
Feeding habits, food niche overlap of red fox (*Vulpes vulpes* L.) and pine marten (*Martes martes* L.) in hilly moraine highland, Lithuania

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Feeding habits of red fox (*Vulpes vulpes*) and pine marten (*Martes martes*) were studied in hilly moraine highland, East Lithuania, using faecal analysis. Frequency of occurrence (FO) and relative volume (RV) were quantified. Mammals, especially *Microtus* sp., *Apodemus* sp. and *Clethrionomys glareolus*, were the staple food in winter–spring seasons both for red fox (96.5–83.3% RV) and pine marten (84.4–62.4% RV), whereas, in summer–autumn seasons both plants (*Malus* sp., *Pirus* sp.) and mammals (small rodents) were equally important for red fox (37.6–48.9% RV and 51.5–44.9% RV, respectively). In case of pine marten, consumption of plants in summer and autumn increased up to 41 and 75.8% RV, respectively (mainly *Sorbus* sp., *Pirus* sp., *Malus* sp.) and it made the staple food in autumn. Birds, insects, as seasonal food in larger amounts were consumed in spring and summer. The food niche overlap between species reached 0.6–0.7.

Key words: *Vulpes vulpes*, *Martes martes*, diet, seasonal variation, niche overlap, hilly moraine highland landscape, Lithuania

INTRODUCTION

Red fox (*Vulpes vulpes* L.) and pine marten (*Martes martes* L.) are common and abundant predators in Lithuania [27]. Some studies on feeding habits of these predators in Lithuania were carried out only in the 6th decade by Prūsaitė [17, 30] and Maldžiūnaitė [16, 29], whereas there are many studies on feeding, niche breadth, niche overlap in different parts of Europe both on red fox [3, 6, 7, 8, 10, 12, 13, 20, 21] and on pine marten [2, 5, 6, 8, 9, 15, 19, 20, 22, 23, 25, 31].

Hilly moraine highland covers 21% of Lithuania [1]. For this type of landscape a great variety of relief forms, water bodies, soil and vegetation is characteristic. The shredded relief defines a great variety of microclimatic and hydrological conditions, the mosaic structure of biotopes. Small-size coniferous-deciduous forests prevail in mixed with arable lands, pastures, meadows, human settlements. There are many little swamps, lakes, streams [27]. Both red fox and pine marten are abundant and typical for this landscape, where they use various biotopes. In 1990–1993, in the studied area the density was 16 ind./1000 ha for pine marten [26] and 14 ind./1000 ha for red foxes [28].

The aim of this research was to investigate feeding habits of red fox and pine marten, to evaluate

their niche breadth and food niche overlap in hilly moraine highland.

STUDY AREA AND METHODS

The research was carried out in East Lithuania, Molėtai District (55°09'N; 25°20'E). The study area covered two little forests (approximately 800 ha), where spruce, asp and oak predominated (28.1; 26.3 and 20.7%, respectively) and adjacent meadows, pastures, arable lands (approximately 900 ha). The area was hilly, with many little swamps and swampy ravines. There are many single farmsteads (part of them were derelicted) by the edge of forests.

The diet of red fox and pine marten was studied by faecal analysis. During two years (1999–2000), 148 faeces of foxes and 156 faeces of martens were collected in different seasons. Seasons were divided according to availability of resources and feeding peculiarities of predators: summer (July–September), autumn (October–November), winter (December–March) and spring (April–June). Scats of foxes were collected on forest roads and at breeding dens, whereas, pine marten scats were collected from known places established during snow tracking on fallen trees (in order to avoid the possibility to gather faeces of stone marten which is found here, too). Analysis of scats followed the standard pro-

cedure [4, 14, 15]. Undigested food remains were identified according to Pucek [18], Teerink [24]. Food remains were classified into 28 categories (Table 1; waste means human left waste materials).

Food composition was expressed in the frequency of occurrence (FO) – the percentage of samples in which a given food item occurred and in relative volume (RV) of each kind of food eaten by predators.

Niche breadth was estimated by measuring the standardised Levin's index (B) and Levin's standardised niche breadth (B_A) [11]:

$$B = 1/\sum p_j^2,$$

where p_j is the proportion of records in each food category j ;

$$B_A = B - 1/n - 1,$$

where n is the number of possible food categories.

