The Patterns of Wolf Attacks on Humans: an Example from the 19th Century European Russia

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Abstract

Wolf attacks exhibit distinct patterns in attacks on humans with different consequences. We analyzed 483 wolf attacks recorded during 1841-1861 in European part of Russia to reveal temporal patterns of wolf attacks. According to our results, wolf predatory attacks dominated in summer, whereas attacks of rabid wolves took place predominantly in winter. While the number of rabid attacks correlated with human density taking place usually near settlements, the number of predatory attacks did not. Nearly all victims of predatory attacks (99%) were children under 15 years of age, the age of victims was mostly unknown in rabid attacks. Using a generalized linear mixed model (GLMM), we provide the first evidence for 11 year cycle in rabid wolf attacks on humans. Although the rabies has been virtually eliminated in many European countries, it remains as a major threat to livestock and humans in some European countries and in Russia, providing a potential ground for rabies to return sporadically to currently rabies-free areas, and wolves can be considered as a significant vector for the spread of the disease.

Key words: wolf attacks, predatory and rabid attacks, cyclicity.

Introduction

The relationship between wolves and humans has been close throughout the history. High numbers of wolves increases conflict with humans, primarily due to predation on livestock, spreading diseases and direct attacks. This has caused severe intolerance towards wolf and as a consequence, this carnivore was during the 19th century in many European countries partly or totally extirpated (Boitani 1995). However, despite the persecution, wolves remained numerous in Russia (Pavlov 1990, Linnell et al. 2002) where the wolf population (about 50,000 in 2010 http://mnr.gov.ru/regulatory) is among largest in the world (Cherkasskiy 1988, Ovsyanikov et al. 1998).

Wolf is considered as a vector for several important zoonotic diseases, such as rabies (caused by rabies virus; Linnell et al. 2002) and echinococcosis (caused by cestodes *Echinococcus multilocularis* and *E. granulosus*, Moks et al. 2006), of which rabies has been the most feared. Compared with many other wildlife species, rabid wolves are generally less common nowadays and the main source of human rabies are domestic dogs, though the epidemiology of rabies varies according to geographical region (Linnell et al. 2002, Woldehiwet 2002). However, the wolf-transmitted rabies was relatively frequent in Europe in earlier times, when control measures for rabies were less adequate and wolf abundance was higher (Linnell et al. 2002).

Wolves may attack humans under a number of different circumstances. Linnell et al. (2002) defined several different categories of wolf attack: (1) attacks by rabid wolves; (2) predatory attacks, where wolves regard humans as prey; (3) and defensive attacks, where wolves are provoked or cornered. Predatory attacks may become more frequent if wolf's typical prey species are scarce or due to lack of a strong human social system (Linnell et al. 2002). In Russia, for the 1870s, wolf abundance had increased until levels to cause significant damage to national economy, for example, wolves were destroying annually about 6 million rubles worth domestic cattle (Pavlov 1990). Wolf problem was so grave, that in 1846, The Ministry of

Interior of Czarist Government put into effect a wolf control plan, which (1): offered bounties for killing wolves; (2) drive hunts were organized for wolves and (3) the hunters were appointed to kill wolves (Graves 2007). Attack by a rabid wolf is more likely to have severe consequences for the victim than by a non-rabid animal. There are 581 records of attacks on humans by rabid wolves between 1847 and 1978 in Russia (Pavlov 1990). Considering the size of Russia and the number of wolves, the actual number of rabid wolf attacks was probably considerably higher. Another estimate for the number of rabid attacks was provided by the Russian Central Committee of Statistics, according to which 1445 people were attacked during 1870-1887 in the 49 provinces comprising the European part of the former Russian Empire, while around 3000 people were hospitalized in Pasteur Institutes throughout this area (Moscow, St. Petersburg, Kharkov, Odessa, Warsaw, Samara and Tbilisi) following attacks by rabid wolves during 1886-1890 (Brochaus and Effron 1899). Nowadays, rabid wolf attacks in Russia still occur but are rare compared to the frequency of attacks in the past: eight cases were documented during 1980—1998 (Kuzmin et al. 2004). Although rabies has been virtually eliminated in many European countries following effective anti-rabies vaccination programs, it still remains as a major threat to livestock and humans in some European countries and in Russia, where such programs have not been implemented. This situation provides potential ground for rabies to return sporadically to currently rabies-free areas, and wolves are one of possible vectors for the spread of the disease.

