Diet and prey selectivity of wolf *Canis lupus* in middle- and south-eastern Estonia

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Diet composition and prey selectivity of wolf *Canis lupus* Linnaeus,1758 were investigated by examining 606 scats collected in early spring (518 scats) and in August (88 scats) of 1996 and 1997. Stomachs of 37 shot wolves were also analysed. Using encounter rates of prey species with wolf tracks as indices of relative abundance of ungulates, Ivlev's selectivity indexes were calculated.

Wild ungulates were the main prey of the wolf and accounted for about 80% and 50% of frequency of occurrence respectively in winter and summer diets, respectively.

Wild boar and roe deer were preferred prey species; moose was generally avoided. Structure coefficient of selection (SCS) for wild boar was 0.9 in our study, indicating selection for adults.

Key words: *Canis lupus*, diet, ungulates, prey selectivity, Estonia

Introduction

The wolf in Estonia has a status of game species, the number of which should be controlled to avoid negative effects on native fauna and livestock husbandry. Sound management of the wolf population, although, requires information upon which to base estimates of viable population levels. This, in turn, requires extensive research on the biology and ecology of the species. Also, as for North America (Ballard *et al.*, 1987), predator - prey relationships between wolves and wild ungulates and wolf's role in regulation and/or control of wild ungulate populations (Gasaway *et al.*1983) in Europe are also beginning to assume importance.

However, no analysis of wolf diet and prey preferences have been attempted to date in regions with similar prey availability.

The main purpose of the study was to analyse wolf diet and prey selectivity in the Middle-and South-eastern part of Estonia.

Materials and methods

Scat samples were collected by authors from forest roads and trails, which had been regularly used by wolves from an area approximately 100×120 km in middle- and south-eastern part of Estonia. Estonian territory is about 45 000 km^2.

Study area is mostly open to hunting and present three species of ungulates: roe deer *Capreolus capreolus*, wild boar *Sus scrofa* and moose *Alces alces*. Human settlements are relatively sparce and not many cows and sheep are present. Stray dogs are quite abundant.

The number of wolves, inhabiting study area was not assessed, but about 50 wolves were shot in study area in 1996 and about 30 in 1997.

To determine species composition of wolf diet, we depended on the scat samples (n=606) and stomach content (n=37). The methodology of scat analysis has been reviewed (Putman,1984; Reynolds & Aebisher,1991; Ciucci *et al.*,1996) and applied in several diet studies of wolves (Rusakov, Timofejeva,1984; Mattioli, *et.al.*,1995; Olsson *et al.*,1997). The stomachs of wolves, shot with "fladry" (n=10), did not contain any remains of prey; we suggest, that as in the hunting process wolves often are kept in "fladry" for overnight, the remains could have been already digested. "Fladry, a common means of wolf hunting in Estonia, is basically a line with small (10x10 cm) flags fastened on it. Flags are usually red, but principally can be of any colour. If wolves are located somewhere, the area will be surrounded with "fladry". The height of line ground is kept about 60-80 cm. If not hunted with "fladry" before, wolves can stay inside of surrounded area for several days. After successfully escaping the "fladry" once, they are not afraid of it any more and can not be hunted by this way later. The wolves analysed were generally in very good body condition, three wolves were infested with sarcoptic mange. The mean weight of some shot wolves was 46 kg (range 28-62 kg; n = 10). The mean number of

embryos per one pregnant female was 4,7 ± 0,47 (range 3-7; n = 7).

Scats were collected in early spring (representing winter diet) and in August (representing summer diet) 1996 and 1997. Some fresh scats were intentionally left to see how long they will survive in field conditions. It was found,that depending on the contents and the weather conditions. it took from two weeks till approximately 3 months for scats to disappear completely. Scats that contained high percentage of hair, remained intact for longer time.

