The impact of large carnivores on the mortality of semi-domesticated reindeer (*Rangifer tarandus tarandus* L.) calves in Kainuu, southeastern reindeer-herding region of Finland

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Abstract: During 2006-2008 the survival of reindeer calves was studied in the reindeer-herding cooperative of Halla in Kainuu area where totally 546 calves were equipped with radio mortality collars mainly at the age of 1-3 days. The survival was monitored from the calving in May until winter round-ups in October to January. The rate, timing and causes of mortality of reindeer were assessed. In 2006-08 totally 177 radio-collared calves were found dead (mean mortality 32.4%) until mid-January. The results showed significant annual variation in calf mortality and predation. Independent of year the mortality of radio-collared calves was highest during the first two months after birth, and the total mortality was 30.7% at the end of October and reached 34.6% by mid-January. The sex of calves and pelt colour did not affect significantly survival of calves. Predation comprised 70.0% of total mortality. Predation by wolf, bear, lynx and wolverine comprised on average 38.4%, 20.3%, 9.0% and 2.3%, respectively. Birth weight of calves lost or killed by predators did not differ from surviving calves. However, birth weight of calves killed by brown bears was significantly lighter (mean 5.84 kg), whereas calves killed by Eurasian lynx was significantly heavier (mean 6.67 kg) than birth weight of calves that survived (mean 6.26 kg). Bears killed calves mainly in May to July, wolves in July to October and lynx in August to December. Of 209 radio-collared adult females, 17 were found dead (8.0%). These females had calved in May and they were killed mainly by wolves (52.0%) in August to October.

Key words: calf mortality, large carnivores, predation, *Rangifer*, reindeer, survival.

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Introduction

Several studies have shown the major role of large terrestrial carnivores on the neonatal mortality of large and medium-sized ungulates (see Linnell *et al.*, 1995). Reindeer and caribou are notable among ungulates in that their protein balance may be negative for much of the year (Gerhart *et al.*, 1996). This may increase the importance of access to spring forage in order to meet high nitrogen demands following winter consuming low-protein, lichen-dominated diets. Therefore, the predation risk-foraging trade-off may be more obvious than in other ungulate species (Gustine *et al.*, 2006). After harsh winters calving of semi-domesticated reindeer is also delayed and the smallest females die before calving or produce stillbirths. Indeed calves are highly vulnerable to predators (Tveraa *et al.*, 2003). However, after their first few weeks, the predation risk decreases (Adams *et al.*, 1995; Tveraa *et al.*, 2003).

Apart from herding activities and common supplementary feeding during winter months because of poor winter pastures, semi-domesticated reindeer in Finland are free-ranging for most of the year, especially so during the summer season. Supplementary feeding has a positive effect on spring body weight especially of

