegian University of Life Sciences, Faculty of Environmental Sciences and Natural Resource Management, Ås, Norway Fagrapport 63.

Bischof R, Milleret C, Dupont P, et al. (2020) Estimating and forecasting spatial population dynamics of apex predators using transnational genetic monitoring. Proceedings of the National Academy of Sciences of the United States of America 117(48), 30531–30538.

Blumstein DT, Mari M, Daniel JC, et al. (2002) Olfactory predator recognition: wallabies may have to learn to be wary. Animal Conservation 5(2), 87–93.

Breuer K, Hemsworth PH, Barnett JL, et al. (2000) Behavioural response to humans and the productivity of commercial dairy cows. Applied Animal Behaviour Science 66(4), 273–288.

Brown JS, Laundré JW, Gurung M (1999) The ecology of fear: optimal foraging, game theory, and trophic interactions. Journal of Mammalogy 80, 385–399.

Buchanan KL (2000) Stress and the evolution of condition-dependent signals. Trends in Ecology & Evolution 15(4), 156–160.

Christensen JW, Keeling LJ, Nielsen BL (2005) Responses of horses to novel visual, olfactory and auditory stimuli. Applied Animal Behaviour Science 93(1), 53–65.

Creel S, Christianson D (2008) Relationships between direct predation and risk effects. Trends in Ecology & Evolution 23(4), 194–201.

Dahle B, Swenson JE (2003) Family breakup in brown bears: are young forced to leave? Journal of Mammalogy 84, 536–540.

Elfström M (2005) Regional förvaltningsplan för stora rovdjur i Dalarnas län. Report 2005:13, 67 p. (In Swedish).

Ericsson G, Sandström C, Kindberg J, Støen O-G (2010) Om svenskars rädsla för stora rovdjur, älg och vildsvin. Rapport 2010:1, 15 p. (In Swedish).

Fletcher QE, Boonstra R (2006) Do captive male meadow voles experience acute stress in response to weasel odour? Canadian Journal of Zoology 84(4), 583–588.

Forkman B, Boissy A, Meunier-Salaün MC, et al. (2007) A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. Physiology & Behavior 92(3), 340–374.

Grant RJ, Albright JL (2001) Effect of animal grouping on feeding behavior and intake of dairy cattle. Journal of Dairy Science 84, 156–163.

Hegab IM, Kong S, Yang S, et al. (2015) The ethological relevance of predator odors to induce changes in prey species. Acta Ethologica 18(1), 1–9.

Johnsen CB (2017) Naïve dairy cattle do not produce less milk in response to brown bear *(Ursus arctos)* fecal odor. Master Thesis, University College of Southeast Norway, Bø, Norway.

Jouan PN, Pouliot Y, Gauthier SF, Laforest JP (2006) Hormones in bovine milk and milk products: a survey. International Dairy Journal 16(11), 1408–1414.

Kaczensky P (1999) Large carnivore depredation on livestock in Europe. Ursus 11, 59–71.

Kaczensky P, Knauer F, Krze B, et al. (2003) The impact of high speed, high volume traffic axes on brown bears in Slovenia. Biological Conservation 111, 191–204.

Kluever BM, Howery LD, Breck SW, Bergman DL (2009) Predator and heterospecific stimuli alter behaviour in cattle. Behavioural Processes 81, 85–91.

Larsson J (2009) Fäbodväsendet 1550–1920. PhD thesis, Sveriges Lantbruksuniversitet, 416 p. (In Swedish).

Linnell JCD, Odden J, Smith ME, et al. (1999) Large carnivores that kill livestock: do 'problem individuals' really exist? Wildlife Society Bulletin 27, 698–705.

Moe TF, Kindberg J, Jansson I, Swenson JE (2007) Importance of diel behaviour when studying habitat selection: examples from female Scandinavian brown bears *(Ursus arctos)*. Canadian Journal of Zoology 85, 518–525.

Monclús R, Palomares F, Tablado Z, et al. (2009) Testing the threat-sensitive predator avoidance hypothesis: physiological responses and predator pressure in wild rabbits. Oecologia 158(4), 615–623.

Murie A (1948) Cattle on Grizzly Bear Range. Journal of Wildlife Management 12, 57–72.

Nellemann C, Støen O-G, Kindberg J, et al. (2007) Terrain use by an expanding brown bear population in relation to age, recreational resorts and human settlements. Biological Conservation 138, 157–165.

Parsons MH, Blumstei DT (2010) Familiarity breeds contempt: kangaroos persistently avoid areas with experimentally deployed dingo scents. PLoS ONE 5(5), e10403.

Pfister JA, Müller-Schwarze D, Balph DF (1990) Effects of predator fecal odors on feed selection by sheep and cattle. Journal of Chemical Ecology 16(2), 573–583.

Putman RJ (1986) Grazing in temperate ecosystems: large herbivores and the ecology of New Forest. Croom Helm, London, UK, 224 p.

Rushen J, De Passille AMB, Munksgaard L (1999) Fear of people by cows and effects on milk yield, behavior, and heart rate at milking. Journal of Dairy Science 82(4), 720–727.

Servheen C, Herrero S, Bernie P (1999) Bears: status survey and conservation action plan. IUCN / SSC Bear and Polar Bear Specialist Groups, IUCN, Gland, Switzerland and Cambridge, UK, 309 p.

Sjölander-Lindqvist A (2009) Social-natural landscape reorganised: Swedish forest-edge farmers and wolf recovery. Conservation and Society 7, 130–140.

Stenset NE, Lutnæs PN, Bjarnadóttir V, et al. (2016) Seasonal and annual variation in the diet of brown bears *(Ursus arctos)* in the boreal forest of southcentral Sweden. Wildlife Biology 22, 107–116.

Steyaert SMJG (2009) Habitat modelling as a predictive tool in human-wildlife conflicts: brown bear *(Ursus arctos)* and free-ranging cattle in central Sweden. Master of Science thesis, Wageningen University, Wageningen, Netherlands.

Steyaert SMJG, Støen OG, Elfström M, et al. (2011) Resource selection by sympatric free-ranging dairy cattle and brown bears *Ursus arctos.* Wildlife Biology 17(4), 389–403.

Terlouw EC, Boissy A, Blinet P (1998) Behavioural responses of cattle to the odours of blood and urine from conspecifics and to the odour of faeces from carnivores. Applied Animal Behaviour Science 57(1–2), 9–21.

Waiblinger S, Menke C, Coleman G (2002) The relationship between attitudes, personal characteristics and behaviour of stockpeople and subsequent behaviour and production of dairy cows. Applied Animal Behaviour Science 79(3), 195–219.

Welp T, Rushen J, Kramer DL, et al. (2004) Vigilance as a measure of fear in dairy cattle. Applied Animal Behaviour Science 87(1–2), 1–13.

Zabel A, Holm-Muller K (2008) Conservation performance payments for carnivore conservation in Sweden. Conservation Biology 22, 247–251.

Zimmermann B, Wabakken P, Dötterer M (2003) Brown bear-livestock conflicts in a bear conservation zone in Norway: are cattle a good alternative to sheep? Ursus 14, 72–83.