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SEASONAL FEATURES OF THE DIET OF PREDATORY MAMMALS IN THE WESTERN REGIONS OF UKRAINE

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Key words

carnivorous mammals, trophic relationships, diet of predators, seasonal variability of nutrition, diversity of forage base, Ukraine

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Abstract

The article analyses feeding specifics depending on the season of five species of predatory mammals belonging to two families: Mustelidae and Canidae. It was established that the largest number of food objects in the red fox's diet is characteristic for the winter period (44 objects). In winter, this species enriches its diet with invertebrates, fish, domestic mammals, and ungulates in small quantities. The main objects of food during this period are rodents (19%) and birds (16.6%). Rodents are also the basis of the weasel's winter diet (50%). Both species of marten also consume rodents and birds in the winter, however, the pine marten hunts birds more often (17.4%) compared to rodents (13%), whereas the stone marten rarely hunts birds in the winter and the basis of its diet is made up by rodents (23.1%). The spring period is characterised by a sharp decrease in objects of plant origin in the diet of all carnivorous mammals considered. In spring, the stone marten consumes the largest share of animal feed (80%). The share of animals in the pine marten's diet also increases, but this species actively hunts invertebrates (37.1%). Birds were not detected in the diet of the pine marten in spring, but they are present in the diet of the weasel in this period (5.9%). Almost half of the summer diet of all species considered consists of plant objects. All predators are characterised by the consumption of a large number of invertebrates during this period, with the lowest share of them in the diet of the stone marten (5.6%), whose main food in the summer is plants (55.6%), rodents (22.2%) and birds (16.7%). In autumn, the share of plant components in the diet of predators is more than 50%, and this period is characterised by having the highest share of juicy fruits in the diet throughout the year, except for the weasel, in the diet of which plants are rarely found during this period (21.4%). The basis of the diet of this species during this period is mammals (64.3%). The share of rodents (15.5%) and birds (8.3%) in the red fox's diet increases in the autumn period. Inedible objects were recorded in food samples of two species: red fox and pine marten. For the marten, the largest number of these objects was registered in the summer period, and for the fox, non-food objects were absent only in the summer diet.

Cite as

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Сезонні особливості трофіки хижих ссавців в умовах західних областей України

Марія Марців, Ігор Дикий

Резюме. У статті проаналізовано особливості харчування в залежності від сезону п'яти видів хижих ссавців, які належать до двох родин: Mustelidae та Canidae. Встановлено, що найбільша кількість харчових об'єктів у раціоні лиса рудого характерна для зимового періоду — 44 об'єкти. Взимку цей вид збагачує раціон безхребетними, рибами, домашніми ссавцями та копитними у невеликих кількостях. Основними об'єктами харчування в цей період є гризуни (19 %) та птахи (16,6 %). Гризуни є основою і зимового раціону ласиці (50 %). Обидва види куниць у зимовий період також споживають гризунів та птахів, проте, куниця лісова в цей період частіше полює на птахів (17,4 %), а серед гризунів (13 %), кам'яна куниця навпаки, рідко полює взимку на птахів, а основою раціону є гризуни (23,1 %). Весняний період характеризується різким зниженням об'єктів рослинного походження у раціонах всіх хижих ссавців. Весною куниця кам'яна споживає найбільшу частку кормів тваринного походження — 80 %. Частка тварин зростає і в раціоні лісової куниці, проте цей вид активно полює на безхребетних (37,1 %). Птахів у весняний період в раціоні лісової куниці виявлено не було, проте в раціоні ласиці в цей період вони присутні — 5,9 %. Літній раціон для усіх видів складається майже на половину з рослинних об'єктів. Для всіх хижаків характерне споживання в цей період великої кількості безхребетних, найнижча їх частка у раціоні куниці кам'яної (5,6 %), основним кормом влітку якої є рослини (55,6 %), гризуни (22,2 %) та птахи (16,7 %). Восени частка рослинних компонентів у раціонах хижих становить більше половини, цей період характеризується найвищою часткою соковитих плодів протягом року, окрім ласиці, в раціоні якої рослини в цей період трапляються рідко — 21,4 %. Основу раціону даного виду в цей період становлять ссавці 64,3 %. У раціоні лиса рудого в осінній період зростає частка гризунів (15,5 %) та птахів (8,3 %). Неїстівні об'єкти зафіксовані у зразках харчування двох видів: лиса рудого та куниці лісової. Для куниці найбільша кількість цих об'єктів зареєстрована у літній період, а для лиса лише в літньому раціоні відсутні нехарчові об'єкти.