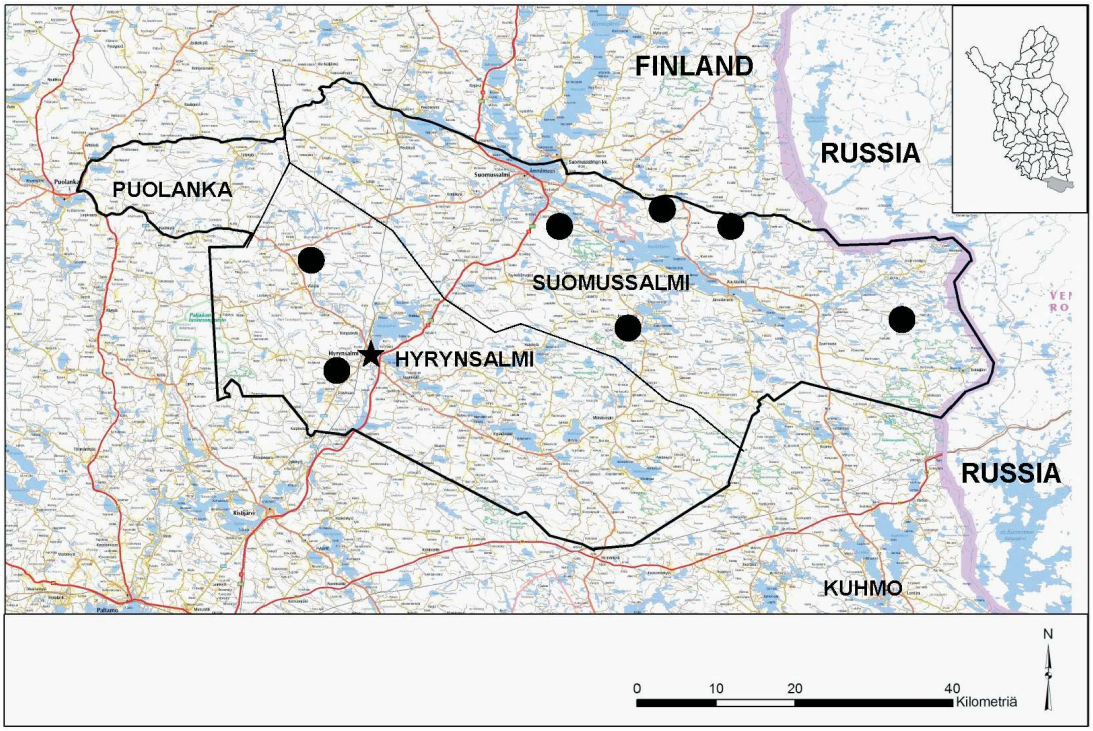

Fig. 1. Study area, the reindeer-herding cooperative of Halla, where reindeer calves and also adult females were fitted with radio-collars in different corrals (●) in 2006-08. The village of Hyrynsalmi is shown (★).

smaller reindeer females (Bårdsen *et al.*, 2008). The condition of supplementary fed reindeer is usually good during winter and spring, and calf-production and birth weight of newborn calves are also good (Soppela & Nieminen, 2001).

However, locally large carnivores may cause significant losses for reindeer husbandry. According to reindeer herders in Finland, calf mortality is extensive between calving, midsummer ear-marking round-ups and subsequent autumn and winter round-ups in October to January. Brown bear *Ursus arctos*, wolf *Canis lupus*, Eurasian lynx *Lynx lynx*, wolverine *Gulo gulo* and golden eagle *Aquila chrysaetos* are all potential predators in Finnish reindeer-herding cooperatives (Norberg *et al.*, 2005: Norberg & Nieminen, 2007).

The objective of this study was to examine the mortality among reindeer, calves from the age of 1-3 days to 7-8 months and adult females in Halla reindeer-herding cooperative in Kainuu area near the Russian border and about 20 km to the north of the wild forest reindeer (*Rangifer tarandus fennicus* Lönnb.) area.

Study area

The 8th largest reindeer-herding cooperative in Finland Halla with 70 reindeer herders is situated in the municipalities of Suomussalmi, Puolanka and Hyrynsalmi (Hyrynsalmi village, 64°40'N, 28°29'E, Fig. 1) and it covers a total land area 3592 km^2 in the Kainuu area, which belongs to the middle boreal vegetation zone (Ahti *et al.*, 1968). The landscape is dominated by Norway spruce *Picea abies* and Scotch pine *Pinus sylvestris* forests with ericaceous heather, lichen and boggy areas. There were 1200 to 1600 adult (>1 year old) reindeer in the cooperative during the study, and about 500-700 calves were born annually.

