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DISEASES AND MORTALITY IN FREE-RANGING BROWN BEAR (*URSUS ARCTOS*), GRAY WOLF (*CANIS LUPUS*), AND WOLVERINE (*GULO GULO*) IN SWEDEN

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ABSTRACT: Ninety-eight brown bears (*Ursus arctos*), 20 gray wolves (*Canis lupus*), and 27 wolverines (*Gulo gulo*), all free-ranging, were submitted to the National Veterinary Institute, Uppsala, Sweden, during 1987–2001 for investigation of diseases and causes of mortality. The most common cause of natural death in brown bears was infanticide. Infanticide also was observed in wolverines but not in wolves. Traumatic injuries, originating from road or railway accidents, were the most common cause of death in wolves and occurred occasionally in brown bears. Most wolverines were submitted as forensic cases in which illegal hunting/poaching was suspected. Sarcoptic mange was observed in several wolves but not in brown bears or wolverines. Sarcoptic mange most likely was acquired from infected red foxes (*Vulpes vulpes*) that were killed by wolves. Other parasites and infectious diseases were only found sporadically.

Key words: Brown bear, *Canis lupus*, diseases, forensic medicine, *Gulo gulo*, infanticide, mange, mortality, pathology, *Sarcoptes scabiei*, trauma, *Ursus arctos*, wolf, wolverine.

INTRODUCTION

Free-ranging populations of brown bear (*Ursus arctos*) and gray wolf (*Canis lupus*) have increased on the Scandinavian Peninsula during the last two decades, whereas wolverine (*Gulo gulo*) numbers have slowly declined. The brown bear population in Sweden was estimated at approximately 1,000 animals in the year 2001; the most recent estimate of the wolverine population was 250 animals (Anonymous, 1999). Approximately 25 yr ago, the wolf population included less than five individuals, but during the last 20 yr, it has increased to more than 100 animals (Anonymous, 1999). Sweden has a hunting season for brown bears, and approximately 50–60 are harvested annually. General county permits issued by the Swedish Environmental Protection Board regulate this hunting, and a limited number of permits are issued to each county. Permits to capture or kill wolverines (usually two–five animals) are issued by the Swedish Environmental Protection Board for protecting semidomestic herds of reindeer (*Rangifer tarandus*) in northern parts of Sweden. The wolf is almost completely protected by national legislation, and only a limited number of permits for killing individual problem wolves have been issued.

Brown bears, wolves, and wolverines that are found dead in nature, that die during research, or that are shot with permission from the Swedish Environmental Protection Board or county authorities are, according to Swedish legislation, the property of the Swedish state. Dead animals of these species must be reported to the local police and, thereafter, submitted to the National Veterinary Institute (NVI) or the Swedish Natural History Museum for examination and preservation. Because it is responsible for forensic cases, the NVI receives a majority of these animals when natural mortality because of disease is suspected and when the cause of death is not obvious. Animals that die in conjunction with wildlife research projects also are submitted to the NVI.

General knowledge about diseases and natural mortality among free-ranging bears, wolves, and wolverines in Sweden is

sparse, mainly because of the depressed populations during recent decades and limited submissions for diagnostic evaluation. This information is important, because excessive natural mortality can have negative impacts on management success for these species. With recent increases of large-predator populations in Sweden, increasing numbers of animals are available for diagnostic evaluation at the NVI every year. The present study summarizes diseases and causes of death of brown bears, wolves, and wolverines examined at the NVI from 1987 to 2001.

MATERIALS AND METHODS

Ninety-eight free-ranging brown bears, 20 wolves, and 27 wolverines examined at the NVI between 1987 and 2001 were included in the present study. Necropsies were conducted on all animals according to a standard protocol, with special attention given to forensic cases. For cases in which poaching was suspected, as well as in most forensic cases, the whole animal was radiographed to detect fragments of bullets or lead pellets. Animals were aged according to body size, weight, and dental development and were classified as juvenile (<1 yr), young (1–2 yr), or old (≥3 yr).