Scats were carefully weighed and washed. Prey remains such as hair, bones, hooves and teeth were separated and identified. Hair from scats was compared to those in our reference collection using features such as colour, length, thickness and medullary configuration to identify prey species. As a rule, we found only one prey species per scat (we did not identify species in small rodents and birds). In wild boar it was possible to separate young animals (up to one year) from older ones by hair colour. As proposed by J.C.Reynolds and N.J.Aebischer (1991), c^2-test was used to test differences between summer and winter diets.

Frequency of occurrence of mammalian prey species in carnivore scats is a commonly used parameter in predator diet studies, but if prey sizes are highly variable, occurrence of frequency can considerably distort the relative numbers of different prey types in the diet (Ackerman, Lindzey & Hemker, 1984). In such cases, estimates of relative biomass and numbers of different prey need to be computed. The regression method of Floyd et al. (1978), considered accurate for the purpose (Huggard,1993; Karanth & Sunquist.1995), extrapolated for ungulate prey animals (roe deer, wild boar and moose), was used to convert per cent occurrence in scats to the proportion of biomass provided by each ungulate species. Average body weights were obtained for roe deer from T. Randveer (1989), for wild boar from H. Valdmann (1991) and for moose from P. Kozlo (1983).

Diet analyses were simplified in our study because of the absence of scats containing more than one prey item (excluding scats containing remains of small rodents, pooled into one category). This allowed an accurate evaluation of biomasses and relative number of prey (Floyd *et al.*, 1978), as has occurred in most North American wolf studies (Fritts and Mech, 1981).

Food niche breadth (B) was calculated after Levins (1968). Relative biomass eaten and relative number of preys eaten were calculated for ungulates (wild boar, roe deer and moose); * - traces (< 0,05 %). Food niche breath (B) was calculated after Levins (1968) for 6 main food groups (roe deer, wild boar, moose, hares, small rodent and other carnivores). $B = 1/\sum p_i^2$, where p_i - per cent occurrence of a particular prey group.

The impact of wolf predation on the age composition of population of wild boar was estimated with the structure coefficient of selection (SCS)

$$SCS = \frac{\text{number of adults / number of young in the population}}{\text{number of adults / number of young in wolf scats}} \quad (1)$$

The tracks of potential prey ungulates (338 crossings), that crossed those of wolves, were recorded and used as an index of the species of prey encountered by wolves as suggested by Huggard (1993). Ivlev's index of selectivity was calculated for each ungulate prey species (winter diet). For comparison, we estimated prey selectivity of wolves in study area by different methodology. Moose density was estimated by pellet group counts, densities of roe deer and wild boar were estimated using kilometric index (the suitability of methods had been tested earlier). Bootstrap simulation (n=5000) was used for generating hypotetical distribution of prey species in scats (unpublished data). In both cases we got similar results.

Results

Wild ungulates were the primary prey of wolves in winter, accounting for 80% of frequency of occurrence in winter diet (Table 1). In summer diet ungulates account for 50 % of frequency of occurrence (Table 2).

Table 1. Composition of wolves diet in the study area (winter and spring)

Food items	Number of scats, n	Frequency of occurrence, %	Ungulate biomass eaten, kg	Relative ungulate biomass eaten, %	Relative number of ungulate preys catch, %
Roe deer	264	51	103	18.4	65
Wild boars	87	17	107	19.3	14
Moose	61	12	348	62.3	21
Hares	30	6			
Beavers	1	*			
Small rodents	53	10			
Wolves	4	} 4			
Raccoon dogs	3				
Foxes	2				
Dogs	8				
Reptiles	2	*			
Birds	2	*			
Squirrels	1	*			
Total	518	100	558	100	100
Food niche breadth (B)		3.2			

Table 1. Composition of wolves summer diet in the study area

Food items	Number of scats, n	Frequency of occurrence, %	Ungulate biomass eaten, kg	Relative ungulate biomass eaten, %	Relative number of ungulate preys catch, %
Roe deer	32	36	12.6	35.5	70
Wild boars	14	16	17.2	48.5	28
Moose	1	1.2	5.7	16	2
Hares	13	15			
Small rodents	22	25			
Raccoon dog	**2**	}			
Dog	1	} 4.5			
Wolf	1	}			
Beaver	2	2.3			
Total	88	100	35.5	100	100
Food niche breadth (B)		4.1			

Proportions of food items in winter/spring and summer diets differed significantly ($P \leq 0,05$;df = 13; χ^2=45,63).