Ключові слова: хижі ссавці, трофічні зв'язки, раціон хижаків, сезонна мінливість харчування, різноманітність кормової бази, Україна.

Introduction

One of the main issues in the study of the biology of carnivorous mammals is the investigation of their nutrition and trophic relationships, which depend on their abundance and the stability of ecosystems [Soe *et al*. 2017]. Such studies are extremely important for the development of effective methods of conservation of many animal species [Balestrieri 2011].

A predator's diet reflects its ecological niche, adaptation to the environment, competition with other species, and impact on biodiversity. An animal's diet can be either diverse or specialised, depending on the species, sex, season, and other factors. Carnivorous mammals, such as the red fox, stone marten, and pine marten have a fairly wide range of food objects, which indicates their high ecological plasticity [Baltrunaite 2001; Davis *et al.* 2015]. The weasel and Eurasian otter are characterised by a smaller variety of diet [Abelentsev 1968; Likheev 2011].

Season is one of the determining factors affecting the composition of the diet of predators [Martsiv *et al.* 2021]. The availability and abundance of certain trophic objects will increase or decrease depending on the season. Carnivorous mammals adapt to environmental changes by switching to more available types of food [Kidawa & Kowalczyk 2011]. However, it can increase competition between some species in certain periods [Lanszki *et al.* 2007].

The study of seasonal features of the diet of carnivorous mammals is important for understanding patterns of coexistence of these animals. Therefore, the aim of this study was to investigate seasonal features in the diet of carnivorous mammals in the territory of the western regions of Ukraine.

Materials and Methods

The material for this study was collected during 2015–2021 in the territory of the western regions of Ukraine. Two methods were used, namely the analysis of collected excrements and the analysis of stomach contents. A total of 319 food samples were processed, including 115 samples from the red fox (*Vulpes vulpes*), 66 samples from the pine marten (*Martes martes*), 32 samples from the stone marten (*Martes foina*), 36 samples from the weasel (*Mustela nivalis*), and 70 samples from the Eurasian otter (*Lutra lutra*).

The collected excrements were soaked in water for a day. After that, the excrement samples were washed separately through a sieve with a minimum opening size of 0.54 mm. Sieves of three fractions (large, medium, and small) were used to collect samples, which were placed one above the other. The analysis of stomach contents was carried out similarly but without pre-soaking.

To identity the taxonomic affiliation of the samples, a morphological approach was used, which has its limitations, so not all food objects can be identified to species. The determination of the content of food samples was carried out using a Carl Zeiss Q1 microscope and PZO NSK binoculars. The determination of the remains was carried out according to morphological keys [in particular, Pucek 1984; Zagorodniuk 2002] and with the involvement of specialists (ornithologists, entomologists, and botanists). The share of a certain food object was determined from the total number of food objects in the diet of a certain species of predator in a specific period of the year.

Results

Data on the diet of five species of carnivorous mammals from two families were collected and analysed: *Vulpes vulpes* from the Canidae family and *Martes martes*, *Martes foina*, *Mustela nivalis*, and *Lutra lutra* from the Mustelidae family.

Red fox (Vulpes vulpes)

We analysed 115 samples of red fox food in different seasons: winter—45 samples, spring—12 samples, summer—30 samples, and autumn—28 samples. The number of food items is the largest in the winter period—44 food items, including polyethylene. In spring, 22 food items are registered. In the summer period, 32 edible objects were registered, and no inedible objects were found. In autumn, 33 components of the diet were registered, as well as 2 non-food components—polyethylene and foam plastic.