Specimens from liver, spleen, kidney, heart, and lung, as well as any tissue with signs of disease, were fixed in 10% neutral buffered formalin, sectioned at 4 μ, and examined histologically. When bacterial infections were suspected, liver and spleen or tissues with lesions were cultured for bacterial growth. In cases when parasitic infections were suspected, macroscopic examinations of the stomach, intestine, and lungs as well as fecal floatation and washing tissue through a sieve were used to recover parasites for identification. Samples of diaphragm or cheek muscle were routinely evaluated for *Trichinella* spp. by trichinoscopy or a digestion method (Roneus and Christensson, 1979).

RESULTS

Brown bear

Causes of mortality in brown bears are shown in Table 1. The most frequent cause of natural death was traumatic injury; 16 bears (16% of total submissions) were killed by other bears. All but one of these cases were young bears, and based on supporting observations from the field, these were classified as infanticide. Nine of these bears were less than 1 yr old, and six were 1–2 yr old. Eight were females, and seven were males. One bear was an adult female, and in this case, a male bear killed both cub and sow. Road accidents were the cause of mortality in five bears (5%). Three bears (3%), all younger than 1 yr, died from starvation.

TABLE 1. Causes of mortality in brown bears (*Ursus arctos*) examined at the National Veterinary Institute, Sweden, in the years 1987–2001.

Cause of mortality	No. of animals (%)
Killed by bear	16 (16)
Vehicular collision	5 (5)
Emaciation	3 (3)
Circulatory collapse	2 (2)
Septicemia	1 (1)
Forensic cases[a]	41 (42)
Euthanized[b]	12 (13)
Wildlife research[c]	9 (9)
Unknown	7 (7)
Total	98 (100)

[a] Killed by hunters in self-defense or suspected to be illegally shot

[b] Killed because either repeatedly killing domestic animals or appearing in villages and/or eating out of garbage bins or bee houses

[c] Died in conjunction with immobilization

Most forensic cases involved bears killed by hunters in self-defense during moose hunting. Seven bears were killed with special permission, because they were repeatedly appearing inside villages and/or eating from garbage bins.

Nine and 41 bears were examined for intestinal parasites and *Trichinella* spp., respectively. No parasites were detected.

Wolf

Causes of mortality in wolves are shown in Table 2. The most common cause of death in wolves (seven animals, 35% of total) was traumatic injuries associated with vehicular collisions.

One wolf, a young female, was killed as a result of a broken skull. Presumably, this injury was inflicted by a moose, as determined by supporting field evidence (observed tracks) that indicated a fight had

TABLE 2. Causes of mortality in wolves (*Canis lupus*) examined in the National Veterinary Institute, Sweden, in the years 1987–2001.

Cause of mortality	No. of animals (%)
Sarcoptic mange	4 (20)
Traffic collision	7 (35)
Killed by moose	1 (5)
Septicemia	1 (5)
Malformation	1 (5)
Forensic cases[a]	4 (20)
Euthanized[b]	1 (5)
Unknown	1 (5)
Total	20 (100)

[a] Killed by hunters in self-defense or suspected to be illegally shot

[b] Killed because either repeatedly killing domestic animals or appearing in villages and/or eating out of garbage bins or bee houses

taken place between a moose and wolves. Sarcoptic mange, most likely acquired from affected red foxes (*Vulpes vulpes*), was the primary mortality factor in four wolves. Three of the four cases of sarcoptic mange occurred in the year 2001 in a family group; one 1-yr-old animal and two 1.5-yr-old animals were affected. Septicemia, caused by *Pasteurella multocida,* was observed in one wolf.

Malformation of the spinal cord was observed in a 6-yr-old male with hemivertebra of the seventh thoracic vertebra. Increasingly debilitating clinical signs were observed by volunteers tracking this animal approximately 3 wk before it was killed. The animal was finally paralyzed in the hind legs and was incontinent.