Young animals are generally most affected by wolf predation (Mech,1970).

Age composition of wild boar population in Estonia had been estimated earlier (Valdmann,1991).

Of 87 wolf scats (representing winter and spring diet), containing hair of wild boars, 41 contained remains of animals below one year of age. The structure coefficient of selection (SCS) for wild boar, which accounted for the actual ratio adult/young in the populations, was 0,9, indicating slight selection for adults. Small sample size (14 scats) restricted us estimating SCS for summer diet.

A total of 37 wolf stomaches were analysed (wolves were shot in winter), 27 of them contained prey remains (Table 3).

Table 3. Stomach contents of shot wolves(with remains of prey)

Food item	Number of stomachs, containing the item	Frequency of occurrence, %
Roe deer	12	44.4
Wild boar	3	11.1
Moose	6	22.2
Hares	2	7.4
Dog	4	14.9
Total	27	100

Several different factors generate prey selectivity in wolf-prey interactions as discussed by Huggard (1993). He also estimated, that encounter rates of prey types with wolf tracks were generally proportional to their relative densities. The selectivity of wolves, based on proportional abundances of ungulate species is presented in Table 4. Wolves apparently preferred wild boars, slightly preferred roe deer and avoided moose.

Table 4. Relative abundances of ungulate prey species and Ivlev's indexes of selectivity

Prey species	Relative abundance	Ivlev's index of selectivity
Roe deer	0.56	0.07
Moose	0.31	-0.35
Wild boar	0.13	0.23

Discussion

Wolf diet is generally a function of food availability within the limitations of body size. There is quite direct relationship between carnivore body size and size of prey (Bekoff *et al.*, 1984). If such prey is available, wolves prefer to prey on medium-size mammals – with weight less than 100 kg (Bibikov, 1985; Gittleman, 1984). Social hunting patterns may extend the prey size limits up to moose.

Ungulates are preyed on intensively in several locations in Western and Eastern Europe, contributing substantially to their total natural mortality (Mattioli *et al* 1995; Okarma,1995; Olsson *et al.*,1997) .

Wolves in Estonia coexist with several species of ungulates under relatively natural conditions in contrast to other localities in Europe.

The percentage of wild ungulates in our study area was comparably high in winter and also in summer diets (Tables 1 and 2). It is attributed to local availability of such preys, as study area has previously been intensively managed for ungulate game animals and despite recent social changes still exhibit relatively high numbers of ungulates. Snowshoe and European hare densities, in contrast, have decreased during recent years. Snowshoe hare and roe deer populations must also have to tolerate predation from an high population of lynx (*Lynx lynx*.L.)

Trophic niche breadths were relatively high in our study, maybe due to significant utilization of small rodents both in summer and winter diets. We suppose, that the phenomena occured as a result of destroying regular composition of wolf packs in the process of wolf hunting. Their remaining small groups and solitary wolves are forced to feed more intensively on small rodents, raccoon dogs, hares (in summer) and stray dogs (Dronov, 1991).

Prey selectivity is the nonrandom representation of the available food in the observed diet (Chesson, 1978). In contrast to most European locations, where wild boar are avoided (Beljanin, 1979; Rykovskii, 1980, Nesterenko, 1988; Jedrzejevska *et al.*, 1994; Okarma *et al.*, 1995a), in our study area wild boar was a preferred prey as in Russia (Litvinov *et al.*, 1981) and Italy (Mattioli *et al.*, 1995).