Niche overlap was measured through Pianka's index [11]:

$$O_{jk} = \frac{\sum_i p_{ij} p_{ik}}{\sqrt{\sum_i p_{ij}^2 \sum_i p_{ik}^2}},$$

where O_{jk} is Pianka's measure of niche overlap between species j and k ;

p_{ij} (or p_{ik}) is the proportion of the food category i recorded in the diet of the species j (or k);

n is the total number of food categories.

RESULTS

Red fox diet

According to the main food components, the diet of red fox could be divided into two periods: 1) summer and autumn – when both plants and mammals are equally important; 2) winter and spring – when mammals were defined as the staple food (Fig. 1).

Table 1. Diet composition of red fox in different seasons (FO – frequency of occurrence, %, RV – relative volume, %), 1999–2000

Item	Summer		Autumn		Winter		Spring		Annual	
	FO	RV	FO	RV	FO	RV	FO	RV	FO	RV
Insectivora	2.7	1	2	1	3.7	3.7	0	0	2	1.3
<i>Apodemus</i> spp.	2.7	0.1	3.9	2.8	11.1	4.4	9.1	3.9	6.1	2.7
<i>Clethrionomys glareolus</i>	10.8	9.5	2	0.8	18.5	13	15.2	13.2	10.1	7.9
<i>Arvicola terrestris</i>	5.4	4.5	2	1.9	0	0	6.1	4.7	3.4	2.8
<i>M. arvalis/agrestis</i>	24.3	23.2	35.3	25.2	40.7	34.8	30.3	24.7	32.4	26.3
<i>M. oeconomus</i>	0	0	0	0	7.4	6.9	0	0	1.4	1.3
<i>Microtus</i> spp.	13.5	10.5	15.7	7.7	29.6	23.3	21.2	16.1	18.9	13.1
<i>Ondatra, Castor</i>	0	0	3.9	2.3	0	0	9.1	4.1	3.4	1.7
Undet. Rodentia	2.7	1.1	3.9	0.2	3.7	0.4	6.1	2.9	4.1	1.1
<i>Lepus europeus</i>	8.1	1.6	2	1	3.7	3	3	3	4.1	2
Carnivora	0	0	0	0	0	0	3	2.4	0.7	0.5
<i>Sus scrofa, Cervidae</i>	0	0	3.9	2	18.5	5.9	12.1	8.3	7.4	3.6
Undet. Mammalia	0	0	0	0	3.7	1.1	0	0	0.7	0.2
Total mammals	62.2	51.5	60.8	44.9	100	96.5	93.9	83.3	79.1	64.3
Aves	16.2	8.1	5.9	1.8	3.7	0	6.1	1.8	8.1	3
Reptilia, Amphibia	0	0	0	0	0	0	18.2	0.8	4.1	0.2
<i>Coleoptera</i>	18.9	0.5	19.6	2.6	0	0	51.5	9.4	23	3.1
<i>Hymenoptera</i>	10.8	1.6	2	0.1	0	0	0	0	3.4	0.4
<i>Orthoptera</i>	8.1	0.3	5.9	0.2	0	0	0	0	4.1	0.1
Larvae	0	0	2	0	0	0	0	0	0.7	0
Total insects	32.4	2.4	25.5	2.9	0	0	45.5	9.4	27	3.6
<i>Malus</i> sp.	18.9	8	37.3	14.8	7.4	0.6	0	0	18.9	7.2
<i>Pirus</i> sp.	16.2	10.1	35.3	27.9	0	0	0	0	16.2	12.2
<i>Prunus</i> sp., <i>Cerasus</i> sp.	13.5	12.3	9.8	3.5	0	0	0	0	6.8	4.3
<i>Rubus</i> sp.	2.7	2.6	0	0	0	0	0	0	0.7	0.6
<i>Sorbus</i> sp.	2.7	2.7	0	0	0	0	0	0	0.7	0.7
Corn	0	0	2	0.8	0	0	0	0	0.7	0.3
Grasses	13.5	1.9	15.7	1.7	7.4	1.8	15.2	4.7	13.5	2.5
Other plants	0	0	2	0.2	0	0	0	0	0.7	0.1
Total plants	62.2	37.6	86.3	48.9	14.8	2.4	12.1	4.7	50.7	27.9
Waste	5.4	0.4	2	1.5	7.4	1.1	0	0	3.4	0.8