Material and methods

The study was carried out during the years 2006 to 2008. The females were rounded up in calving corrals and fed for 1.5 month with silage and concentrates (PoronHerkku, Rehu-Raisio) during the spring and calving period. Calves were weighted and totally 546 calves (286 males, 260 females) (106 calves in 2006, 260 in 2007 and 180 in 2008) equipped with silent mortality detecting radio-transmitters (Televilt Inc., Lindesberg, Sweden; frequencies 138 MHz and 230 MHz) fixed on expandable neck collars. This was mainly done at the early age of one to three days. Marking took place yearly also in the last weeks of June and the first weeks of July, when totally 78 of the calves were radio-collared at the age of four to six weeks. The collars weighed about 100 grams and corresponded to 0.7-2.3% of the body weight of the calves at the start. Most of the calves were marked in the Suomussalmi area (72.9%). Each calf was sexed and pelt colour was recorded on a five-step scale (1 = white, 2 = light, 3 = normal brown, 4 = dark brown and 5 = black). In addition, 209 adult females (100 females in 2007, 109 (10 without calves) in 2008, about 8% of all females) were equipped with mortality radio-transmitters. After marking, the animals were radio-tracked by ground triangulation to locate dead animals. Trackings were performed in intervals of two to three days until the end of September. During October to January, ground triangulations were made once per week.

After locating the activated transmitters, persons found them using hand receivers (Televilt RX-8910®, Televilt Inc., Lindesberg, Sweden and hound radar modification by Tracker Inc., Oulunsalo, Finland). Cause of death was first investigated in the field (e.g. evidence supporting presence of predator/scavenger species, such as tracks, scats and feathers/downs) and then supported by necropsies conducted by biologists in the laboratory at the Reindeer Research Station in Kaamanen. The presence of haemorrhages and perforations, both in the skin and soft tissues of the dead calf, were critical for determining the cause of death when depredation was suspected (see Bjärvall, *et al.* 1990). If the combined evidence from the field site and the necropsy was inadequate, usually due to late discovery of carcass, the cause of death was classified as unknown. The study periods were terminated in late January of the following years, when the majority of calves and some adult reindeer were selected for slaughter during the round-ups in autumn and winter.

Physiological condition of dead reindeer was determined by using the oven-dry method of metatarsal marrow fat. Condition was expressed as percent of marrow fat (see Nieminen & Laitinen, 1986).

Statistical analysis

The daily survival estimates and "reindeer days"(one "reindeer day"= one radio collared reindeer out for one day) for the radio-collared calves were calculated using the Kaplan-Meier product/limit method (Kaplan & Meier, 1958) and using the computer program "Kaplan-Meier survivorship analysis version 1.0" (Pollock *et al.*, 1989) to obtain daily and total survival estimates for the study periods. Daily survival estimates were used to present survivorship curves between May and January for the years 2006-08. For calculating monthly survival estimates, cause-specific mortality rates and 95% confidence limits, the program "Micromort version 1.3" (Heisey & Fuller, 1985) was used. Differences in monthly survival rates between the three years were tested using ANOVA multivariate analysis of variance. The survival estimates were calculated based on documented cases, i.e. in the survival analysis including only the calves that 1) were found dead, 2) had dropped their radio-collars during the study or 3) were recovered in the

Table 1. Mortality of radio-collared calves (n=546) in different areas in Halla reindeer-herding cooperative in 2006-08.

	Suomussalmi			Hyrynsalmi/ Puolanka			Total			Total
Death causes	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006-08
Wolverine	1		3				1		3	4
Lynx		1		8	7		8	8		16
Wolf	10	22	15	7	10	4	17	32	19	68
Brown bear	2	32	2				2	32	2	36
Traffic	1				2	1	3		1	4
Drowning		3						3		3
Knocking by other females		2	1					2	1	3
Collar accident	1			1			2			2
Bad condition	1	4					1	4		5
Disease	1		1				1		1	2
Unknown	3	1	5	1		1	4	1	6	11
Unknown, eaten by wolverine	1						1			1
Unknown, eaten by lynx				1			1			1
Unknown, eaten by wolf		2	1					2	1	3
Unknown, eaten by brown bear	4	8	5		1		4	9	5	18
Radio-collared calves, total	55	200	143	51	60	37	106	260	180	546
Dead calves, total	25	75	33	20	18	6	45	93	39	177
Dead calves, %	45.5	37.5	23.1	39.2	30.0	16.2	42.5	35.8	21.7	32.4

winter round-ups (survivors) when radio-collars were taken off. All other statistical tests (birth weight, sex, pelt colour, study year and possible interactions) were carried out by use of SPSS ver. 7.0 for Windows. The data were examined for statistical significance at $P<0.05$.

