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Authors: Kojola, Ilpo, Ronkainen, Seppo, Hakala, Antero, Heikkinen, Samuli, and Kokko, Sanna

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Interactions between wolves *Canis lupus* and dogs *C. familiaris* in Finland

Ilpo Kojola, Seppo Ronkainen, Antero Hakala, Samuli Heikkinen & Sanna Kokko

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We examined wolf *Canis lupus* attacks on domestic dogs *C. familiaris* in six Finnish wolf territories occupied by mated pairs and packs. Most incidents (76%, N = 21 confirmed cases) took place inside one territory. The wolves mostly (70%) attacked dogs in house yards. It appeared that wolves in the territory were actively seeking for dogs rather than killing them as a result of random encounters. A strong tendency to attack dogs seemed to be adopted by pups born to the wolf pack. We did not find evidence that the density of primary prey or resident dogs were associated with the risk of wolf attacks.

Key words: Canis familiaris, Canis lupus, domestic dog, Finland, interaction, wolf

Ilpo Kojola, Antero Hakala & Samuli Heikkinen, Finnish Game and Fisheries Research Institute, Oulu Game and Fisheries Research, Tutkijantie 2 A, FIN-90570 Oulu, Finland - e-mail addresses: ilpo.kojola@rktl.fi (Ilpo Kojola); anterovk.hakala@pp.inet.fi (Antero Hakala); samuli.heikkinen@rktl.fi (Samuli Heikkinen)
Seppo Ronkainen & Sanna Kokko, Finnish Game and Fisheries Research Institute, Taivalkoski Game and Fisheries Research, Ohtaojantie 19, FIN-93400 Taivalkoski, Finland - e-mail addresses: seppo.ronkainen@pp5.inet.fi (Seppo Ronkainen); sanna.kokko@hytti.uku.fi (Sanna Kokko)

Corresponding author: Ilpo Kojola

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In many parts of Europe, large carnivores must be conserved in the multiple-use landscape surrounding human settlements (Linnell, Swenson & Andersen 2001). Within these landscapes, a variety of conflicts, such as depredation of livestock, competition with hunters and predation of domestic dogs, may occur. Interactions between wolves *Canis lupus* and domestic dogs *C. familiaris* have seldomly been subjected to scientific research. Encounters are often aggressive (Persson & Sand 1998, Karlsson & Thoresson 2001, Kojola & Kuittinen 2002), although wolves and dogs may also hybridise in the wild (Anderzone, Lucchini, Randi & Ozolins 2001, Vila, Walker, Sundquist, Flagstadt, Anderzone, Casulli, Kojola, Valdmann, Halverson & Ellegren 2003). The interactions may also influence the prevalence of parasites, e.g. *Trichinella* spp. (Pozio, Casulli, Bogolov, Marucci & La Rosa 2001).

Wolf attacks on dogs may be just one form of aggressive intraguild interaction (Peterson 1995, Palomares & Caro 1999). Overlapping niches and consequent killing of smaller carnivore can, for example, explain why wolf and feral dog populations are inversely related in the Russian nature reserves (Ovsianikov & Poyarkov 1996).

Wolves almost always eat the dogs they kill (Kojola & Kuittinen 2002). When wolves attack dogs in resi-

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dential areas, their primary motivation may be nutritional. Dog-killing wolves usually act alone, which may be a consequence of their inability to effectively kill larger, primary prey such as moose *Alces alces* (Kojola & Kuittinen 2002). Fritts & Paul (1989) examined wolf attacks on dogs that occurred in Minnesota, USA, and suggested that the attacks are not a result of random encounters between wolves and dogs, but that some wolves are actively seeking for dogs.

Identification of potential 'problem individuals' in large carnivore populations is a noteworthy management question when considerable livestock losses to carnivores occur. It is not, however, clear if some individuals have a stronger than average tendency to attack livestock or other domestic animals. In their review, Linnell, Odden, Smith, Aanes & Swenson (1999) noted that differential numbers of attacks on livestock can be explained mostly by disproportionate access to livestock within individual large carnivore home ranges, and stressed that available field data do not allow firm conclusions about individual differences when livestock availability and differential encounter rates are considered.

