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Winter diet of wolf (Canis lupus) after the outbreak of African swine fever and under the severely reduced densities of wild boar (Sus scrofa)

Type

Short note

Keywords

wild boar, ASF, scat analysis, wolf diet

Abstract

The outbreak of the African swine fever (ASF) in Estonia in 2014 resulted in heavy hunting pressure on wild boar, issued by authorities to stop further spread of the virus. As a consequence, local wolf prey base changed abruptly. To investigate the effects of this change to wolf diet, we collected 121 wolf scats from November to April in 2017-2018 from five Estonian counties and compared the results with the wolf dietary data from 1998. To eliminate possible dog scats from the material collected from areas close to settlements, genetic analysis was used. We found that ungulates still formed the bulk of the wolf diet, however, the occurrence of moose, wild boar, small rodents and hares has dropped considerably. The proportion of the roe deer and mammalian predators has increased from 51% to 55% and 4% to 10%, respectively. Moreover, plants, being totally absent in the previous study, were found in 25% of scats, in many cases representing the only food item. Food niche breadth has widened from 1.54 to 2.3. While roe deer was found to be a highly preferred, moose was still an avoided prey species.

Explanation letter

10. Aug. 2020

Dear Editor,

Thank you for sending your editorial decision and the comments of the reviewers on our manuscript. We would like to thank you once again for handling our manuscript and for the positive and constructive reviews. We believe that the refined manuscript now meets a publishable standard.

Yours sincerely,
Harri Valdmann (on behalf of both authors)

Answers to reviewers comments and suggestions

Reviewer: I still do not think you can conclude that in areas with reduced wild boar densities the

situation resulted certainly unfavourable for wolf, leading to starvation (lines 156-158), especially because wild boar was not and is not the main food item. You have observed a change in the proportion of food item, an increase of trophic niche and a recent approach of human settlements, but you had no evidences to conclude that population parameters have changed as well and that in population you found more sick or starved individuals. If you have all these parameters you should add them like supplemental materials, otherwise I suggest being more prudent in some of your conclusions.

Answer: We reworked our conclusion accordingly.

Reviewer: In my opinion, it is very important to test the operator's capacity to identify prey species from the hairs before carrying out scat analysis; usually operators were tested by means of a blind test and only operators who did never fail to recognize the species, performed the analysis. This is a well-recognized procedure in this field, and you should have considered this before staring scat analysis.
Answer: We did not perform any blind tests specifically for this study as we have published several papers, which had included stomach or scat analysis and had done it before for these papers.
We made changes to the text according to specific comments of referee and added density values.
We also made corrections to the reference section.

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Winter diet of wolf (*Canis lupus*) after the outbreak of African swine fever and under the severely reduced densities of wild boar (*Sus scrofa*)

Running title

Wolf diet under reduced densities of wild boar

Abstract

The outbreak of the African swine fever (ASF) in Estonia in 2014 caused heavy hunting pressure on wild boar issued by authorities to stop further spread of the virus. To investigate the effects of wild boar shortage to wolf diet, we analysed 120 wolf scats from November to April in 2017-2018 from five Estonian counties and compared the results with the wolf dietary data from 1998. To eliminate possible dog scats from the material collected from areas close to settlements, genetic analysis was used. We found that ungulates still formed the bulk of the wolf diet, however, the occurrence of moose, wild boar, small rodents and hares has dropped considerably. The proportion of the roe deer and mammalian predators has increased from 51% to 55% and 4% to 10%, respectively. Moreover, plants, being totally absent in the previous study, were found in 25% of scats, in many cases representing the only food item. Food niche breadth has widened from 1.54 to 2.3. While roe deer was found to be a highly preferred, moose was still an avoided prey species.

Keywords: ASF, wolf diet, wild boar, scat analysis

The grey wolf (henceforth 'wolf') is one of the most important apex predators and keystone species in Europe and in many other parts of the World (Krofel et al. 2017, Beschta and Ripple

2016, Mech and Boitani 2004). Being a major source of human–carnivore conflict, the welfare of the wolf depends strongly on policies that facilitate coexistence of humans and wolves in changing environments (van Eeden et al. 2018, Treves and Bruskotter 2014). However, such policies should be based on scientific evidence, of which dietary data are among the most critical.

Wolf diet has been studied at local scales in several countries in Europe (Sidorovich et al. 2016, Llaneza and López-Bao 2015, Meriggi et al. 1996), including the Baltic States (Žunna et al. 2009, Valdmann et al. 2005, Kübarsepp and Valdmann 2003, Valdmann et al. 1998). As a generalist predator, wolf diet is largely shaped by the prey availability (Baudrot et al. 2016). In Europe, their diet consists mainly of large- and medium-sized wild ungulates such as roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), moose (*Alces alces*) and red deer (*Cervus elaphus*), but also of livestock and other anthropogenic foods, if available (Newsome et al. 2016, Zlatanova et al. 2014, Meriggi and Lovari 1996). In areas where beaver (*Castor fiber*) is abundant, it can also form a significant portion of wolf diet (Sidorovich et al. 2016, Andersone and Ozolins 2004).