It is crucial to understand whether wolf attacks on humans by rabid or non-rabid wolves exhibit a temporal pattern, and which factors influence such attacks. These may include human density and behavior, wolf numbers, rabies prevalence and alternative prey availability. It has been suggested that wolf numbers in Russia depend not only on biological, socio-economical and anthropological factors, but ultimately also on periodic climatic factors, leading to cycles of abundance (Mihhailov and Kljukin 1997).

The aims of this study were: (1) to analyze spatial and temporal patterns of attacks by rabid and non-rabid wolves on humans, and (2) investigate evidence for cyclicity in wolf attacks, based on data published in Russia during 1841-1861.

Materials and Methods

The data for this study were collected from the Estonian Historical Archives and Estonian Academic Library archive materials. The main source was the Journal of the Home Office (*Журналь Министерства Внутреннихь Дель)*, published monthly during the 19th century by the Russian Home Office. Regular data for wolf attacks was found only for years 1841-1861, and all available editions from this period were examined to collect usable data. Altogether, 483 wolf attacks on humans described during 1841-1861 were included in the analysis: 168 cases of predatory attacks and 315 cases of rabid attacks, all reported from 51 (ca. 1.5 million km$^{2)}$ provinces in the European part of Russia.

Correlation analysis was performed with Statistica 7.1 (StatSoft, Inc. 2001). To analyze the temporal dynamics of attacks by rabid wolves, a generalized linear mixed model (GLMM) was developed using SAS 9.1 (SAS Institute Inc. 2006). GLMM is an extension to the generalized linear model, in which the linear predictor contains random effects in addition to the usual fixed effects. Our model included the number of attacks as a response variable, and year and province as random effects (normally-distributed random variables). The number of rabid attacks during the year k years previously in the same province was considered as a fixed explanatory variable. Therefore, the expected number of rabid attacks (EY) was modelled as:

$$\mathrm{Log_e}(EY) = \mu + \lambda_i + \tau_j + c_{1,k} \times \upsilon_k + c_{2,k} \times A_k,$$

where Y – putative number of victims; λ_i – effect of year; τ_j – effect of province; $c_{1,k}$, $c_{2,k}$ - coefficients; υ_k – variable indicating whether or not a rabid wolf was killed k years ago in the corresponding province, A_k – number of rabid attacks k years ago. Therefore, the significance of coefficient $c_{2,k}$ can be indicative of whether or not the number of rabid attacks k years ago is a useful predictor for the number of rabid attacks in the current year and thus of a cyclical effect (with k equal to the cycle length). Such models were fitted for different values of k and Bonferroni correction used to eliminate inflation of Type I error due to multiple testing.

Results

Predatory attacks

Predatory attacks were most numerous in years 1844 (28 attacks), 1850 (20) and 1846 (19) (Figure 1), and the mean number of attacks per year was 8.1. The numbers of rabid and predatory attacks per month differed substantially (Figure 2). Predatory attacks were most numerous in summer (53 attacks in July and 49 in August throughout the study period), comprising 60 % of all attacks (95 % confidence interval (CI): 52 %-67 %). The mean number of attacks per month across the whole study period was 14.3.

Of 143 victims of predatory attack, only two were adults (i.e. over 18 years old): a 40-year old woman and a 30-year man. Most victims (99 %) were under 15 years of age. Girls slightly dominated among victims of predatory attacks, although the difference was not statistically significant. There was no statistically significant difference the between the age of attacked girls (8.0) or boys (8.3 years).

Almost half (46 %; CI 38 %-55 %) of predatory wolf attacks on humans during the period 1841-1861 occurred in three provinces of European Russia: Mogiljev (20 %; CI 14 %-28 %), St. Petersburg (14 %; CI 9 %-21 %) and Podolsk (13 %; CI 8 %-20 %), which are all situated in the north-west of European Russia (Figure 3). The average number of predatory attacks per region was 3.5. The number of predatory attacks was not significantly correlated with human density per region.

Rabid attacks

The number of rabid attacks was highest in years 1850 and 1851 (29 and 31 attacks, respectively). The mean number of attacks per year was 15.8. The number of rabid attacks per month (Figure 2) was highest in winter (January - April), constituting about half of all the rabid attacks during the year (52; CI 47 %-58 %).

The average number of attacks per province was 6.2 and was highest in Mogiljev (13 % of all attacks; CI 9 %-17 %), Podolsk (9 %; CI 6 %-13 %) and Vilnius (7 %; CI 5 %-11 %) provinces. The number of rabid attacks was significantly correlated with human density per region (per km², $r = 0.41$ $df = 50$, $p = 0.002$).