We analysed the effects of dog and prey densities on the frequency of wolf attacks on dogs within their territories in eastern Finland. Furthermore, we examined whether such behaviour is traditionally inherited within wolf packs.

Study area and methods

We performed our study in east-central Finland (Fig. 1) during 1999-2001. The study area is mostly comprised of exploited coniferous forests dominated by Scots

Figure 1. Location of the study area in east-central Finland where six wolf territories were examined during 1999-2001.

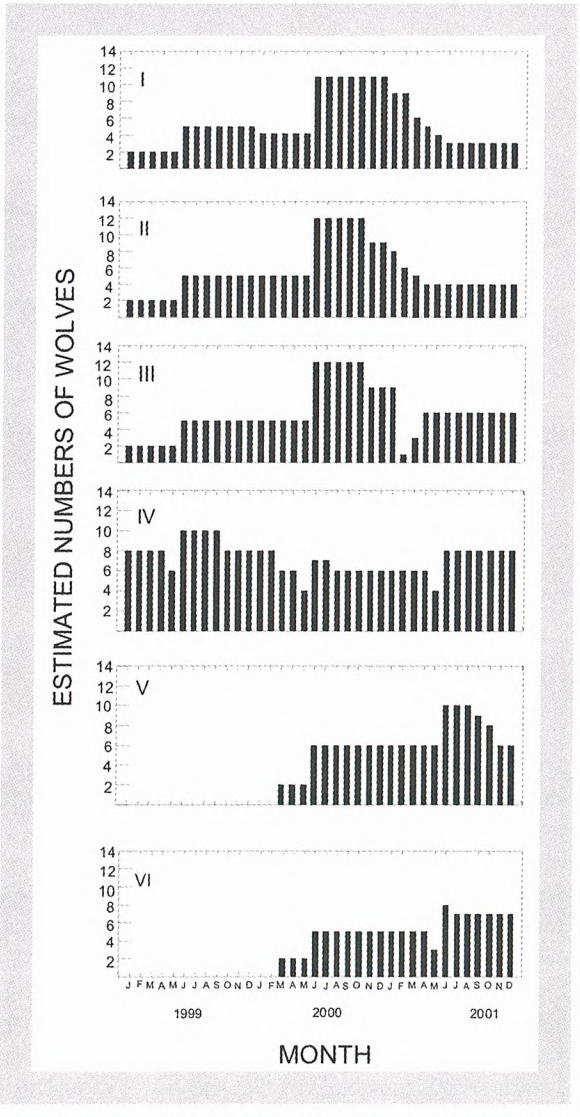

Figure 2. Study periods and estimated numbers of wolves in each of the six (I-VI) wolf territories monitored during 1999-2001.

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pine *Pinus sylvestris* and Norway spruce *Picea abies*. The topography is relatively flat. Bogs and fens, lakes, ponds and shallow rivers are also typical components of the landscape. The overall winter density of moose is 300-400 animals/1,000 km^2 (V. Ruusila, unpubl. data) and of wild reindeer *Rangifer tarandus fennicus* ca 200 animals/1,000 km^2 (K. Heikura, unpubl. data).

The human population within each wolf territory was sparse (1-2 people/km^2) and was scattered in small villages and remote single houses. Few livestock existed within our study area, and only seven sheep farms with 20-40 sheep each were situated within the study area. Of these, wolves killed 19 (six in 1999 and 13 in 2001) during the study period.

We monitored a total of 21 wolf attacks inside a total of six territories; two in 1999, nine in 2000 and 10 in 2001, respectively. The monthly number of wolves per territory ranged within 1-12 (Fig. 2). We radio collared a total of 25 wolves which were caught in February-March using snowmobiles when the snow was soft and at least 80 cm deep. The wolves were put in a wooden box that was strengthened with metal grating from the outside and had doors at both ends. They were kept for 30 minutes before injection of the anaesthetic which was a mixture of medetomin and ketamin (Jalanka & Roeken 1990). Once the individual wolf was radio collared, marked with ear-tags and measured for several size parameters it was placed back into the box, and the antagonist (atipamezole) was injected so that the wolf could recover before release.