Results

Of 546 radio-collared reindeer calves during 2006 to 08, a total of 177 (92 males, 85 females) were found dead between marking in May or June/July and mid-January (Table 1). The mean calf mortality was 32.4% in Halla reindeer-herding cooperative, and it was slightly higher in Suomussalmi (33.4%) than in Hyrynsalmi/Puolanka area (29.7%). The mortality was highest (42.5%) in 2006 and lowest (21.7%) in 2008. There were great annual differences in survival of calves during the study period ($P<0.001$). Between 1 May and 15 January, survival of radio-collared calves was 0.265 (SE = 0.080) in the 2006 cohort, 0.580 (SE = 0.030) in the 2007 cohort and 0.711 (SE = 0.036) in the 2008 cohort. Total survival curve for calves of the 2006 to 2008 cohort was 0.654 (SE = 0.036) (Fig. 2).

The mortality (M=1-Survival) of radio-collared calves was great during the first two

months after birth and reached 31.7% by the end of June in 2006, 21.1% in 2007 and 13.4% in 2008. Mortality of calves was 46.4% at the end of August in 2006, 59.9% at the end of October and reached 73.5% by mid-January. In 2007 mortality of radio-collared calves was 37.9% at the end of October and 42.0% in mid-January. In 2008 mortality of calves was 28.9% at the end of October and also 28.9% in mid-January. The total mortality in 2006-08 was 30.7% at the end of October and reached 34.6% by mid-January (see Fig. 2). The birth weight of male and female calves and pelt colour did not significantly affect survival differently, as there were no significant interaction between sex and colour on calf survival.

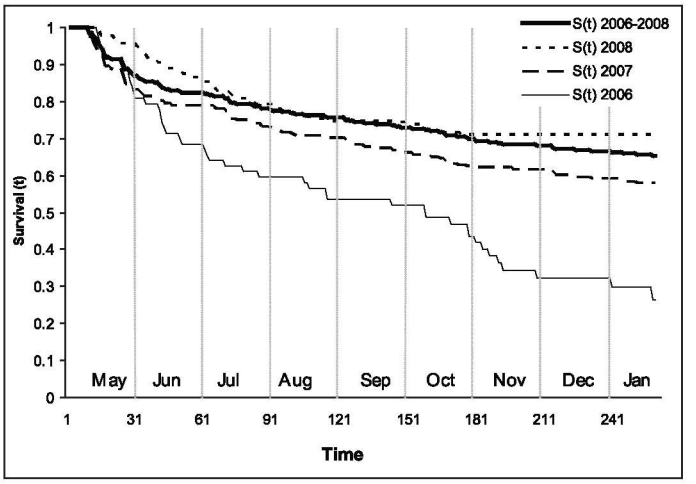

Fig. 2. Survivorship curves for radio-collared reindeer calves in Halla reindeer-herding cooperative in 2006-08, related to expressed as days after 1 May (day 1). Total survival curve is S(t) 2006-2008. (Mortality (M) = 1 – Survival (S)).

Predation comprised 70.0% of total mortality (predation out of total number of dead radio-collared calves recovered) during three years in 2006 to 2008. Predation showed significant ($P<0.001$) annual variation. Predation by wolf comprised on average 38.4%, by bear 20.3% and by lynx 9.0% of all radio-collared calves (Fig. 3). Wolverines killed only four marked calves (2.3 %) during this study, one in May and three in January. Bears killed reindeer calves mainly in May-July, wolves in July-October and lynx in August-December. No calves were killed by golden eagles in the cooperative of Halla.