In Estonia wolf is spread all over the country, having recently also recolonized the two largest islands, Saaremaa and Hiiumaa (Plumer et al. 2016). The number of wolf packs in Estonia has ranged around 25 (150-160 wolves) in recent years and the numbers of legally killed wolves were 67 (2018/19), 104 (2017/18) and 114 (2016/2017) (Estonian Environment Agency). In 1998 official wolf numbers in Estonia were about 300 (Estonian Ministry of Environment). Wolf predation on livestock, mainly on sheep, has been a major source of human-wolf conflicts in Estonia and understanding wolf food habits is crucial to develop effective strategies for wolf conservation and management, and for mitigation of wolf-human conflicts.

The most comprehensive previous wolf diet study in Estonia (Valdmann et al. 1998) demonstrated that while the roe deer is the major item in wolf's diet (50.9%), the preferred

prey was the wild boar, albeit its frequency of occurrence was considerably smaller (16.8%). Moose was also consumed (11.8%), but according to the analysis was avoided.

On the 6th of September 2014, for the first time, the African swine fever (ASF) was diagnosed in Estonia.

Since then the ASF has spread all over Estonia excluding the relatively isolated island Hiiumaa and the outbreak reached its peak in 2015-2017 (Borklund et al. 2018). As a result of ASF, high wild boar hunting quotas were introduced to diminish the effects of ASF, resulting in very low numbers of wild boar.

Several scenarios could be predicted locally if ungulate species composition will abruptly change. We hypothesise that under the limited availability of wild boar, the proportion of other ungulate species in wolf diet will increase, especially of the roe deer, as its densities have been quite stable. Alternatively, wolves may take advantage of fox- or coyote-type foraging behavior (Newsome et al. 2016) including intraguild predation. We also hypothesise that as a result of reduced wolf packs (Valdmann et al. 2004), caused by ongoing wolf hunting, moose may be continuously avoided.

To address these questions, we performed a scat analysis to investigate the effects of changes in local prey base to wolf diet and compared the results with the previous study (Valdmann et al. 1998). To ensure that all scats belonged to wolf, particularly the scats collected in close proximity of settlements, a genetic analysis was conducted to discriminate between wolves and dogs.

For the study 121 wolf scats were collected from the hunting grounds in the Central- and South-East Estonia (Nov-Apr. 2017-2018) with very low densities of wild boar (<1.5 ind/1000 ha). Scats were collected along forest roads and all samples were frozen at –80°C.

To obtain results comparable with previous wolf diet study in Estonia, scats were collected from approximately the same area (Valdmann et al. 1998), and during early spring as in the previous study (we did not compare summer diets).

To identify food items, the scat samples were processed according to standard laboratory procedures (Ciucci et al. 1996, Reynolds and Aebischer 1991). Non-mammal remains recovered in wolf scats were identified by comparison with reference materials and mammal remains by examining the cuticular pattern and the medulla of the hairs using a reference manual (Teerink 1991) and hairs collected from hunted animals.

Scat contents were divided into five prey categories: ungulates, small rodents, mammalian predators, plant material, lagomorphs (*Lepus sp*.) and quantified by the frequency of occurrence (FO) of prey species in scats. To compare the proportions of ungulate prey in scats with the proportions of their numbers in the study area, chi-square test was used (Statistica 7). Ivlev's electivity indices (Krebs 1997) were calculated for each ungulate prey species. The densities of moose (~ 3.2 ind/1000 ha) and roe deer (~ 16 ind/1000 ha) were obtained from yearly estimations of hunting clubs from study area. Food niche breadth was calculated after Levin's (1968). To obtain estimates of confidence limits for niche breadths we used bootstrap procedure (n=10000) (Krebs 1997, Efron 1982), employing statistical package R.

Scats of wolves and free-ranging dogs are sometimes difficult to distinguish and to avoid mixing the data of both species, we conducted a genetic analysis according to Plumer et al. (2018) for three scat samples that we could not assign and also for 21 samples collected from close proximity of settlements that we identified as wolf scats. The length of the final alignment was 245 bp and the dataset was further aligned with homologous wolf and dog sequences from Estonia (Plumer et al. 2018, Hindrikson et al. 2012). Molecular identification

of species was possible due to specific nucleotide characters that distinguish between wolves and dogs in Estonia (see Plumer et al. 2018). Out of the three analysed samples that we could not assign to species (wolf or dog) with confidence, two belonged to wolf and one to dog. All 21 samples that we identified as wolf scats (based on morphology, smell and content) were assigned by the genetic analysis also as wolves. The dog data was excluded from further analyses and thus the final number of wolf scats was n=120.

