



COMPARATIVE ANALYSIS OF THE DIET OF MEMBERS OF THE FAMILIES MUSTELIDAE AND CANIDAE

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Abstract

The article analyzes 151 food samples of carnivorous mammals of two families. It was found that the diet includes 49 food items in the studied species of the family Canidae and 42 items in species of the family Mustelidae, of both plant and animal origin. It was revealed that plant food is an important component of the diet of predators, since the frequency of registration of these objects is 46.4%. Most often, it is the remains of cereals and plant seeds. Rodents are the main food for both families (19% in Canidae, 21% in Mustelidae). A seasonal change in diet for both families was noted. Members of the family Mustelidae consume plants more often in summer and winter, while in spring and autumn mammals prevail in their diet when the share of juicy fruits is the lowest. Rodents are consumed throughout the year, but their largest share was noted in spring, when this family is characterized by the greatest variety of food (Shannon's index is 2.0). For members of the family Canidae, the most important component of the diet in winter is dry fruits. The number of rodents in their diet also increases in spring. The summer period is characterized by the consumption of invertebrates and the absence of animal carcasses in the diet. In autumn, the share of juicy fruits increases and during this period the diet of Canidae is the most diverse (1.9). The lowest variety of food in species of the two families was registered in summer. Competition between the studied families may increase in spring when the most important food for the representatives of both Canidae and Mustelidae is rodents. There are some sex-related trophic preferences in both families. In particular, males of the family Mustelidae consume rodents more often (68.7%), while females more often feed on plants (56.1%). As for the family Canidae, the analysis was carried out on the example of the red fox. It was found that females of this species prefer plant foods and there are no ungulates in their diet. Males consume fewer plants (41.4%) and often forage in cattle burial grounds and landfills. Accordingly, the diet of males is more diverse compared to that in females. The Shannon index is 3.3 and 2.5, respectively.

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COMPARATIVE ANALYSIS OF THE DIET OF MEMBERS OF THE FAMILIES MUSTELIDAE AND CANIDAE

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Comparative analysis of the diet of members of the families Mustelidae and Canidae. — M. Martsiv, I. Dykyy. — The article analyzes 151 food samples of carnivorous mammals of two families. It was found that the diet includes 49 food items in the studied species of the family Canidae and 42 items in species of the family Mustelidae, of both plant and animal origin. It was revealed that plant food is an important component of the diet of predators, since the frequency of registration of these objects is 46.4%. Most often, it is the remains of cereals and plant seeds. Rodents are the main food for both families (19% in Canidae, 21% in Mustelidae). A seasonal change in diet for both families was noted. Members of the family Mustelidae consume plants more often in summer and winter, while in spring and autumn mammals prevail in their diet when the share of juicy fruits is the lowest. Rodents are consumed throughout the year, but their largest share was noted in spring, when this family is characterized by the greatest variety of food (Shannon's index is 2.0). For members of the family Canidae, the most important component of the diet in winter is dry fruits. The number of rodents in their diet also increases in spring. The summer period is characterized by the consumption of invertebrates and the absence of animal carcasses in the diet. In autumn, the share of juicy fruits increases and during this period the diet of Canidae is the most diverse (1.9). The lowest variety of food in species of the two families was registered in summer. Competition between the studied families may increase in spring when the most important food for the representatives of both Canidae and Mustelidae is rodents. There are some sex-related trophic preferences in both families. In particular, males of the family Mustelidae consume rodents more often (68.7%), while females more often feed on plants (56.1%). As for the family Canidae, the analysis was carried out on the example of the red fox. It was found that females of this species prefer plant foods and there are no ungulates in their diet. Males consume fewer plants (41.4%) and often forage in cattle burial grounds and landfills. Accordingly, the diet of males is more diverse compared to that in females. The Shannon index is 3.3 and 2.5, respectively.

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Introduction

Carnivorous mammals are an important component of various types of biogeocoenoses. They control the abundance of other mammals and some species of birds. Despite the substantial role of predators and their trophic connections, in the territory of western Ukraine, knowledge on the diet of these species is insufficient. The last thorough works on this issue were carried out in the 1960s. In particular, the feeding of predators in the western regions was mentioned in the works of Tatarinov and Polushina (Tatarinov 1956; Polushina 1963).