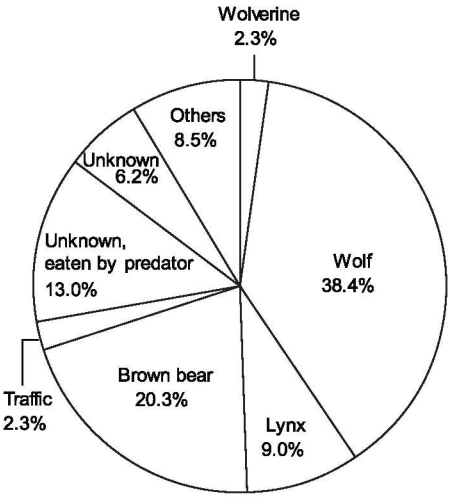

Fig. 3. Death causes for calves in Halla reindeer-herding cooperative in 2006-08.

Causes not associated with predation comprised 10.7% of total mortality, and included traffic accidents (4) and other accidents (8) and other known causes (7). Metatarsal fat content was <25% in calves that died from starvation (5) and disease (2). Excluding the deaths with unknown causes (11), and if the other unknown deaths of calves eaten by different predators (see Fig. 3), mainly by bears (18), were also caused by these predators, total predation was very high, 83.1%.

Birth weight of all calves that were lost or killed by predators during the study was on average 0.2 kg, but not significantly lower than that of survived calves (mean 6.26 kg). Birth weight of calves killed by wolves was not significantly but by bears significantly ($P<0.05$) lower (mean 5.84 kg) and by lynx significant-

ly ($P<0.05$) higher (mean 6.67 kg) than birth weight of surviving calves. Condition of all predator killed calves was, however, fair or good (metatarsal fat content >30%).

Totally 17 radio-collared adult females (8%) were found dead during 2007-2008 until mid-January; of those nine were killed by wolves (52.0%). Females were killed mainly during August to October, and they were in good condition (metatarsal fat content >60%). All dead females had calved in May.

Discussion

The design of the present study was rather similar to that of the reindeer calf mortality study in Sweden in the 1980s (Bjärvall *et al.*, 1990), to the studies in 1995-1996 in mid Norway (Nybakk *et al.*, 2002) and in 1997-1998 in northeastern Finnish Lapland (Norberg *et al.*, 2006). However, the total mortality recorded in the present study was much higher (32.4%) than the total mortality (14.3%) recorded in Umbyn, Sweden and in Lappi reindeer-herding cooperative in Finland (8.5%) but similar to that in North-Trøndelag in mid Norway (31.0%).

Predation accounted for a larger part of total mortality recorded in the present study (70.0%) than in studies in Sweden (65%) (Bjärvall *et al.*, 1990) and in Finland (53%) (Norberg *et al.*, 2006). In the Norwegian study, the part of predation was even higher (75.3%) (Nybakk *et al.*, 2002) than in the present study. According to Bergerud (1980) caribou herds exposed to predation may lose usually 50% of the annual calf crop, and predation has been reported to constitute up to 93% of the total annual mortality in calves (see Mahoney *et al.*, 1990). If the other unknown death causes of calves eaten by different predators, mainly by bears, were really killed by these predators, total predation was highest in present study, totally 83.1%. In our study from Kuusamo, also in the southeastern reindeer-herding region in Finland, the total mortality of reindeer calves was 42-46% by mid-January in 2005-2006, and the total rate due predation was at least 21%. Predator-killed calves comprised 53% of all of the dead calves found (Norberg & Nieminen, 2007).