One female was killed because of increasing interactions with male dogs. Concern existed that cross-breeding might occur, and she had repeatedly killed hunting dogs. Four wolves were examined as forensic cases, and all four animals were killed illegally (either shot or run over by snowmobile).

Seven animals were investigated for intestinal parasites and nine for *Trichinella* spp. Of these, one wolf was infected with *Taenia hydatigena* and another with *Uncinaria stenocephala.*

TABLE 3. Causes of mortality in wolverines (*Gulo gulo*) examined in the National Veterinary Institute, Sweden, in the years 1987–2001.

Cause of mortality	No. of animals (%)
Predator/other wolverine	11 (41)
Nephritis	1 (4)
Forensic cases[a]	9 (33)
Wildlife research[b]	3 (11)
Unknown	3 (11)
Total	27 (100)

[a] Killed by hunters in self-defense or suspected to be illegally shot

[b] Died in conjunction with immobilization

Wolverine

Causes of mortality in wolverines are shown in Table 3. The most common cause of death (11 animals, 41% of submissions) was traumatic injuries inflicted by other predators or wolverines. Other wolverines were identified as the source of this trauma in four cases; the source was uncertain in the remaining seven cases. Chronic nephritis was the primary cause of death in an old and emaciated male. Nine wolverines were examined as forensic cases, and all were found to have been either shot or killed in an illegal activity, such as being run over by a snowmobile and killed by a head trauma.

DISCUSSION

The present study was restricted to animals submitted to the NVI, and the results may not accurately represent all causes of natural mortality among these species in Sweden. For example, very young animals will be underrepresented in such submissions because of the den-related behavior of these species. These results, however, do provide information about causes of death associated with animals likely to be detected and reported by both the public and wildlife professionals. Many of the submitted animals were radiocollared as part of unrelated scientific studies. This was particularly true for wolves, because a large proportion of the existing population in Sweden is radiocollared and

most adults are found after death. This should provide very complete and accurate information regarding adult wolf mortality in the future.

Overall, the most common cause of death in brown bears, wolves, and wolverines was traumatic injuries, and in wolves, these injuries were associated with vehicles. This may reflect the natural habit of wolves to move long distances from forests in the west and north of Sweden into more populated and road-dense areas in the east and south. Only five brown bears (5%) and none of the wolverines died from vehicle-related injuries, reflecting that these animals live in sparsely populated mountain and forest areas in the north and west of Sweden; both areas have few major roads. This contrasts with the results reported for black bears (*Ursus americanus*) in Florida, USA, where accidents related to vehicles caused more than 50% of reported mortality (Dunbar et al., 1998). This difference may be explained by the fact that Florida has a road-dense area.

In brown bears and wolverines, intraspecies killing (infanticide) was the most common cause of natural mortality. Infanticide often could be verified with supportive field evidence of fighting, because animals were radiocollared or being tracked. Infanticide is believed to relate to limited resources, social pathology, parental manipulation, predation, and/or sexual selection (Hausfater and Hrdy, 1984), and it has been reported in a large number of animal species and humans (Hrdy, 1979; Hausfater and Hrdy, 1984; Dunn et al., 2002). Infanticide has been reported previously among brown bears in Sweden (Swenson et al., 1997). Intraspecific fighting among wolverines also has been reported previously in northern Scandinavia and was the most important cause of juvenile mortality (Person et al., 2003). Infanticide in brown bears probably is associated most commonly with territorial males (Swenson et al., 1997). As indicated by one observed case in which both an adult female and her cub were killed, such mortality also may occur in adults while presumably defending their young.

Several ongoing wildlife research programs in Sweden involve large predators, and a large number of the brown bears, wolves, and wolverines are currently fitted with radiocollars or intra-abdominal radiotransmitters. These animals are easily found when dead; this allows accurate estimates of illegal hunting, which unfortunately still occurs in Sweden (World Wildlife Fund Sweden, 2001).