The age of victims was mostly unknown in cases of rabid attacks. Out of 249 rabid attacks with an exact location identified, 223 (90 %; CI 85 %-93 %) took place inside settlements and only 26 (10 %; CI 7 %-15 %) in wooded areas or fields close to a settlement. The number of victims per case was often 2-5 (56 % of all cases; CI 50 %-61 %) but sometimes up to 6-10 persons were attacked (22 %; CI 18 %-28 %), (Figure 3).

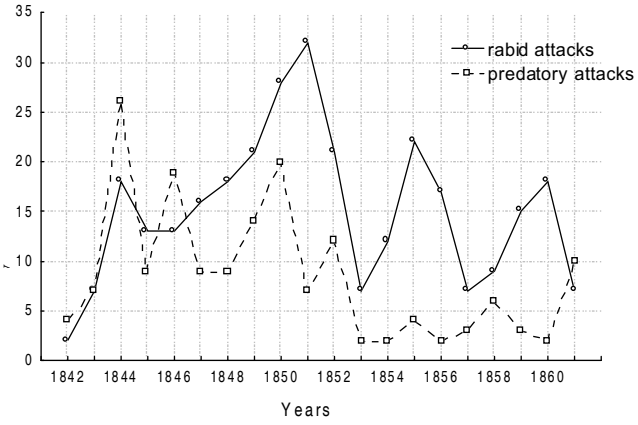

Figure 1. Numbers of rabid and predatory attacks by wolves on humans in European Russia during the period of 1841-1861

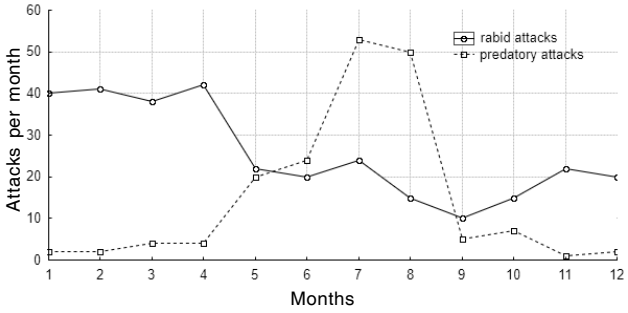

Figure 2. Numbers of rabid and predatory attacks by wolves on humans by months in European Russia during the period of 1841-1861

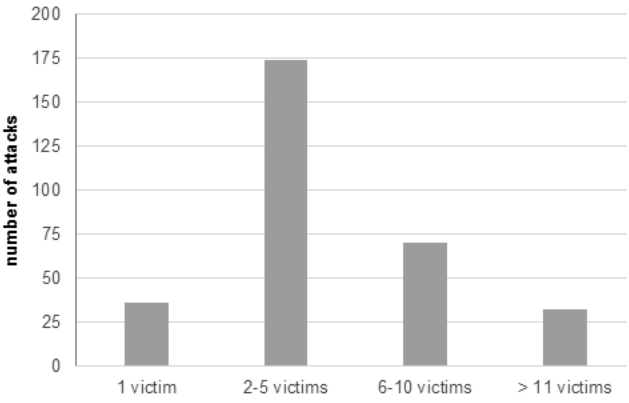

Figure 3. Numbers of victims per attack in rabid wolf attacks in European Russia during the period of 1841-1861

Cyclicity

Our GLMM model revealed an 11-year cycle in the frequency of rabid attacks ($p = 0.005$), (Figure 4). The analyses also indicated four and eight year cycles, but these were weak and not statistically significant.

Discussion

Despite the fact that humans are currently not considered to be common prey for wolves, data on wolf attacks in European Russia during 1841-1861 suggest that in relatively recent history wolf attacks on humans were frequent and unexceptional. Russian literature is filled with stories of wolves attacking and killing peasants and their livestock.

The number of recorded predatory attacks depended heavily on season and was highest in July and August. We suggest this is probably because children