The proportion of plant and animal objects changes depending on the season. In particular, the share of plant components is the highest in the autumn period (55.7% of the total diet). Also, there is a high share of plant consumption in winter and summer is 49.9% and 49.2%, respectively. This indicates that plants are an important component of nutrition throughout the year. In all seasons among the plant components dry fruits dominate, including other plant remains, in particular the remains of cereals. We assume that this species consumes grasses for better digestion, to obtain additional trace elements, and also to combat numerous endoparasites [Lanszki *et al.* 1999].

Foxes diversify their diet with juicy fruits throughout the year, but the highest share of these objects is in autumn, when this kind of food is abundant and most often it is the fruits of pears, apples, and blueberries. In winter, foxes most often consume apples (4.3%). In summer, cherries and raspberries are found in the diet. Invertebrates are an important component of the fox's summer diet and make up 24.2%; most often they are insects (Fig. 1).

The highest share of food of animal origin is in the spring period (58.1%). Vertebrates make up a significant part of them (46.5%). In the spring period, the fox mainly hunts birds (14%) and rodents (11.6%), the common vole occurs in the diet of this species more often than other rodents and its share is 7%.

Birds make up a notable share of the diet in the winter period (16.6%). Bird hunting in the winter–spring period is closely related to the nesting period, during which both adult birds and nestlings are easy prey for the fox [Dell'Arte *et al.* 2007]. However, the main food of this predator in the winter period remains rodents, the share of which in this season is higher than in other periods of the

year (19%). These include various rodent species, among which the common vole occurs the most often (10.4%).

In the winter period the fox consumes a variety of foods. In particular, a small share of ungulates (3.1%) and domestic animals (3.1%), as well as fish (1.2%), appear in the diet. The presence of polyethylene (in 9% of samples) in the winter period indicates the feeding of these predators with food waste. In addition to the high share of plant objects in the autumn period, the fox also consumes a large number of rodents (15.5%), and the share of the common vole (*Microtus arvalis*) is the highest in this season (11.3%). Also, the highest share of domestic animal consumption is in autumn (6.2%). Ungulates are also present in the fox's autumn diet (2.1%).

Pine marten (Martes martes)

We analysed 66 food samples of the pine marten collected in all seasons (Fig. 2). In winter, 8 samples were collected and 15 food objects were registered. During this period, the pine marten consumes plants (52.2%) and animals (47.8%) in almost equal quantities. As in all seasons, plants are largely represented by dry fruits; in winter their share in the diet is also high (34.8%). Most often, these are various herbs. The pine marten also consumes juicy fruits in winter (13%), in particular apples and grapes.

The animals in the pine marten's winter diet are mainly represented by birds and rodents, 17.4% and 13%, respectively. The same eating behaviour is characteristic of the fox during this period, but we did not find remains of the common vole in the diet of the pine marten in winter.

In the spring period, 11 samples of pine marten food were collected, and 21 food components were registered as well as plastic (in one case). The spring period is characterised by an increase in animal components of the diet, the share of which is the highest in this season (54.3%). A large share of these objects are invertebrates (37.1%), namely insects. Vertebrates are rare in the spring diet (17.1%), and mainly include rodents (11.4%), occasionally reptiles (2.9%), and other mammals. The share of plants in the spring diet is lower than in other seasons and is 45.7%. These are mainly dry fruits and herbs (31.4%), and in some cases the consumption of juicy fruits was recorded.