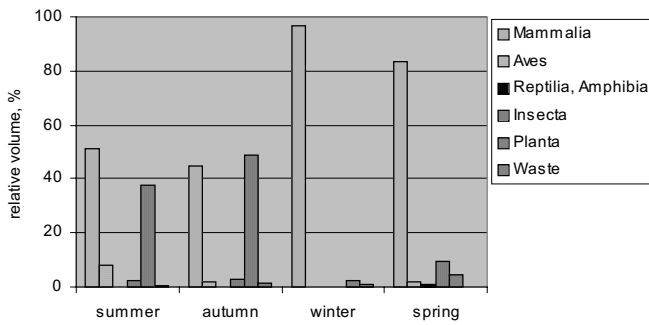


Fig. 1. Relative volume (%) of the main food categories of red fox in different seasons, 1999–2000

In the first period, *Microtus* sp. were most frequently used among mammals (33.7–51% RV, summing all *Microtus*). The relative volume of plants reached 37.6–48.9% (mainly *Pirus* sp., *Malus* sp., *Prunus* sp. and *Cerasus* sp.; Table 1). Birds were an important prey in summer time (8.1% RV). The frequency of insect occurrence reached high values, but their relative volume didn't exceed 3%. In winter–spring time the main food resources were small rodents (mainly *Microtus* sp. and *Clethrionomys glareolus*), and also carcasses of wild ungulates (total mammals 96.5–83.3% RV; Table

1). In spring, 9.4% of relative volume was made by insects. The other food components were consumed in little amounts and didn't have any importance.

Pine marten diet

The marten diet according to the main food components can also be divided into two periods: the first, summer and autumn, when plants predominated or equalled with mammals in the diet, and the second, winter and spring, when mam-

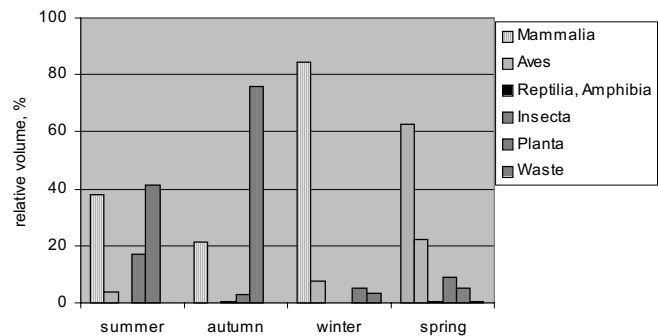


Fig. 2. Relative volume (%) of the main food categories of pine marten in different seasons, 1999–2000

Table 2. Diet composition of pine marten in different seasons (FO – frequency of occurrence, %, RV – relative volume, %), 1999–2000

Item	Summer		Autumn		Winter		Spring		Annual	
	FO	RV	FO	RV	FO	RV	FO	RV	FO	RV
Insectivora	14.6	6.3	0	0	3.8	3.8	2	2	5.8	3.2
<i>Apodemus</i> spp.	14.6	11	15.6	12.8	26.9	20	16	13.8	17.3	13.8
<i>Clethrionomys glareolus</i>	12.5	10.3	3.1	1.4	23.1	17.3	24	19.8	16	12.7
<i>Arvicola terrestris</i>	2.1	2.1	0	0	3.8	0.8	8	7	3.8	3
<i>M. arvalis/agrestis</i>	8.3	8.1	6.3	6.3	19.2	18.5	18	15.9	12.8	12
<i>M. oeconomus</i>	0	0	0	0	3.8	3.8	0	0	0.6	0.6
Undet. Rodentia	8.3	0.2	6.3	0	0	0	6	1.9	3.8	0.7
<i>Lepus europeus</i>	0	0	0	0	7.7	4	0	2	1.3	0.7
Carnivora	0	0	0	0	3.8	1.2	2	0	1.3	0.8
<i>Sus scrofa</i> , <i>Cervidae</i>	0	0	0	0	19.2	14.8	0	0	3.2	2.5
Undet. Mammalia	0	0	3.1	0.6	3.8	0.2	0	0	1.3	0.1
Total mammals	43.6	38	31.3	21.1	92.3	84.4	72	62.4	58.3	50.1
Aves	6.3	3.8	0	0	11.5	7.5	26	22.4	12.2	9.6
Reptilia, Amphibia	0	0	3.1	0.3	0	0	4	0.6	1.3	0.3
<i>Coleoptera</i>	8.3	1.5	6.3	1.1	0	0	24	5.8	11.5	2.5
<i>Hymenoptera</i>	29.2	12.9	6.3	1.7	0	0	8	3.2	12.8	5.3
<i>Orthoptera</i>	2.1	2	0	0	0	0	0	0	0.6	0.6
Larvae	2.1	0.8	0	0	0	0	4	0.1	1.9	0.3
Total insects	12.5	17.2	12.5	2.8	0	0	32	9.1	23.1	8.7
<i>Malus</i> sp.	12.5	8	21.9	18.9	19.2	5	0	0	9	7.2
<i>Pirus</i> sp.	10.4	10.2	25	23.8	0	0	0	0	8.3	8
<i>Prunus</i> sp., <i>Cerasus</i> sp.	6.3	4.3	3.1	3.1	0	0	0	0	2.6	2
<i>Rubus</i> sp.	22.9	10.8	0	0	0	0	0	0	7.1	3.3
<i>Sorbus</i> sp.	10.4	7.7	28.1	28.1	0	0	0	0	9	8.1
Grasses	0	0	3.1	1.9	0	0	8	5	3.2	2
Total plants	60.4	41	81.3	75.8	19.2	5	10	5	41	30.6
Waste	0	0	0	0	3.8	3.1	2	0.5	1.3	0.7