Mainly wolves and bears caused great losses among calves in the present study, and predation by wolf comprised on average as much as 38.4% of the radio-collared calves. Bears killed calves mainly from May to July, wolves in July to October and lynx in August to December. Also in Kallioluoma reindeer-herding cooperative in Kuusamo area, most of the dead calves found (53%) were killed by predators and of them 45% by wolves. Wolf predation was on average 18% while the total rate of predation was at least 21% (Norberg & Nieminen, 2007). In mid Norway 89.3% of the total mortality in calves was due to predation, and predation by lynx was the dominant cause (42.4%) (Nybakk *et al.*, 2002). Also in northern Norway predation accounted for 75% of the calf losses during summer and winter, and the lynx was the main predator (55%) (Mathisen *et al.*, 2003). In northeastern Finnish Lapland a minimum of 53% of the total mortality was attributed to predation, with golden eagles being the main predator. Mortality caused by golden eagles comprised, however, only 2.8% to 4.2% in 1997-99 (Norberg *et al.*, 2006). In an earlier study in mid Norway also 5.3 % of the total loss of radio-collared reindeer calves was caused by golden eagles (Nybakk *et al.*, 1999).

The golden eagle population in whole Finland is around 440 pairs or territories. About 80% of all golden eagles are living in Lapland (maximally 350 pairs in 2006, Large Carnivore Working Group, 2008) and 90% in the whole reindeer-herding area. In Kainuu area, there were only 11 territorial pairs of golden eagle in 2009 (Ollila, 2009). In the present study, golden eagles killed no reindeer calves and adult females in the forest area. In mortality studies conducted in mid Norway and in northeast-

ern Finnish Lapland, the most of the radio-collared reindeer killed by golden eagles were discovered in open alpine terrain (see Nybakk *et al.*, 1999; Norberg *et al.*, 2006). Increased risk of golden eagle predation seems to associate with alpine highlands.

Birth weights of calves that were lost or killed by predators in the present study was slightly lower, but calves killed by brown bears significantly ($P<0.05$) lower, than birth weight of the calves that survived. In an earlier study in nine reindeer herding cooperatives in Finland, birth weights of the lost calves was on average 0.4-0.5 kg lower than birth weight of the surviving calves. In Oivanki cooperative in Kuusamo area, calves killed by bears were 0.5 kg lighter at birth compared to those surviving (Norberg *et al.*, 2002). Calves killed by lynx in this study had, however, 0.4 kg and significantly ($P< 0.05$) higher birth weights (mean 6.67 kg) than surviving calves. Most small calves were lost or killed by bears during early and mid-summer, and lynx killed bigger reindeer calves mainly during autumn. In mid Norway, predation by lynx also peaked in autumn and early winter (Nybakk *et al.*, 2002).

In the present study the birth weight of male and female calves and pelt colour did not affect survival. There was also no significant interaction between sex and pelt colour on calf survival. In studies on ungulates where bias in neonatal predation is apparent, it is usually male biased, and according to Aanes & Anderson (1996) sex difference in calf behaviour has been suggested as potential explanation. According to Mathisen *et al.* (2003) male reindeer calves stray usually farther away from their mothers, exhibit a higher level of locomotive behaviour in terms of play and walking, and are therefore more vulnerable to predation than are females calves.

During the last five years predators have caused increased losses in the Finnish semi-domesticated reindeer stock (totally 3500-4000 reindeer/year), especially in the southeastern regions, and mainly due to the expansion of the wolf population into the Kainuu area. Based on reindeer herding statistic from 1976 to 2008 large carnivores have killed around 2000 reindeer (based on reindeer found dead) annually in the Finnish reindeer-herding area. The reindeer were killed mostly by wolverines (around 45%), brown bear (25%), wolf (20%) and lynx (10%) (Nieminen, 2009). During 1994-2008 large carnivores have killed mainly adult females (59.2%), calves (<1 year-old) (27.4%) and adult males (9.5%). The calves were killed mainly by bears (around 30%), wolverines (29%), wolves (23%) and lynx (18%) (Nieminen, 2009).

