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Wolf visitations close to human residences in Finland: The role of age, residence density, and time of day

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ABSTRACT

Large carnivorous mammals, such as the gray wolf (*Canis lupus*) have been recently expanding to human-dominated landscapes in many regions. Although wolves tend to avoid human infrastructure, visitations close to human residences might be unavoidable in territories that are highly fragmented by residential areas. House yard visits are of particular concern: according to the Finnish legislation, wolves that repeatedly approach within 150 m from the nearest residential building can legally be killed for human safety. We analyzed the average distance from house yards and probability of house yard visitations by wolves against sex, age class, time of the day, season and house density for 25 territorial GPS-tracked wolves in Finland. Generally, wolves avoid houses — with mean distances higher than from random locations in the territory. This difference became higher with decreasing house density for sub-adults while for adults this difference decreased slightly with decreasing house density. Probability of visitation in house-yards increased with increasing house densities, was far higher at night than in the daytime, a difference that was greater with increasing house density. Sub-adults visited house-yards more often than adult wolves in the first summer after spring dispersal from the natal pack to a territory, but there was no difference in winter. The indication that wolves learn within a season to avoid moving to near residential buildings in human-dominated territories is when the territory becomes more familiar to wolves which is a noteworthy result for the management.

1. Introduction

Large carnivorous mammals were once forced to withdraw from human-dominated landscapes (Woodroffe, 2000) but in many regions they have been recently returning (Okarma, 1993; Swenson et al., 1995; Breitenmoser, 1998; Mech and Boitani, 2003; Bragina et al., 2015). There are, in particular, many recovering populations of gray wolves (*Canis lupus*) in Europe (Chapron et al., 2014). Although the location of wolves' breeding territories indicates that wolves tend to spatially avoid human infrastructure (Mladenoff et al., 1995; Karlsson et al., 2007; Kaartinen et al., 2005, 2015), movements by wolves closer to human residences are probably unavoidable when wolves live in areas of high human activity.

The wolf is an admired while also a feared animal. The fear stems from both legends and a few confirmed incidents where wolves have attacked humans (Løe and Røskaft, 2004; Behdarvand et al., 2014). While occasionally causing livestock depredation in pastures outside villages, wolves may at times intrude into house-yards and attack domestic dogs (Fritts and Paul, 1989; Kojola and Kuittinen, 2002; Kojola et al., 2004). Conflicts related to the range expansion by wolves have aroused campaigns against wolf management policies that are regarded to be too conservation-oriented (Brownlow, 2000; Skogen et al., 2008; Lyon and Graves, 2014).

In Northern Europe human densities are relatively low (Chapron et al., 2014), and wolves generally thrive in human-modified forest areas. For example, in Finland most have learned to use timber roads to facilitate travel and also strongly to avoid paved roads (Gurarie et al., 2011). The number of wolves in Finland started to grow around the mid-1990's after their legal conservation status had improved (Bisi et al., 2007; Kojola et al., 2014). The number of family packs increased from 4 to 25 from 1996 to 2006 (Kojola et al., 2014). The present population estimate is 220–240 wolves and the wolf is classified as a highly endangered species (Rassi et al., 2010). Population size has been mainly limited by poaching and legal hunting (Jansson et al., 2012; Kojola et al., 2014). During the early 2000s the first dispersers from the core eastern range established territories in westernmost Finland, where wolves had been absent for about 100 years (Kojola et al., 2006). In these new

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western wolf territories the mean density of humans is many times higher than within their natal territories in the east and the landscape is more fragmented by farms and human infrastructure.

In Finland the wolf population is controlled through quota-based management hunting or special licenses. Wolves' movements near human residences have been one of the most important criteria for a license to kill a wolf (e.g. Ministry of Agriculture and Forestry, decision 277/13/2012). Therefore we examined data from remotely tracked wolves throughout Finland to explore factors that could account for the variation in the frequency of wolves' visits near residences. Our first order predictions were that (1) wolves approach houses more often at night than during the day, because European wolves are mostly nocturnal (Ciucci et al., 1997; Kusak et al., 2005; Theuerkauf et al., 2007) and that (2) overall density of residences might influence the probability at which visits occur because the selection of a given resource may vary as a function of its availability (Mysterud and Ims, 1998; Benson et al., 2015). Visitations have been shown to be more frequent with higher human density in cougars (*Puma concolor*; Knopff et al., 2014) and wolves in the Canadian Rockies (Hebblewhite and Merrill, 2008). We also expected, based on the “naivety hypothesis” (see review by Elfström et al., 2012), that (3) sub-adult wolves might approach house-yards more than adult individuals. Finally, sexual selection that favors differential personality traits and boldness is probably of higher significance for male than female fitness (Smith and Blumstein, 2008). Based also on the finding that in domestic dog males are usually bolder than females (Kubinyi and Miklosi, 2009; Starling et al., 2013), we expected that (4) male wolves might move close to residential buildings more often than female wolves.