mals were the most important food item (Fig. 2). In summer–autumn, the pine marten diet consisted mostly of plants (41–75.8% RV; mainly *Sorbus* sp., *Pirus* sp., *Malus* sp. and also *Rubus* sp., *Prunus* sp.). In summer time, mammals (mainly *Apodemus* and *Clethrionomys glareolus*) were an important prey, too (38% RV; Table 2). Insect consumption reached 17.2% RV in summer. In the second period, pine marten consumed mostly small rodents (*Apodemus* sp., *Clethrionomys glareolus* and also *Microtus* sp.) and carcasses of wild ungulates (total mammals 84.4–62.4% RV). As a seasonal food in this period, birds were important in winter (7.5% RV) and spring (22.4% RV), and insects in spring (9.1% RV) diet. Other food resources (reptiles, amphibians) were consumed in very little amounts.

Food niche breadth, food niche overlap

The food niche breadth for foxes was relatively low, it reached 0.2–0.3 in different seasons. Martens' niche breadth seasonally varied from 0.2 to 0.5 (Table 3). As for food niche overlap, the most extensive values were established in summer and winter (0.67 and 0.65, respectively).

Table 3. Food niche breadth and overlap of red fox and pine marten based on relative volume (B – Levin's index, B_A – standardized Levin's index, Ojk – Pianka's index, n – number of food items)

Season	Red fox (n = 27)		Martens (n = 24)		Ojk
	B	BA	B	BA	
Summer	8.6	0.29	11.3	0.45	0.67
Autumn	5.7	0.18	5.2	0.18	0.63
Winter	4.9	0.15	7.2	0.27	0.65
Spring	7.7	0.26	6.8	0.25	0.63
Annual	8.2	0.28	11.8	0.47	0.68

DISCUSSION

The hilly moraine highland landscape in East Lithuania is characterised by a great variety of biotopes. The area study included two little coniferous-deciduous forests with mosaic biotopes, arable lands, pastures, meadows; there were many small swamps, wet lowlands. That was reflected in predators' feeding. My study revealed that in the summer–autumn period both plants (mainly *Malus* sp. and *Pirus* sp.) and mammals (mainly *Microtus* sp.) were the most important prey for red foxes (37.6–48.9% RV and 51.5–44.9% RV, respectively), whereas in winter and spring the staple food were mammals (96.5–83.3% RV). As seasonal food, birds and insects were consumed in larger amounts in spring (8.1% RV and 9.4% RV, respectively). Other investigations carried

out in Lithuania [17, 30] showed the highest frequency of occurrences for mammals, especially *Microtus* sp., for all seasons (60.8–86.1% FO). Birds were an important prey in spring and summer (49.5–47.8% FO), whereas plants and insects were found in 50–60% of all occurrences in the summer–autumn diet, but in small amounts. In many studies small mammals are defined as the staple food for red fox (30–80% FO, up to 50% RV and 55% consumed biomass) all year round [6, 7, 8, 10, 13, 20]. Just in Central Poland with a mosaic of fields, meadows, forests, hares predominate in spring (43% consumed biomass) [3]. Ungulate carcasses are an important prey in cold season (24.5–28.5% of biomass) [6]. Plants as the dominating food resource (over 50% RV) in summer–autumn diets are characteristic of southern latitudes [21].