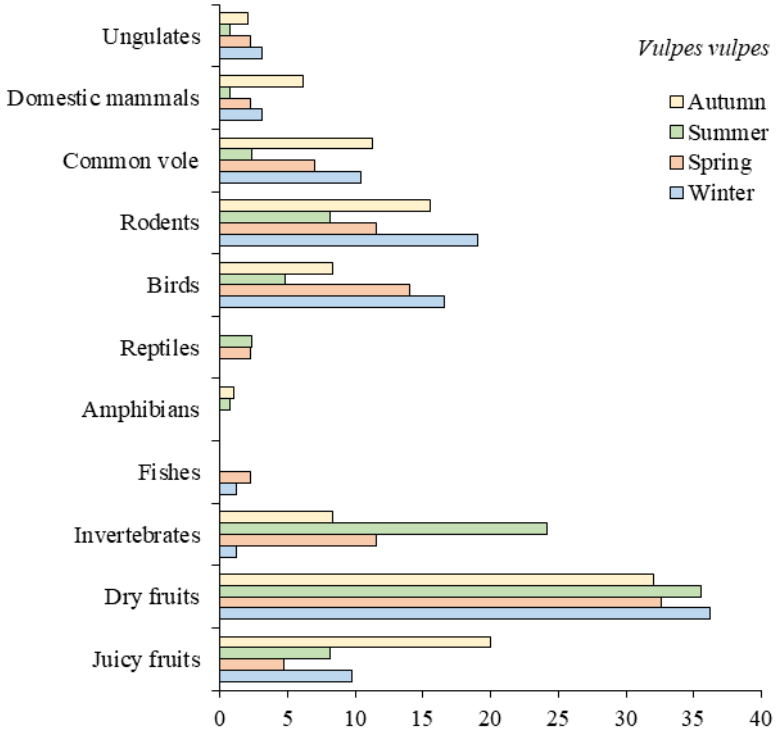

Fig. 1. Seasonal variation of the diet of the red fox in the western regions of Ukraine.

Рис. 1. Сезонна мінливість раціону лисиці звичайної на території західних областей України.

The pine marten's summer diet was best studied, as 37 food samples were collected during this period, and 32 food objects and 2 non-edible objects (polyethylene and foil) were registered. The share of animals in the diet of the pine marten in the summer period is 53.1%.

As in the spring period, this predator consumes a large number of invertebrates (34.6%). These are mainly insects (34%), in particular, representatives of the order Coleoptera (14.8%), as well as various larvae (7.4%). The share of vertebrates in the pine marten's summer diet is 18.5%. The main food during this period is birds and eggs (7.4%) as well as rodents (6.8%). The common vole is rare during this period (1.2%). Regarding objects of plant origin, the share of dry fruits and herbs is lower than in other seasons (25.3%). Juicy fruits in summer make up 14.8%, mainly blackberries (6.2%) and blueberries (4.3%).

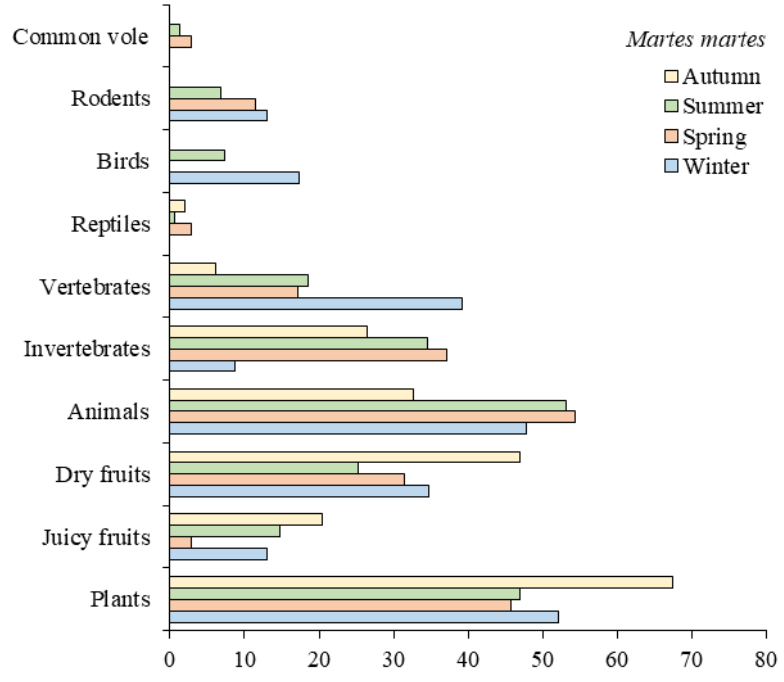

Fig. 2. Seasonal variation of the diet of the pine marten in the western regions of Ukraine.