Analysis of scat composition revealed that as in previous study (Valdmann et al. 1998), ungulates dominated in wolf diet, the roe deer being the main prey, the proportion of which has increased from 51% to 55% (Table 1). The occurrence of moose, wild boar, small rodents and hares has dropped considerably. On the other hand, the proportion of mammalian predators and plants has increased, especially the latter, which occurred in 25% of analysed samples in this study, while being absent in the previous one. Bias adjusted food niche breadth was 2.3 (95% confidence intervals 1.95 - 2.64), compared to 1.54 in the previous study. Composition of ungulate prey proportions in diet differed significantly from their availability ($\chi^2 = 32.75$; df =2; $P < 0.05$). According to the Ivlev's electivity indices (Table 2), roe deer was highly preferred and moose was avoided, whereas wild boar was close to neutral.

Our results indicate significant shift of preferences and FO-s in local wolf diet compared to the previous study of wolf winter diet in Estonia (Valdmann et al. 1998). Also, the food niche breadth has widened considerably. As the availability of wild boar was very low in the study area, its consumption was reduced by more than 4-times, from 17% to 4%. As predicted, roe deer formed the bulk of the wolf diet (55%), although the increase compared to the 1998 data (51%) was less than expected. Roe deer was found as a preferred food item also in a study conducted in western and central parts of Poland (Nowak et al. 2011). However, in some of the other studies conducted in Europe, roe deer was avoided (Jedrzejewski et al. 2000,

Okarma 1995). We anticipated that wolves increase the consumption of moose, but it dropped from 12% to a mere 1%. The likely reason is the reduced wolf packs in Estonia due to high hunting pressure, legal and illegal (Valdmann et al. 2004). Moose has been an avoided food item also in other studies conducted in Europe (Jedrzejewski et al. 2000, Okarma 1995).

Concerning the intraguild predation in our study ('mammalian predators' in Table 1), wolves exclusively fed on raccoon dog (*Nyctereutes procyonoides*). According to Paquet and Carbyn (2003), shortage of ungulate prey may increase the proportion of other predators in wolf diet. As sarcoptic mange is widespread among raccoon dogs in Estonia, weakened animal is an easy prey for wolves. As a negative effect of intraguild predation, mange will be easily transferred over to a wolf as canids are very susceptible to this parasitic infection, probably causing wolves, like other infested canids, to come closer to human settlements in their search for food. Thus, shortage of regular food (e.g., wild boar) can be detrimental to wolf population as they consume more mammalian predators, including the infected raccoon dogs. As a result, wolves get more frequently infected and getting weaker and unable to hunt for a regular prey, come closer to human settlements, posing danger to dogs. Although we did not found dog remains in wolf scats, a dog was reportedly killed by wolf in study area during this period. The health condition of a wolf was unknown, but we actually saw an infected wolf near the attack place.

Wolves may be brought closer to human settlements also by other factors. Roe deer can concentrate near settlements as a response to a very high predation pressure by wolves and also by lynx, for which roe deer has been a staple food in Estonia (Valdmann et al. 2005). The numbers wolves seen around settlements has been steadily increasing in the study area and elsewhere in the country.

Concerning the consumption of plant material, its proportion was unusually high, being found in 25% of scats, in many cases representing the only food item. Apples and hay were the most common plant items found. Although plant items are energetically not important for wolf (Jedrzejewska and Jedrzejewski 1998), they can be used as an emergency food during a period when wolves suffer from food deficiency. As suggested by Homkes et al. (2020), plant items can be consumed more by wolves than previously believed. Another reason could be intentional consumption of grass as a self-medicating behavior against parasites. This type of behavior has been observed in several other species, including dogs and cats (Hart 2008, Sueda et al. 2008) and raccoon dogs (Laurimaa et al. 2016).

We are uncertain whether the high proportion of plant items in our study is the result of reduced prey availability, abundance of apples due to the their rich crop during study period or an interaction of these conditions. But the remarkably high intraguild predation on raccoon dog is certainly unfavourable for local wolf population, facilitating the spread of sarcoptic mange.

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Table 1. Comparison of frequency of occurrence (FO) of main prey categories between two studies: Valdmann et al. (1998) and this study (2018)

Prey category	1998 FO %	2018 FO %
Wild ungulates:		
Moose	11.8	< 1
Wild boar	16.8	4
Roe deer	50.9	55
Mammalian predators	3.3	10
Plant material (apples and hay)	-	25
Small rodents	10.2	4
Lagomorphs	5.8	1

Table 2. Comparison of Ivlev's electivity indices for ungulate prey in previous study (Valdmann et al. 1998) and this study (2018)

Ungulate prey species	Ivlev' electivity index (1998)	Ivlev' electivity index (2018)
Moose	-0.35	-0.9
Wild boar	0.23	-0.05
Roe deer	0.07	0.61

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