Bear scats collected during summer 2005 in whole Kainuu (23 000 km^2), also outside the reindeer husbandry area, were analysed using faecal DNA-methodology, and a total of 46 brown bears were indentified (RKTL, 2008), and in winter 2007, 55-62 wolves were estimated to live in the nearby Kuhmo area. In the whole Finnish reindeer husbandry area, the estimated minimum numbers of the predators were estimated 15 to 25 wolves and more than160 bears, 75 wolverines and 50 lynx (RKTL, 2008). The majority of the today wolf population in the reindeer husbandry area is found in Kainuu, in the areas of the Halla and Näljänkä reindeer-herding cooperatives. In winter 2008 the size of the Kainuu wolf population was estimated at 29–37 animals, a decrease of about 50% compared with the previous year. The population size of the lynx was estimated at 140-190 individuals, including 23–31 litters, and the size of the wolverine population at 36–53 animals (Siira *et al.*, 2009). During 2006 to 2008 big predators (mainly wolf and lynx) killed yearly 380 to 455 reindeer in Halla, and compensations of predator killed reindeer to reindeer owners were 5-6.5 times more than slaughter incomes. Thus, many wolves from Russia and from the wild

forest reindeer area Kuhmo are visiting Halla reindeer-herding cooperative killing reindeer mainly during summer and autumn months (Nieminen, 2009).

My results showed very high predation and calf mortality in Halla reindeer-herding cooperative, and the economic consequences makes it questionable to what extent reindeer husbandry in its present form can be continued in Kainuu, the southeastern reindeer-herding region of Finland.

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Suurpetojen vaikutus poronvasojen (*Rangifer tarandus tarandus* L.) kuolleisuuteen Kainuussa, Suomen poronhoitoalueen kaakkoisosassa

Abstract in Finnish / Tiivistelmä: Vuosina 2006-2008 tutkittiin poronvasojen selviytymistä Kainuun alueella Hallan paliskunnassa, jossa yhteensä 546 vasalle laitettiin kaulaan kuolevuuslähettimet pääasiassa 1-3 vuorokauden iässä. Vasojen selviytymistä seurattiin toukokuisesta vasonnasta talvierotuksiin saakka loka-tammikuun aikana. Tutkimuksessa selvitettiin porojen kuolemien suuruutta, ajoittumista ja syitä. Vuosina 2006-08 löydettiin kuolleena yhteensä 177 radiopantavasaa (keskimääräinen kuolleisuus 32,4%) tammikuun puoliväliin mennessä. Tulokset osoittivat merkitsevää vuosittaista vasakuolemien ja petojen osuuden vaihtelua. Riippumatta vuosista radiopantavasojen kuolleisuus oli suurinta kahden ensimmäisen kuukauden aikana vasonnasta, ja kokonaiskuolleisuus oli 30,7% lokakuun lopussa ja 34,6% tammikuun puolivälissä. Vasojen sukupuolella ja turkin värillä ei ollut merkitsevää vaikutusta vasojen selviytymiseen. Petojen osuus oli 70,0% kokonaiskuolleisuudesta. Suden, karhun, ilveksen ja ahman osuudet kuolleisuudesta olivat vastaavasti keskimäärin 38,4%, 20,3%, 9,0% ja 2,3%. Menetettyjen tai tapettujen vasojen syntymäpainot eivät eronneet selviytyneiden vasojen syntymäpainoista. Karhun tappamisen vasojen syntymäpaino oli kuitenkin merkitsevästi pienempi (keskiarvo 5,84 kg) mutta ilveksen tappamien vasojen merkitsevästi suurempi (keskiarvo 6,67 kg) kuin selviytyneiden vasojen syntymäpaino (keskiarvo 6,26 kg). Karhut tappoivat vasoja pääasiassa touko-heinäkuun, sudet heinä-lokakuun ja ilvekset elo-joulukuun aikana. 209 radiopantavaatimesta löydettiin kuolleena 17 (8,0%). Nämä vaatimet olivat vasoneet toukokuussa, ja pääasiassa sudet (52,0%) olivat tappaneet ne elo-lokakuun aikana.