Рис. 2. Сезонна мінливість раціону куниці лісової на території західних областей України.

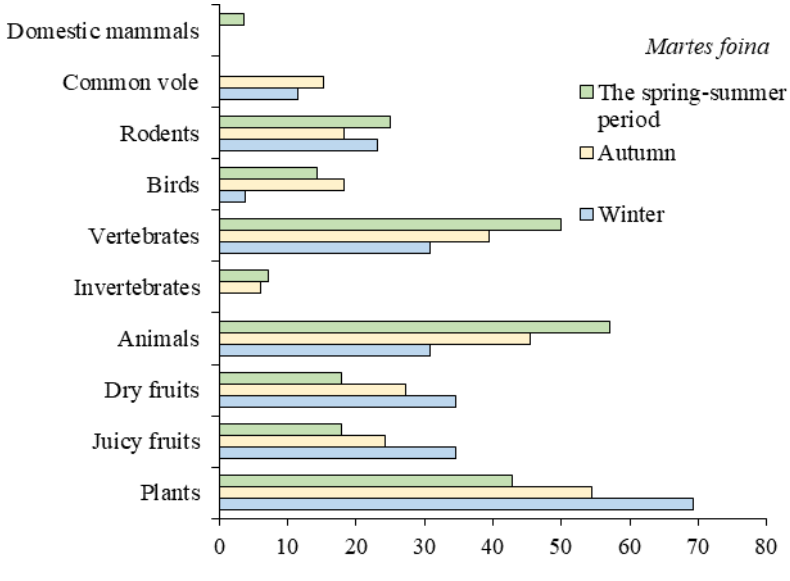

Fig. 3. Seasonal variation of the diet of the stone marten in the western regions of Ukraine.

Рис. 3. Сезонна мінливість раціону куниці кам'яної на території західних областей України.

In the summer period, polyethylene and foil were noted in 25% of food samples. However, all these samples were collected in the attic of the offices of the Cheremoskyi National Nature Park, where foresters spend the night. We assume that these objects entered the pine marten's diet with human food leftovers.

In autumn, we collected 10 food samples of this predator and noted 25 food objects. During this period, the pine marten consumes mainly plants that make up 67.3% of the diet. These are mainly dry fruits and herbs (46.9%) and various juicy fruits (20.4%) represented by apples, pears, plums, raspberries, blackberries, and blueberries. The share of invertebrates in the autumn diet is also higher than that of vertebrates and is 26.5%. These are representatives of the orders Coleoptera (6.1%), Hymenoptera (6.1%), Orthoptera (2%), as well as insect larvae. Vertebrates in the autumn diet were rare (6.1%). They are represented by mammals (4.1%) and reptiles (2%). Rodents, which we consider separately from other mammals, were not found during this period. However, the autumn diet, as well as the winter and spring diet, require additional research with a larger number of samples.

Stone marten (Martes foina)

We analysed 32 food samples of the stone marten collected in all seasons (Fig. 3). In particular, in winter and autumn, we collected 12 food samples each, and in summer and spring—4 samples each. Since there was a limited number of samples for analysis in the warm seasons, we combined the data for the spring-summer period.

According to our data, the winter diet of the stone marten includes 14 food items. During this period, this predator prefers food of plant origin (69.2%). Juicy (apples, pears, and blackthorns) and dry fruits (seeds, herbs, wheat, and sunflower) occur with the same frequency (34.6%).

Animals in the winter diet of the species is represented only by vertebrates (30.8%), mainly mammals, namely rodents (23.1%), and less often birds (3.8%). In addition to the common vole (11.5%), the house mouse (*Mus musculus*) (3.8%) was also found in the stone marten's diet.