A dense network of small forest roads allowed comprehensive radio tracking from the ground. Each wolf was located 2-5 times weekly. The duration of the various study periods in the different territories varied from 12 to 36 months (see Fig. 2) and the annual territory sizes (100% minimum convex polygons, MCP) ranged within 499-1,721 km^2 (I. Kojola, S. Heikkinen, A. Hakala & S. Ronkainen, unpubl. data).

The Finnish Government reimburses dog owners for dogs killed by wolves if the incidents can be verified by experts. Wolf attacks were confirmed either by the physical presence of wolves in the near proximity of dog kills (tracks, telemetry locations, sightings) or by examining dog carcasses for bite marks or other characteristics typical for wolf kills. In hunting situations, some dogs were lost for unknown reasons, so not all wolf-killed hunting dogs were necessarily recorded.

The number of dogs resident within each territory was estimated based on a survey of dog presence (sighting of dogs, dog yard, doghouse, dog chain) for ca 70% of all the homes in each territory. The mean number of dogs recorded in the six territories was 48 (SD = 22). The recorded number was then extrapolated for the entire study area, based on the average number of dogs per household and the number of residences within each territory. Dog density was then determined as the number of dogs per unit area within each 100% MCP wolf territory.

Moose and wild forest reindeer are the primary wolf prey in our study area (Kojola 2000). Reindeer occur regularly within three of our study territories (I, II and III), but moose is the most important wolf prey also in these territories (Kojola 2000). In order to compare the densities of the two species between the wolf territories, faecal pellet groups of moose and reindeer were counted in June 2002 within each territory on eight transect lines of 10 km (4 x 2.5 km) and a width of 4 m; the minimum distance between the neighbouring lines was 2 km, and the transect lines were placed so that they did not intersect villages or large bodies of water. Large size and regular shape guaranteed the approximate randomness of the inventory route (Linden, Helle & Wikman 1996).

Results

The number of attacks varied strongly between territories, but 76% of the confirmed attacks (N = 21) happened within one territory (territory II; Fig. 3). This concen-

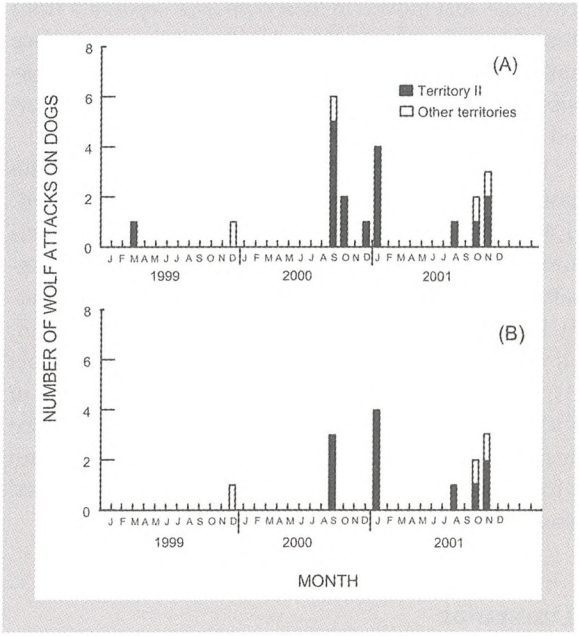

Figure 3. Number of wolf attacks on dogs in territory II and the other five territories for all attacks (A) and attacks in house yards (B) only.

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Table 1. Estimated number of resident domestic dogs and densities of moose and wild reindeer based on numbers of pellet groups/4 ha (mean ± SD), and the rate of wolf attacks on dogs/wolf/year within the six wolf territories in eastern Finland.

Territory	Dogs/km^2	Moose density	Wild reindeer density	Rate of wolf attacks
I	0.04	71.6 ± 62.9	0.0 ± 0.0	0.09
II	0.04	64.1 ± 62.9	0.2 ± 0.7	0.93
III	0.09	58.4 ± 26.8	8.3 ± 4.3	0.17
IV	0.06	64.1 ± 62.9	0.3 ± 0.8	0.00
V	0.08	48.5 ± 36.7	0.0 ± 0.0	0.00
VI	0.12	71.6 ± 58.3	0.0 ± 0.0	0.00

tration was significant ($\chi^2 = 13.6$, df = 1, $P < 0.001$; the expected frequencies were achieved by dividing the number of attacks by the number of territories). The mean rate of wolf attacks/year in territory II was 5-fold and 10-fold higher than in the other two territories where aggressive interactions where observed (territories III and I; Table 1). The majority of the confirmed attacks (70%) in this particular territory took place in house yards. Attacked dogs were most often moose hunting dogs (33%; N = 21) or spitz (24%).