2. Material and methods

2.1. Data

Our 25 wolf territories were located in southern and eastern Finland (Fig 1.). Each territory was represented by one wolf. We captured and collared them with Global Positioning System (GPS) — Global System with Mobile (GSM) transmitters that provided wolf positions at 4 h intervals. Wolves were captured during 2003–2012 by looping them from a snowmobile or darting from the helicopter. Details for the capture and immobilization procedure are given elsewhere (Kojola et al., 2006; Wabakken et al., 2007). None of the study wolves had a collar in the end of 2014 because they had dropped the collar (drop off was set to take place 2 years after collaring) or were legally or illegally killed. When we had data for more than one wolf in a given territory, we selected the individual that provided the largest number of locations. The number of locations per wolf averaged 1269 (± 590 SD, range 447–2789) and the duration of study period 270 days (± 98 SD, range 126–607 days). We did not measure telemetry error but according to a literature review mean location error in GPS collars is 9.7 m (Cain et al., 2005).

We divided our study wolves by sex (10 females, 15 males) and by reproductive status. The *adult* category ($n = 18$) consisted of mated wolves, while *sub-adults* ($n = 7$), were animals that had dispersed from their natal territory and established new territories during the spring (see Kojola et al., 2006; Kojola et al., 2009). Sub-adults were therefore necessarily naive with respect to their habitat, in particular during the first summer. We defined territory boundaries as 100% minimum convex polygons (MCPs, Fig. 1). We chose 100% MCP precisely because it is a generous measure of wolf space use that includes rarely visited outlying areas and the focus of our study is on rare events such as visits close to residences. Geographic locations of residential buildings (mostly referred to as house thereafter) were obtained from official registries that provide the location of houses at the accuracy of ± 5 m. To test the effect of house density, we calculated distances between random location and the nearest house for each wolf position within the given territory using the program ESRI ArcGIS for Desktop 10.2.1.

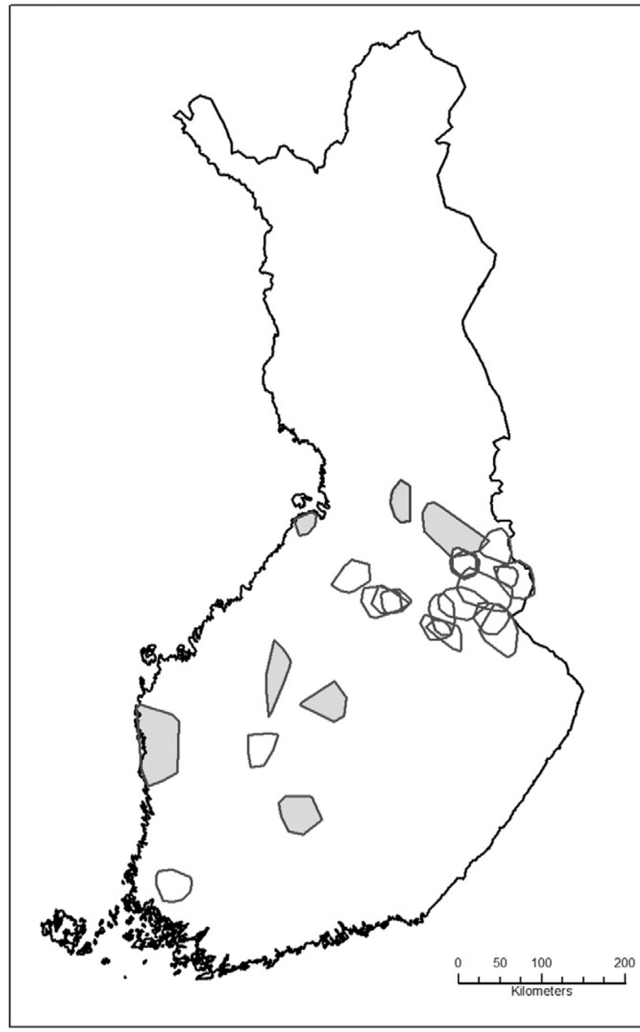

Fig 1. Wolf territories of the study ($n = 25$, territory boundaries as 100% minimum convex polygons) in Finland. Each territory is represented by a single GPS-collared wolf. Gray color indicates sub-adult wolves.

Coefficient of variation (CV) in random distances did not depend on the sample size (range 447–2789, Pearson r = 0.335, $P = 0.102$, $n = 25$). We chose this variable instead of simple houses/area variable as it more accurately reflects the human footprint in a territory by accounting for spatial clustering or non-clustering of houses. Mean house densities among territories ranged between 0.2–3.2 houses/km^2. The time of the day was classified into night and day according to sunset and sunrise times (http://www.moisio.fi/taivas/aurinko.php) in various locations in Finland. To estimate season effect the calendar year was divided into summer (May–September) and winter (October–April).

2.2. Statistical analysis

First we constructed a linear model to study how the of wolves' distances to the nearest house deviated from the distances of the random locations to the nearest house (1):

$$D_i = \left(\frac{1}{n_{ri}}\sum_{k=1}^{n_{ri}} d_{ri}\right) - \left(\frac{1}{n_{oi}}\sum_{l=1}^{n_{oi}} d_{oi.}\right)$$

where D_i is the difference between the distances for wolf *i*, n_{ri} denotes the number of random locations for the wolf *i* that equals the number of locations for the wolf *i* (n_{oi}), d_{ri} is the distance from the random