The autumn diet of the stone marten includes 21 food items. During this period, the predator also consumes a large number of plant components (54.5%). These are more often dry fruits and herbs (27.3%), and less often juicy fruits (24.2%). Also, during this period, individuals of this species most often consume various seeds and fruits of apple, pear, and grape trees. Objects of animal origin also have a significant share in the autumn diet (45.5%). In this period, the stone marten consumes a small share of invertebrates (6.7%). Among vertebrates, the predator hunts mainly rodents and birds, the share of which in the diet is the same (18.2% each). In autumn, the diet of the stone marten includes common magpie (*Pica pica*), grey partridge (*Perdix perdix*), little owl (*Athene noctua*), common blackbird (*Turdus merula*), and brown rat (*Rattus norvegicus*), as well as common vole, which has the highest share among rodents (15.2%).

In the spring-summer period, 19 food objects of this predator were found. During this period, the stone marten consumes a larger number of animals (57.1%). The share of invertebrates in the diet increases (7.1%). Vertebrates are represented by mammals (32.1%), among which the predator most often hunts rodents (25%), birds (14.3%), and domestic mammals (3.6%). The share of juicy and dry fruits is the same in this period (17.9%). These are mainly fruits of cherries, plums, as well as herbs. No inedible objects were found in the diet of the stone marten.

Weasel (Mustela nivalis)

We analysed 36 weasel food samples. The winter diet of this species has not been sufficiently studied since we managed to collect only 5 samples, in which 3 food objects were found. It is the remains of grass plants, amphibians, and rodents.

In the spring period, 11 samples of weasel food were collected and 9 objects in the diet were noted. The main part of the diet during this period is composed of animals (70.6%), particularly vertebrates (58.8%). In spring, the main prey for this species are rodents (41.2%), followed by reptiles (5.9%), birds (5.9%), and other mammals (5.9%). Invertebrates in the spring period have a share of 11.8%, and they are represented by Coleoptera (Fig. 4). Plants are consumed by this species

in small quantities throughout the year. In the spring period, their share in the diet is 29.4%, mainly the remains of cereals and other plants, which could not be determined.

In the summer period, 10 samples of the weasel's diet were collected and the largest number of food objects was noted (14 items). During this period, the share of objects of plant origin increases (45.5%), and in addition to cereals the weasel consumes legumes, various seeds, and roots. Juicy fruits were not noted at this time.

In summer, the share of invertebrates in the diet of this predator also increases (18.2%). As in the spring period, these are mainly representatives of Coleoptera. The summer period is characterised by the lowest number of vertebrates in the weasel's diet (36.4%). In particular, these are fish (4.5%), reptiles (5.9%), birds (5.9%), rodents (13.6%), and other mammals (13.6%).

In the autumn period, we collected 10 samples of food, and 8 food objects were registered. During this period, the share of food of animal origin was the highest (78.6%). Most often, these are vertebrates (71.4%), mainly rodents (35.7%) and other mammals (28.6%). Birds, similarly to invertebrates, are rarely found in the autumn diet of weasels and their share is 7.1% each. As for plant components, they rarely occur in autumn (21.4%). This is the only season in which no herbs were recorded, but remains of juicy fruits, namely grapes, were found.

Despite the high degree of synanthropy of this species, neither inedible objects nor objects of anthropogenic origin were noted in any of the seasons. This indicates that this species is independent of humans, and given the large number of rodents in its diet, individuals of this species are useful for agriculture and humans on the whole.

Eurasian otter (Lutra lutra)

We analysed 70 food samples of the Eurasian otter. For this species, the main food in all seasons is vertebrates, namely fish. However, the consumption of one or another type of fish and the inclusion of other components in the diet varies depending on the season (Fig. 5).

In the winter period, we analysed 18 food samples and found the smallest number of food objects (11). In this period, the main prey of otters is fish (81.8%). Most often, these are representatives of the family Cyprinidae (38.6%), and less often Esocidae, Percidae (15.9%), and other fish (11.4%). In winter, the otter consumes amphibians infrequently (2.3%). Plants in the otter's diet are rare and their share is the smallest in the winter period (15.9%). These are mainly grasses and seeds.