Several explanations have been produced as to why wild boars are preferred/avoided as a prey (Mattioli *et al.*, 1995; Okarma, 1995). The utilization of wild boar by wolves seems to have tendency to increase over time (Rusakov and Timofeejeva, 1984; Mattioli *et al.*, 1995), possibly emphasizing the delay of reaction to the changes of demographic tendencies of his prey species (Mech and Carns, 1977; Gasaway *et al.*, 1983). It was proposed (Mattioli *et al.*, 1995), that positive selection of wild boars can be caused by its vulnerability compared to roe deer or moose and that wild boars form easily identified groups that contain defenceless, relatively slow young animals or having smaller body size than in Central and Eastern Europe.

We suggest, that these qualities are common to wild boar in all localities, thus not explaining the phenomena. We also suggest, that if boars have smaller body sizes, wolves obviously can be smaller as well (Bergmann's rule).

In our study area wild boars were of significantly larger size than in Central Europe (Valdmann, 1993), as in other North-European locations (Rusakov and Timofeejeva, 1984). No special studies have been conducted on wolf morphology in study area, but the majority of adult wolves shot in Estonia are classified as gold medal trophies, so wolf/wild boar body size ratio may not differ from that in Western Europe, probably not explaining the positive selection.

Foraging theory (Stephens and Krebs, 1986) suggests, that all ungulate species should be roughly equal from the perspective of energetic profitability.But wild boar meat is rich in fat (Stribling *et al.* 1984), having higher energetical value than that of cervids and thus probably being more cost-effective for wolves, especially in locations with low temperature.

Real positive selection of wild boar as a prey in study area is confirmed by tracking results; as a rule, wolves kept themselves spatially close to wild boar groupings, like even "grazing" them. They have also developed a special pattern of predation on wild boar, regularly checking and permanently keeping close to places, where supplementary feeding was provided to ungulates (lynx has also developed a similar predatory pattern in study area).

Moose often defend themselves against wolves by means of foreleg kicks (Mech, 1966), and probably being able to fend off the attacks of smaller wolf groupings and pairs (Kochetkov, 1988).

Altogether we suggest, that reducing the size of wolf groupings and, maybe, removal of older animals as a result of wolf control program has reduced their abilities to kill moose and forced them to prey more intensively on wild boar.

Structure coefficient of selection of wild boars (winter diet) in our study was 0.9, indicating selection for adults, like some other places in former USSR (Filonov and Kaleckaja, 1985). We guess, that young boars (≤ 1 year) as a prey were not available in winter during study period and obviously were preyed up by wolves in earlier seasons.

Moose often defend themselves against wolves by means of foreleg kicks (Mech, 1966); probably being able to fend off the attacks of smaller wolf groupings and pairs (Kochetkov, 1988). As wolves were permanently hunted in study area and obviously several groupings were destroyed, the remaining wolves were not able to kill moose effectively, maybe explaining avoidance of moose.

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СОСТАВ ПИЩИ И ИЗБИРАТЕЛЬНОСТЬ ПИТАНИЯ ВОЛКА В ЦЕНТРАЛЬНОЙ И ЮГО-ЗАПАДНОЙ ЭСТОНИИ

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Резюме

В работе представлены результаты изучения состава пищи и избирательности питания волка *Canis lupus* Linnaeus, 1758, основанные на анализе 606 экскрементов, собранных ранней весной (518) и в августе (88) 1996 и 1997 гг. Кроме того, было исследовано содержимое 37 желудков убитых волков. На основе частоты пересечения следов волков со следами их потенциальных жертв, как показателя относительной обильности копытных, были высчитаны индексы селективности Ивлева.

Основными объектами питания волка были копытные, составлявшие в зимнем и летнем питании, соответственно, 80% и 50% встреч. Предпочтение отдавалось кабанам и косулям, тогда как охоты на лосей волки в основном избегали. Структурный коэффициент селекции (SCS) для кабана оказался равным 0,9, что указывает на предпочтение взрослых особей.

Ключевые слова: волк, питание, избирательность питания, копытные, Эстония.