Aggressive encounters were most common during the hunting season, i.e. in autumn and early winter (see Fig. 3). Attacks in house yards were also concentrated in these two seasons (see Fig. 3). Attacks were common in September 2000 in territory II, but no attacks occurred in November after that two yearlings (a female and a male) and a pup (female) in the wolf pack had been killed. In December attacks started again (see Fig. 3); they were made by a radio-collared yearling male and two pups that moved in their own area separated from the other wolf pack members. No depredations took place until autumn 2001, when the alpha female was responsible for several attacks before the end of the study period (see Fig. 3).

The density of the faecal pellet groups of moose did not differ between the territories (Kruskal-Wallis test: 1.46, df = 5, P = 0.917; see Table 1). Within the territories I, II and III, where wild reindeer exist, the density of reindeer faecal pellet groups differed significantly between the territories (Kruskal-Wallis test: 18.88, df = 2, $P < 0.001$), being highest in territory III (see Table 1) where two wolf attacks in house yards occurred in October-November 2001 (see Fig. 3). The density of the resident dogs was highest in territory VI in which no attacks occurred during the 24 months study period (see Table 1).

Discussion

The patterns of wolf attacks on dogs in our study area appeared to fit Fritts & Paul's (1989) findings from Minnesota, USA. The proportion of incidents taking place in hunting situations was not significantly higher than that of attacks occurring in eastern Finland, south of the present study area in 1996-1999 (44% in house yards, N = 43 confirmed cases; $\chi^2 = 1.92$, df = 1, P = 0.167; data from Kojola & Kuittinen 2002). Our results are consistent with those of Fritts & Paul (1989), who found that encounters are unevenly distributed in space and time. In their study area, wolf attacks occurred also in villages as most attacks did in our study area. They suggested that some wolves are actively looking for dogs and this seemed to be true for one wolf pack in our study area too. The number of aggressive interactions with dogs varied between wolf packs also in Sweden, but wolves in the Swedish study area attacked dogs only in hunting situations (Karlsson & Thoresson 2001).

Although wolves of the one particular pack seemed to actively seek for dogs, firm conclusions can not, however, be drawn because movement routes could theoretically be independent of the location of dogs within the pack territory. For example, the rendezvous sites (Harrington & Mech 1982, Dekker 1985) might be situated near villages where wolves attacked dogs. On the other hand, attacks in house yards in December 2000 made by a yearling and two pups, occurred in the area in which no radio locations were made in the preceding summer (I. Kojola, S. Ronkainen & M. Suominen, unpubl. data).

The density of dogs within the wolf territories did not explain the differences in the number of attacks. We could estimate reliably only the number of resident dogs, but we did not have any reason to suggest that including visiting hunters' dogs would change the picture. The proportion of state-owned land where visitors usually hunt was not highest in the territory with most attacks. Furthermore, 96% of the attacks were directed to resident dogs. Therefore, it appears that differential encounter rates would not explain our results.

As our pellet counts did not indicate any differences in moose density, we also suggest that the rate of attacks was not associated with the density of the primary prey. Our results suggest that, in the wolf pack exhibiting strong aggressive and/or predatory behaviour towards dogs, this behaviour may constitute a tradition that may be passed on from generation to generation within a family unit. The hypothesis that aggressive behaviour by wolves towards dogs is an inherited, traditional behaviour, has important management implications and should be investigated further. A long-term study of wolf predation on dogs is needed to better understand the underlying mechanisms of this behaviour and its pos-

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sible inheritability. Experimental removal of particularly aggressive wolves may be an avenue for future research on the hypothesis that such behaviour is traditional within packs and in territories founded by the offspring of such social units.

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