The diet of representatives of the family Mustelidae in Ukraine are well-described in Abelentsev's work (Abelentsev *et al.* 1968). Regarding modern research on the diet of predators, the most studied are the nutrition of the European badger in western Ukraine (Dykyy & Dyka 2005) and the feeding of the wolf in the entire territory of Ukraine (Sagajdak & Shkvyrva 2002; Shkvyrva & Kolesnikov 2008). There are also some fragmentary data on the nutrition of red foxes (Lushchak 2006), pine martens, weasels, and European otters (Stelmakh 2013; Dykyy *et al.* 2018). Most studies on the diet of predators in this area are presented in theses of postgraduate students.

In central and south-eastern Ukraine, more attention was paid to the study of predator nutrition and the results are presented in works of many authors (e.g. Rozhenko 2006). The nutrition of the red fox was studied by N. Lebedeva (2000), while feeding of the wolf was analysed in the works of

S. Zhyla (2006), V. Domnich, and I. Smirnova (2006; Smirnova *et al.* 2010). Feeding of some representatives of the family Mustelidae was studied by M. Mikheyev (2002, 2011).

The study of the diet of predatory mammals is widely represented in the works of European researchers. Many works have been devoted to the diet of the red fox (Panzacchi *et al.* 2008, Soe *et al.* 2017) and the trophic competition of the fox with other predators (Lanszki *et al.* 2006; Lanszki *et al.* 2007, Zhang *et al.* 2009). Many studies now focus on the analysis of various factors influencing changes in the diet of predators: season, longitude and latitude, sex, etc. (Dell'arte *et al.* 2007; Kidawa & Kowalczyk 2011, Noonan *et al.* 2016). In addition, there are works concerning research methods. The results of these studies indicate that the choice of methods (gastric analysis or faecal analysis) has an impact on the results. For example, invertebrates are more commonly recorded in faecal samples, while rodents are more often found in gastric samples (Balestrieri *et al.* 2011).

Predator control is important today. This is especially true for red fox and wolf populations, which are considered pests. The study of nutrition of these species is important to solve this problem because the main criterion for the "harmfulness" of a predator is the level of damage it causes. The hunting economy estimates the number of other economically important species destroyed (for food) by this predator (Pavlenko 2016). This indicates the relevance of our study.

Our work aims to study the diet of members of the families Mustelidae and Canidae in western Ukraine, to establish trophic differences between different species of these families and to determine the influence of season and sex on changes in the diet of predators.

Materials and Methods

We collected the material during 2015–2020 in the territory of western Ukraine. We covered the areas of the Ukrainian Polissia, Podillia, and the Carpathians. We used two methods — the method of collection and analysis of faeces and the method of analysis of gastric contents. We received the stomachs of animals from hunters. We also analysed the stomach contents of animals that were found dead on highways. We identified objects using diagnostic keys (Zagorodniuk 2002) and also involved specialists (ornithologists, entomologists, and botanists). We processed 106 stomachs and 45 samples of excrements (Table 1). We analysed food samples of 10 species of two families: Canidae — *Canis lupus*, *Vulpes vulpes*, *Nuctereutes procyonodius*; Mustelidae — *Martes martes*, *Martes foina*, *Meles meles*, *Mustela putorius*, *Mustela nivalis*, *Mustela erminea*, *Lutra lutra*.

Results and Discussion

All studied species are predators, and the basis of their diet is objects of animal origin. However, they all consume plant food. In particular, the frequency of registration of plant objects is 46.4%, which is almost half of the diet of predators. These are mainly dried fruits and grass (28.6%) and, although the weight of grass and dry components is insignificant, they occur quite often. We suggest that they consume grass for better gastrointestinal function, animals can receive vitamins and minerals from this kind of food, and this may be a way to control endoparasites (Lanszki *et al.* 1999). Among animal objects, predators consume both invertebrates (7.7%) and vertebrates (45.9%). The most important components in the diet of predators of both families are mammals (31%), namely representatives of the suborder Myomorpha (19.1%).