Mortality caused by infectious diseases in free-ranging brown bears appears to be uncommon. Captive brown bears reportedly have died from Aujeszky's disease (Banks et al., 1999), but this disease has not been observed in free-ranging animals, even in areas where wild boar (*Sus scrofa*) are infected (Capua et al., 1997). Mortality caused by infectious diseases, with the exception of sarcoptic mange, also seems to be rare in free-ranging wolves in Sweden. We found one case of septicemia caused by *P. multocida* but no indications of mortality associated with any other infectious disease. Reports on infectious diseases in free-ranging wolves include canine parvovirus infection (Mech and Sagar, 1993; Johnson et al., 1994), rabies (Rupprecht et al., 2001), canine distemper (Johnson et al., 1994), and leptospirosis (Khan, 1991). Mortality among wolf pups has been reported as a possible result of canine parvovirus or canine distemper infection in wild wolf packs in the USA (Johnson et al., 1994; Mech et al., 1997). Both the presence and potential impact of viral infections in Swedish wolves are unknown, and to our knowledge, no serologic data are available. Because the causes of mortality among wolf pups in Sweden are also unknown, obtaining more information regarding viral or bacterial diseases that occur in the wolf population may be warranted. The potential impact of sarcoptic mange, which was found in several wolves of the present study, also deserves attention, especially given the social behavior of

this species and the potential for introduction by other domestic or wildlife species.

Information related to diseases and mortality in wolverines is sparse. Addison and Boles (1978) as well as Wilson and Zarnke (1985) reported on parasites in wolverines, and with the exception of a serologic survey of orthopoxviruses in carnivores in Scandinavia (Tryland et al., 1998), we could find no other reports of infectious diseases in wolverines.

Endoparasites were uncommon in all species included in the present study. This is in contrast to results for these species reported from North America (Addison and Boles, 1978; Phillips and Scheck, 1991) and Belarus (Shimalov and Shimalov, 2000), where endoparasites appear to occur more frequently. *Trichinella* spp. is reported in wolves from many parts of the world (Dick and Pozio, 2001) and in grizzly bears from Alaska (Zarnke et al., 1997). This parasite is quite common in red foxes in Sweden, and it has been found previously in large predators in Sweden (Mörner, 1992). The reason we did not detect *Trichinella* spp. in brown bears in the present study is not understood but may relate to food habits. Brown bears do not normally feed on red foxes or badgers (*Meles meles*) (Dahle, 1996; Sandegren and Swenson, 1997), which represent the main reservoirs of *Trichinella* spp. in Sweden. *Trichinella* spp. also was not found in 20 brown bears examined during the 1970s in Sweden (Roneus and Christensson, 1979) but was reported to be present in 9% of brown bears and 33% of the wolves examined in Finland from 1996 to 1998 (Oivanen et al., 2002). The high prevalence among wolves in Finland could be related to the high infection rate (38%) of *Trichinella* spp. in the raccoon dog (*Nyctereutes procyonides*), which is not present in Sweden (Oivanen et al., 2002). In Finland, the infection rates in brown bears and wolves were highest in the southwestern part of the country, where the raccoon dog is common.

Malformation of the spinal cords was observed in one 6-yr-old male wolf. This male is believed to have sired two litters. If hereditary, this malformation might be important in the future wolf population, as has been described in dogs (Kramer et al., 1982). However, no more cases of spinal cord malformations have been observed during the last 3 yr.

Swedish brown bear and wolf populations currently are increasing, and the animals generally are in good condition. The present report demonstrates that infectious diseases, possibly with the exception of sarcoptic mange in wolves, do not seem to be a factor that is negatively impacting these populations. Illegal killing and mortality associated with other human activity, however, are problems that could potentially impact future management of these species, especially in the case of the wolf population. The cause of the negative trend in wolverine numbers is unknown, but results suggest that it may relate to illegal killing.

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