In case of pine marten, plants predominated in its summer–autumn diet (*Malus* sp., *Pirus* sp. and *Sorbus* sp.; 41–75.8% RV); mammals were important, too (38–21.1% RV). In winter–spring seasons, the marten's diet consisted mostly of mammals, mainly rodents (*Apodemus* sp., *Clethrionomys glareolus*, *Microtus* sp., 59.6–49.5% RV and in winter also of carcasses of wild ungulates (14.8% RV). In spring, consumption of birds and insects reached a high value, too. Maldžiūnaitė's [16, 29] investigations on pine marten diet in winter time revealed that mammals, mainly *Clethrionomys glareolus* and insectivores, made the staple food (over 90% FO). The other important prey category was birds (30% FO). In many studies on pine marten, forest rodents (*Clethrionomys glareolus*, *Apodemus* sp.) and in some cases also *Microtus* sp. made the staple food, consumed biomass reaches about 50% [5, 6, 8, 9, 19, 20, 23, 25, 28]. Pine marten consume large amounts of birds (13–20% of biomass in warm season), too [6, 22]. In South Europe, plants made over 80% FO in summer–autumn diet [2].

Food niche breadth in different seasons varied for both species studied. The highest values for foxes and martens were reached in summer (0.29 and 0.45, respectively). Variation in food niche breadth for fox and martens in different areas depends on season [7, 9, 12]. However, the niche overlap obtained by as (0.63–0.67) was rather extensive as compared with the results gained from similar studies in Poland (0.46–0.59) [6, 8].

Summing up, our results obtained from studies in a hilly moraine highland landscape of East Lithuania are similar to the results of other studies in Europe. But there are some differences: both red fox and pine marten in summer–autumn consumed large amount of plants; consumption of wild ungulate carcasses in winter for foxes was lower, whereas pine marten used a large amount of this prey.

Some differences from other studies are probably caused by different climatic conditions and variety of biotopes. Prūsaitė and Maldžiūnaitė [16, 17, 29, 30] carried out their researches in different parts of Lithuania, besides, they used different methods – scats, guts and food remains gathered near dens (in case of foxes). That could explain some differences, too.

For the studied landscape, a great variety of fragmentary biotopes is characteristic. This allows the predators to increase the number of accessible food resources.

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RUDŲJŲ LAPIŲ (*VULPES VULPES* L.) IR MIŠKINIŲ KIAUNIŲ (*MARTES MARTES* L.) MITYBOS YPATUMAI, MITYBINĖS NIŠOS PERSIDENGIMAS KALVOTOSE LIETUVOS MORENINĖSE AUKŠTUMOSE

S a n t r a u k a

Kalvotų moreninių aukštumų landšafte Rytų Lietuvoje tirta rudosios lapės (*Vulpes vulpes*) ir miškinės kiaunės (*Martes*

martes) mityba. Tyrimų metodika – ekskrementų analizė. Buvo apskaičiuoti aukų sutikimo dažnumas (% , SD) ir jų santykinis kiekis (% , SK). Žinduoliai (ypač *Microtus* sp., *Apodemus* sp. ir *Clethrionomys glareolus*) buvo pagrindinis mitybinis komponentas žiemos ir pavasario sezonais tiek lapių (51–97% SK), tiek kiaunių racione (62–84% SK). Tuo tarpu vasaros ir rudens metu tiek augalai (daugiausia *Malus* sp. ir *Pirus* sp.), tiek žinduoliai (smulkūs graužikai) buvo vienodai svarbūs lapių mityboje (atitinkamai 37,6–48,9% ir 51,5–44,9% SK). Kiaunės augalinio maisto (*Sorbus* sp., *Pirus* sp., *Malus* sp.) suvartojo šiais sezonais iki 41–75,8% SK ir buvo svarbiausias maistas rudenį. Paukščiai, vabzdžiai svarbūs kaip sezoninis maistas, ir didesniais kiekiais aptinkami pavasario ir vasaros metu. Rudosios lapės ir miškinės kiaunės mitybinės nišos persidengimas svyravo 0,6–0,7 ribose.

Raktažodžiai: *Vulpes vulpes*, *Martes martes*, mityba, sezonizacija, nišos persidengimas, kalvotosios moreninės aukštumos, Lietuva