Table 1. The number of analysed samples by species

Табл. 1. Кількість досліджених зразків відповідно до виду

Species	Number	Species	Number
<i>Canis lupus</i>	3	<i>Mustela putorius</i>	4
<i>Vulpes vulpes</i>	60	<i>Mustela nivalis</i>	17
<i>Nuctereutes procyonodius</i>	3	<i>Mustela erminea</i>	3
<i>Martes martes</i>	11	<i>Lutra lutra</i>	5
<i>Martes foina</i>	22	Mustelidae	8
<i>Meles meles</i>	6	Total	142

Family Canidae

We examined 66 samples (faeces and stomach contents) from members of this family, including the red fox (60 samples), the wolf (3 samples), and the raccoon dog (3 samples).

It was found that members of the family Canidae eat plant and animal objects but still prefer objects of animal origin, which make up 51.4% of their diet.

In total, the diet of members of the family Canidae includes 49 food items. There are 25 food items of plant origin. Grass (Poaceae) and dried fruits (sunflower, wheat, oats, walnuts, plant seeds, leaves, and branches) were the most common (33.3%). They also often consume juicy fruits such as apple, pear, quince, plum, raspberry, grapes, dog rose, blueberries, blackberries, and carrot roots (12.2%).

Food of animal origin include 24 objects, both invertebrates (7.2%) and vertebrates (44.1%). Vertebrates are represented by five classes: Actinopterygii (0.9%), Amphibia (0.5%), Reptilia (0.5%), Aves (11.3%), and Mammalia (31.1%). Mammals are the basis of the diet of members of the family Canidae. Usually, these predators mainly prey on murine rodents, which make up 17.6% of the diet. Red foxes often feed on landfills or cattle burial grounds, where they can consume ungulate remains (7.2%).

In the stomachs of wolves, we found only few remnants of the European roe deer and goat fur, and one of them was filled with apples and pears. In the Forest-Steppe and Carpathians, wild ungulates are of the greatest importance in the wolf's diet (Shkvryra & Kolesnikov 2008). We assume that the food base for this predator is insufficient now, and the predators feed on alternative objects (fruits and domestic animals).

We studied the relationship between trophic and sex on the example of the red fox. We found that females consume plants more often (46.2% of their diet) compared to males (41.4%). In addition, females do not have ungulates in their diet. It indicates that they rarely feed on landfills and usually prey on rodents and birds, which make up 25.6% and 20.5 % of their diet, respectively. In our opinion, this is due to the reproductive function of females. For example, some studies confirm the dependence between litter size and the number of voles (Kauhala 1996). In addition, the diet of males is more diverse (Shannon's index is 3.3). In females, this value is much lower (2.5). This difference in nutrition can be explained by two factors: physiological characteristics (males are adapted to hunt large animals) and social behaviour (often males care for the offspring and bring food to cubs) (Macdonald 1987).

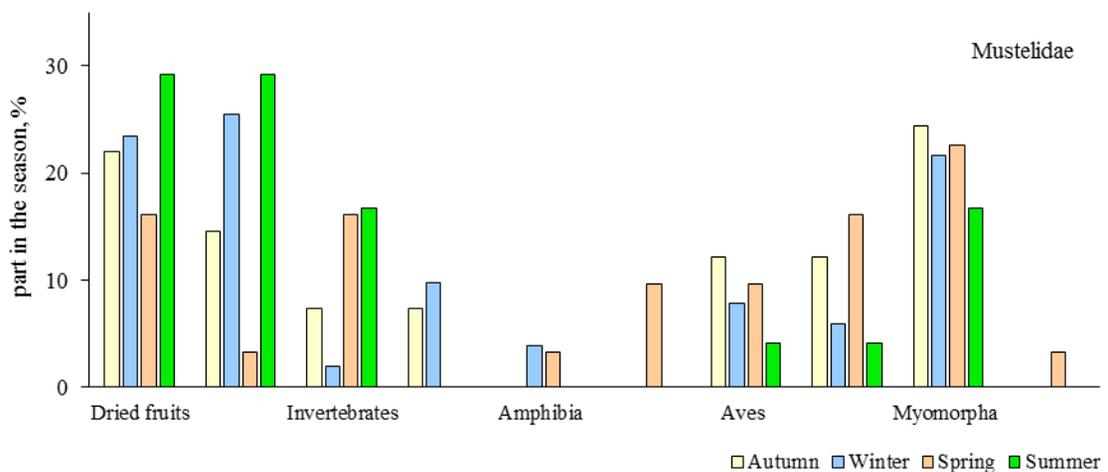


Fig. 1. Seasonal diet of representatives of the family Canidae.