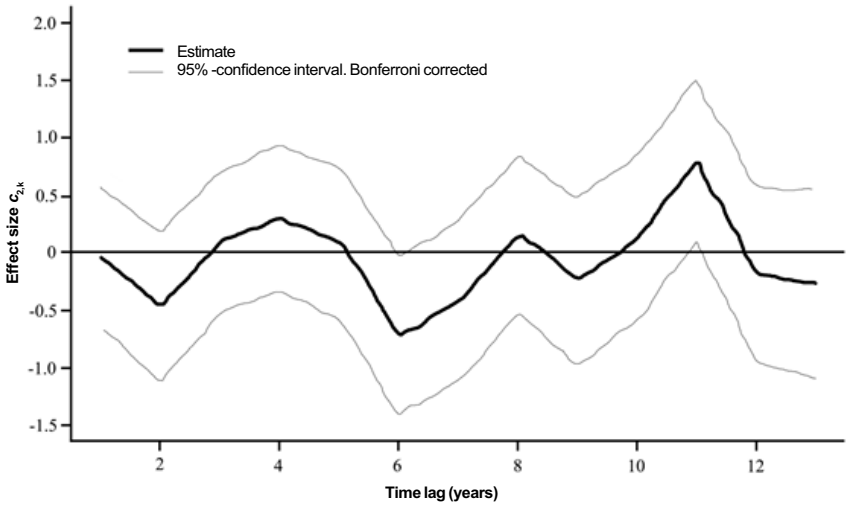

Figure 4. Dynamics of attacks by rabid wolves in European Russia during the period of 1841-1861. Estimates of frequencies of rabid attacks revealed by GLMM are shown. The significance of coefficient $c_{2,k}$ is indicative of the number of rabid attacks 11 years ago being useful predictor for the number of rabid attacks in the current year

were more active during the summer months, for instance acting as shepherds or picking berries and mushrooms in the forests, and thus increase their availability as prey. It also coincides with a period when wolves are feeding actively in order to raise their pups, and thus wolves may have used children as an additional or alternative food resource to their usual prey (Pavlov 1990). Insufficient data on the sex of attacking wolves were available for this study, but according to Ilmar Rootsi (pers. comm.) where such data are available in historical records, most of the wolves attacking children have been females. The decline in attacks in September and October can be explained by the increased mobility of wolf litters and an increased ability to hunt other natural prey.

Attacks by rabid wolves took place predominantly during the winter and spring months, with over half of the cases falling into the period from January to April. The incubation period of rabies in wolves is about 3 weeks, and the rise in the number of rabid animals in spring is apparently connected with reproductive behavior in early spring. I. Rootsi (2003), who studied wolf attacks in Estonia in 1806-1891, found that 70.3 % of all wolf attacks (i.e. both predatory and rabid attacks) took place during winter and spring months (December to May). Similarly, B.L. Cherkasskiy (1988) found rabid attacks to be most frequent during winter, when many wolves disperse and may wander up to 80 km/day, thereby effectively transmitting the disease. In our study, the numbers of rabid attacks also rose slightly in the autumn, a pattern that was not detected by Rootsi (2003). According to Mech and Boitani (2003), most yearlings disperse during autumn and early winter. As wolves were quite intensively hunted during the study period in Russia, packs may also have been destroyed, forcing remaining members to leave the pack territory area and thus increasing the probability of contact with other wolves.

Both rabid and predatory attacks occurred mainly in the western and northwestern part of European Russia – areas that are nowadays part of Ukraine, Belorussia and Russia (provinces of Mogiljev, Podolsk, Vilnius, Vladimir and Chernihiv). While the rabid attacks occurred in almost all provinces of European Russia, predatory attacks only occurred in about half of them. Although we found no direct correlation between the numbers of attacks and the proportion of forested area, more attacks occurred in provinces with at least 20% of the area forested. Wolf attacks were rare in provinces situated in the Central-Russian steppe (Kursk, Kharkov, Odessa, Tula), with forested area less than 10 %.

In our study, most of the victims of wolf attacks were children. The same conclusion was drawn by Linnell et al. (2002), who found that 80 % of the victims of wolf attacks were under 18 years old, and mostly under 10 years old. Wolf attacks on domestic animals probably increased the possibility of a close encounter between wolves and children as children were often used as shepherds and were thus the only barrier between domestic animals and wolves. This is also suggested by Rootsi (2001), who noted that social traditions in 19th century in Russia (children were used as shepherds, berry pickers, help in the field, etc.) made children easy prey for wolves. In fact wolves may have preferred children to domestic animals due to their smaller size and availability. While the frequency of rabid attacks did not vary in relation to the sex and age of the human victim, predatory attacks did. Among children, most victims were girls between the ages of six and ten, followed by boys of the same age. Preference towards girls may have resulted from a

nonequal proportion of girls to boys in that age group. Girls may also have been more frequent berry pickers, thus exposing themselves more to wolf attacks. It is also possible that boys were more able to protect themselves or escape. Young children (under the age of six) tend to remain close to settlements, which makes them a difficult target, despite being light and thus easy to carry away. Older children (over the age of six) are more independent and move further away from homes and settlements and, despite being heavier to carry and to fight with, this is the most likely reason why they fell most often as prey to wolves. This is supported by N. Korytin (1990) who found that the average age of victims and the distance of an attack from a settlement were in positive correlation. In the present study, the mean age of attacked boys and girls was almost the same (8.3 years in case of boys and 8.0 years in girls).