Рис. 1. Сезонна мінливість компонентів раціону представників родини Canidae.

Members of the family Canidae have a change in their diet during the year (Fig. 1). Dried fruits and birds are important components in winter. Juicy fruits make up a significant percentage in autumn. In summer, we did not register sedge in the diet of the family Canidae, but invertebrates often occurred. Mouse-like rodents are consumed throughout the year but their share in spring increases in the diet. The most diverse diet of members of the family Canidae is in autumn (Shannon index 1.9) and winter (1.7). In spring and summer, the variety of foods decreases. The Shannon index is the same and is 1.5 for both seasons. Some authors note that the change in trophic habits of predators is associated not only with seasonal changes, but also with anthropogenic impact (Soe *et al.* 2017).

In addition, we examined the diet of the red fox depending on the area where the material was collection (latitude and longitude, habitat). However, no significant changes were observed in the diet in the study area. We assume that the area of our research is too small to assess the biogeographical features in the diet of predators and such work should be carried out on a much larger scale. (Soe *et al.* 2017).

Family Mustelidae

We examined 76 samples (faeces and stomach contents) of members of the family Mustelidae: *Martes foina* (22 samples), *Martes martes* (11 samples), *Mustela nivalis* (17 samples), *Mustela erminea* (3 samples), *Meles meles* (6 samples), *Lutra lutra* (5 samples), and *Mustela putorius* (4 samples). We also examined one stomach of a juvenile hybrid of *Mustela putorius* x *Neovison vison*. Other samples we identified only at family level.

The diet of the family Mustelidae includes 42 objects of plant and animal origin. However, members of this family consume animals more often (56.9 % of the diet). They also consume grass (cereal residues) and dry fruits such as wheat, sunflower seeds, seeds of other plants, leaves, straw, and pine needles (21.5%). Juicy fruits (apple, pear, thorn, hawthorn, cherry, viburnum, raspberry, blackberry, and blueberry) make up 17.6% of the diet and are the most common in the diet of the stone and pine martens. Representatives of the family Mustelidae feed on invertebrates (8.5%), most of them in spring and summer and it is common for all species. Insects are the most often consumed invertebrates, followed by molluscs and roundworms. In particular, the badger, which is the best adapted to burrowing lifestyle, prefers to feed on insects and their larvae (Dykyy & Dyka 2005).

Vertebrates are represented by 14 food items. Fish make up 5.2% of the diet and are typical prey for the European otter and polecat. Small percentages have amphibians and reptiles (2% each), which also occur in the diet of the latter two species. European otters often hunt amphibians in winter and early spring (Lanszki & Molnar 2003), when the availability of basic food (fish) decreases and amphibians accumulated for hibernation or spawning are easy prey (Weber 1990; Smiroldo *et al.* 2009; Smiroldo *et al.* 2019). An additional factor may be the seasonal migrations of fish.

The importance of birds in the diet of members of the family Mustelidae is exaggerated (Polushina 1963). According to our data, birds in the diet of these predators make up only 8.5% and are represented by the four most common species — wild duck, magpie, blackbird, and little owl. However, there is a different situation in the family Canidae. The red fox has an impact on the density of some bird species, and they try to avoid nesting near these predators (Tryjanowski *et al.* 2002). Mammals have the greatest percentage among food objects of members of the family Mustelidae (30.7%), namely representatives of the suborder Myomorpha (20.9%), most often the common vole. We did not find any polyethylene or ungulate remains in the samples of these species because these predators do not forage in landfills. It is interesting that in our samples no remains of domestic animals were recorded. Only in one stomach of a stone marten, we found remains of a domestic cat.

The analysis of sex-related trophic preferences revealed that males are more likely to hunt rodents, and animal food make up 68.7% of their diet. Females consume plants more often, and the frequency of animals in the diet is 56.1%. Due to plant foods, the diet of females is richer and includes 23 objects, while males only 18. Among all species of Mustelidae, the stone marten consumes plants the most often, but it is also characterized by differences related to sex. In particular, males

prefer animal food (60%), while females prefer plants (55.5%). This family is characterized by sexual dimorphism related to the diet: females are adapted to hunt on smaller prey than males because they are themselves smaller (Abramov & Puzachenko 2009; Magnusdottir *et al.* 2012).