Concerning predatory attacks, adults can also be attacked by wolves in certain cases: (1) if an adult is trying to protect a child or herd, (2) in case of an unexpected encounter with a wolf or during a wolf hunt by humans (such cases are extremely rare) (Korytin 1990). In our data, cases of wolves attacking adults were connected to situations where adults were trying to protect children. The behavior of a wolf encountering humans can be affected by several factors (previous contact with humans, the aggressiveness of the wolf, the behavior of a child, etc.). Of adults, wolves preferred women, probably because they are generally smaller (Linnell et al. 2002).

A negative correlation was found between human population size in European Russia and the frequency of rabid wolf attacks. This can be explained through the rise in the abundance of wolves in low-populated areas. Such a correlation was not apparent for predatory attacks, probably due to the fact that in areas where the abundance of alternative prey is sufficient, humans are not attacked.

There were also considerable differences in the temporal dynamics of different types of attack. In our study, rabid wolf attacks exhibited an 11-year cycle, while predatory attacks exhibited no cycle. To the best of our knowledge this is the first study to report such an attack-cycle. However, cycles in abundance ranging from of six to 11 years have been described in several mammal species in Russia. N. Formozov (1935) reported cyclical dynamics in Russian mountain hare populations, with a 10-year period in the northern tundra and a 6-year period in the southern taiga belt. Newey et al. (2007), who assessed mountain hare population dynamics in Russia, found an eight-year cycle in one series from the north-west and an 11-year cycle in the north-east. Most significantly Mihhailov and Kljukin (1997) observed an 11-year cycle in wolf numbers in Russia. The Russian tundra and taiga biomes represent a substantial proportion of the entire geographic range of the wolf. As suggested by Newey et al. (2007), many of the time-series found in Europe are from landscapes strongly influenced by human activities, while data from less intensively managed areas such as the Russian tundra and taiga may provide considerable insight into the drivers of cyclic dynamics under more natural conditions.

The mechanism underlying the appearance of 11-year cycle in rabid wolf attacks on humans is unclear as rabies generally tends to cycle with shorter periodicity (MacDonald 1980). Recently, 10-year herbivore cycles were linked to lunisolar oscillation (Selås 2013). Meanwhile, Sinclair et al. (1993) and Sinclair and Gosline (1997) suggested that the snowshoe hare cycle is modulated indirectly by solar activity through an amplified climate cycle that affects the whole boreal forest ecosystem. The periodicity of prey abundance might be reflected in predator abundance, with a certain time lag. According to Mihhailov and Kljukin (1997), wolf numbers increased significantly in 1860-1870, when solar activity was also relatively high. However, as very few data about wolf numbers and their prey base are available from the periods when attacks were numerous, it is difficult to analyze the role of different factors in shaping the dynamics of these attacks. Nevertheless, it is still of great importance to reveal whether temporal patterns exist in wolf attacks on humans, as there may be significant consequences for our understanding of animal behavior and disease spread. Of course, mechanisms determining the dynamics of wolf populations can be more complex: during 1841-1861 wolves were heavily hunted in the study area by humans, and the number of natural prey species of wolf (wild boar, moose, and roe deer) declined substantially in European Russia during the start of the 19th century (Kirikov 1960, 1966).

It should be noted that all 51 Russian regions where rabid attacks were documented during the 21-year study period (1841-1861) were included in the data set. This suggests that cyclicity was present over a large area rather than a local phenomenon. Concerning the temporal extent of our data set, we were limited by the availability of data in the periods adjacent to our research period (1841-1861). There is little guidance on how long a time-series should be for a meaningful analysis. Turchin (2003) suggests that time-series should be at least 20 years long and be no shorter than three times the suspected period. In this respect the temporal extent of our data set could be considered narrow, and the conclusions drawn from it should be treated in this light.

Nowadays the frequency of wolf attacks on humans has decreased worldwide, primarily for the following reasons: the non-human prey of wolf is more abundant, the distribution of rabies is more efficiently controlled and children are less often used as shepherds. Besides that the number of wolves has decreased and wolf populations are restricted to protected areas with low human population density, which diminishes the risk of conflict between humans and wolves. Nevertheless, our analysis of wolf attacks on humans showed strong temporal patterns for both rabid and non-rabid attacks and identified the cyclicity of rabid wolf attacks.

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