We noticed a seasonal change in food for members of the family Mustelidae (Fig. 2). In particular, plant food is the most often consumed by members of this family in summer and winter (typical of the stone marten, which finds apples even in winter). In spring, the proportion of invertebrates in the diet increases. We registered amphibians and reptiles in the diet of these predators only in the winter-spring period and fish only in the autumn-winter period. Representatives of the order Rodentia are the main feeding component for Mustelidae throughout the year and occur with approximately the same frequency in all seasons. Mammals (without rodents) and birds are more often registered in autumn and spring when the share of succulent food is the lowest. The variety of food objects is the same in autumn and winter. Shannon's index for both seasons is 1.8.

We observed the greatest diversity of the diet in spring (2.0) and the least diversity in summer (1.6). In our opinion, these seasonal features of food diversity can be explained by several factors. First, in spring, the variety of food increases because the availability of food increases, and after winter, the animals actively diversify their diet. Secondly, in spring, breeding season takes place, and, respectively, females enrich their diet with all possible components.

It may seem at first that the diet of members of the family Canidae is more diverse. It can be explained by the fact that members of this family are able to feed on carrion and food waste (garbage), which is uncommon for members of the family Mustelidae. However, the Shannon index shows that the variety of food of both families is rather high and is the same (4.1 for both Canidae and Mustelidae). For both families, plant and animal foods are weighty components of the diet, but predators consume animals more often (Fig. 3). Juicy fruits are more important for members of the family Mustelidae, whereas members of the family Canidae consume dry fruits more often. Members of the family Mustelidae are more adapted to climbing trees and often live in attics, which gives them greater access to juicy fruits (apple, pear, etc.). Invertebrates do not constitute an important component of diet throughout the year for both families. However, vertebrates are an important food for all species of predators and during all seasons and they consume rodents the most often.

Both families have a very similar diet, and they have a certain trophic competition. The red fox, which is considered omnivorous and quite numerous, can compete not only with forest-dwelling species, but also synanthropic species (stone marten), because it also occurs close enough to human settlements. Abelentsev describes the red fox as an enemy of all species of Mustelidae, including the European otter (foxes can attack otter to take the prey). Small members of the family Mustelidae (weasel and ermine) can also occur in the diet of foxes (Dell'arte *et al.* 2007).

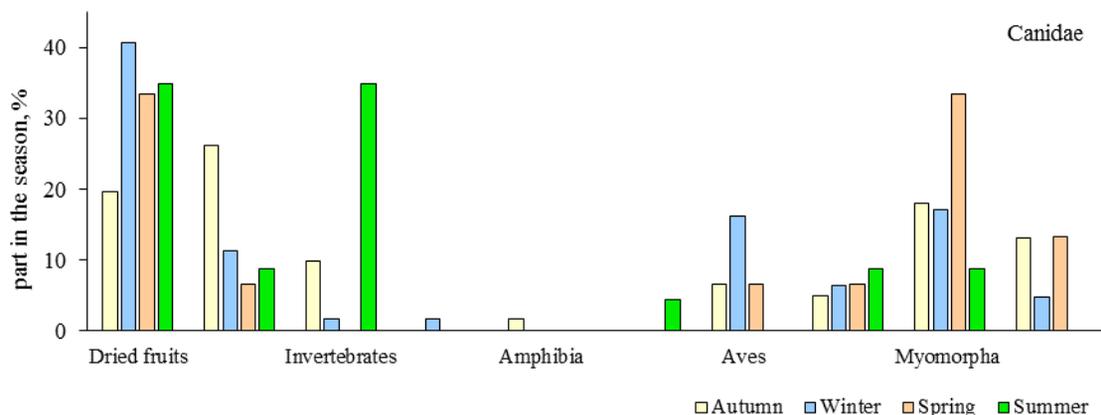


Fig. 2. Seasonal diet of representatives of the family Mustelidae.

Рис. 2. Сезонний раціон представників родини Mustelidae.

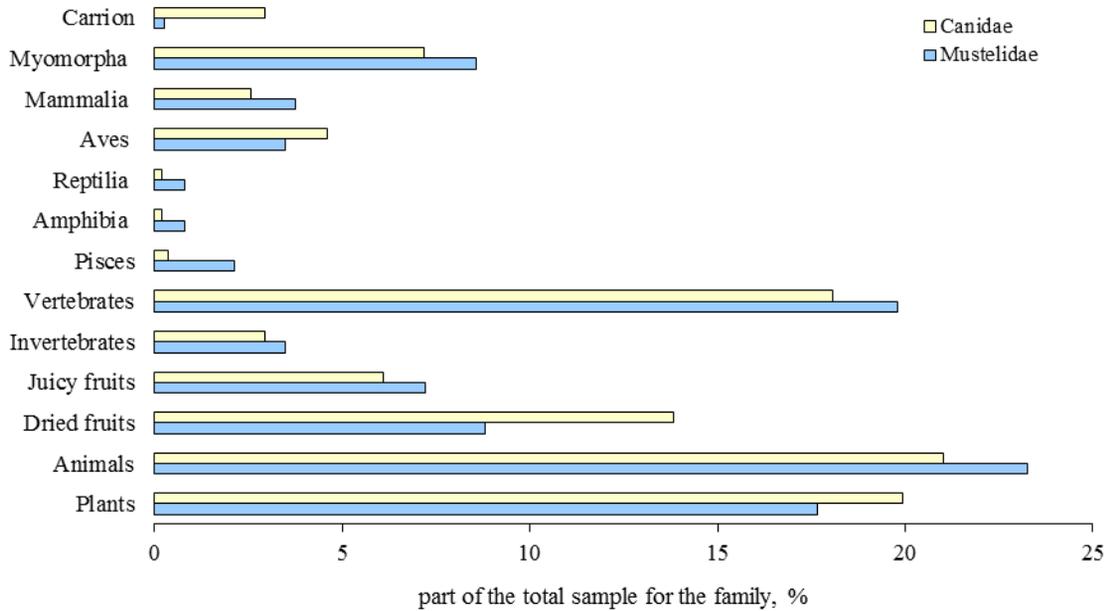


Fig. 3. Comparative characteristics of nutrition in representatives of Mustelidae and Canidae.

Рис. 3. Порівняльна характеристика живлення представників Мустелових та Псових.

The red fox and stone marten have the most similar diets and half of their trophic niches overlap (Lanszki *et al.* 2007). However, for members of the family Mustelidae, spring is the season with the most diverse food base, which increases with the start of the nesting period of birds and the availability of invertebrates. For members of the family Canidae, the most diverse diet is in autumn, when they feed mainly on plants, rodents, and carrion. The least diverse diet for both families is in summer, when the diet almost lacks cold-blooded animals (amphibians, reptiles, and fish), as well as carrion (for Canidae). According to the literature, reptiles are rare in the diet of predators, perhaps because they are agile. Amphibians and fish also do not often are preyed by predators. They are hunted mainly by Eurasian otters, polecats, and raccoon dogs, which prefer wetland habitats. Since our data on these predators are insufficient, the lack of cold-blooded animal in the summer diet can be refuted in further studies.

In our opinion, the decrease in the diversity of the diet in summer is due to the availability of the main (preferred) food of predators, which may indicate their selectivity in nutrition. On the other hand, animals may consume only the food that is the most abundant in this period.

The competition between the studied families may increase in spring, when the most important food for members of both Canidae and Mustelidae are rodents of the suborder Myomorpha.

Conclusions

1. According to the quantitative parameters of food, the diets of both families in the territory of western Ukraine are similar: Canidae consume 49 objects of plant (25) and animal origin (24); Mustelidae feed on 42 objects of the plant (20) and animal origin (22).

2. Members of both families prefer animals and the frequency of occurrence of animal objects is 51% in Canidae and 57% in Mustelidae.

3. Representatives of the suborder Myomorpha are the main food object for both families (19% for Canidae and 21% for Mustelidae).

4. The trophic niches of Canidae and Mustelidae are similar and overlap, which creates trophic competition between members of these families.

5. The variety of food for both families is quite high and the same (4.1 for both Canidae and Mustelidae).

6. During the year, there was a change in the diet of both families. Members of the family Mustelidae have the greatest variety of foods in spring (Shannon index is 2.0), and the members of the family Canidae in autumn (1.9). The least diverse diet of both families is in summer.

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