In the spring period, 17 food samples of this predator were analysed, and 18 food objects were identified. In this period of the year, the share of plants in the otter's diet is the highest and reaches 25%. As in winter, plants are represented by herbs and seeds. Objects of animal origin make up 75% of the diet. In this period, the share of fish in this predator's diet is the lowest (45.5%), and the otter also hunts invertebrates (11.4%), amphibians (9.1%), reptiles (2.3%), and birds (6, 8 %). Among the fish in the spring period, representatives of Cyprinidae (15.9%) and Esocidae (9.1%) dominate.

In the summer, we collected and analysed 17 otter food samples, of which 16 food components were found. Summer is the only period when the otter hunts mammals (6.8%). Also, in this period, the predator also consumes invertebrates (6.9%), amphibians (3.4%), reptiles (3.4%), and birds (3.4%), but all these objects are additional sources of food. The main food remains fish, the share of which in the diet is 58.6%. As in other seasons, the largest share falls on representatives of carp fish (27.6%), less often in the summer otter hunts pike and perch (13.8% for each family).

In autumn, 18 food samples were collected and 13 food objects were identified. The autumn period is characterised by the consumption of mainly fish (75%). In this period, the share of carp compared to summer decreases to 20%, and the share of fish of other families is the highest compared to other seasons: Esocidae—20%, Percidae—17.5%, Odontobutidae—5%, and Cobitidae—5%. During this period, the otter consumes a small portion of invertebrates (5%) and plant remains (25%).

The main seasonal changes in the otter's diet are not related to the partial ratio of plant and animal components but to the proportion of cold-blooded fish (in particular, the species composition) and amphibians. The latter is an important alternative source of food both during cold periods and throughout the year [Korneev 1959; Weber 1990].

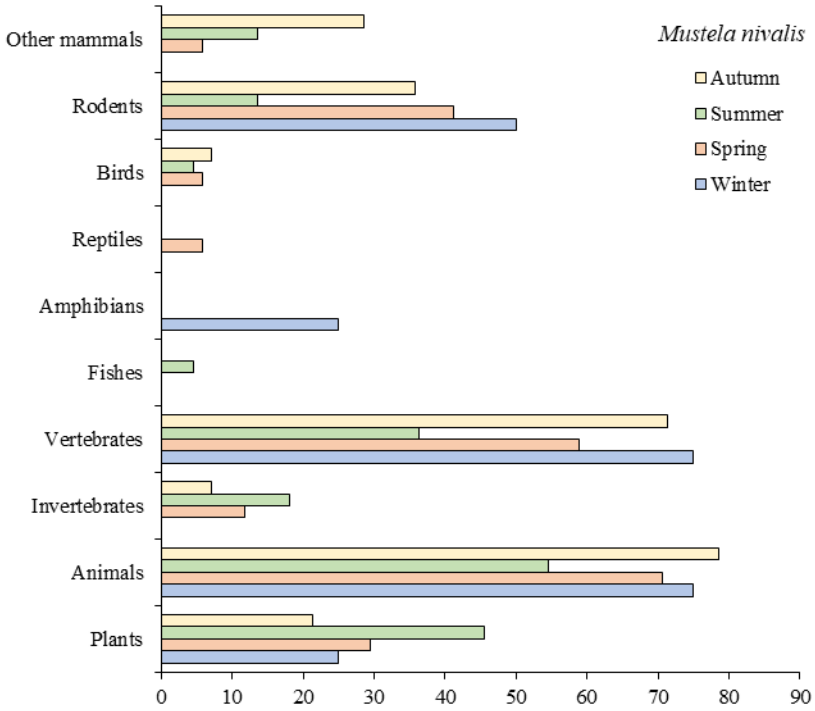

Fig. 4. Seasonal variation of the diet of the weasel in the western regions of Ukraine.

Рис. 4. Сезонна мінливість раціону ласки на території західних областей України.

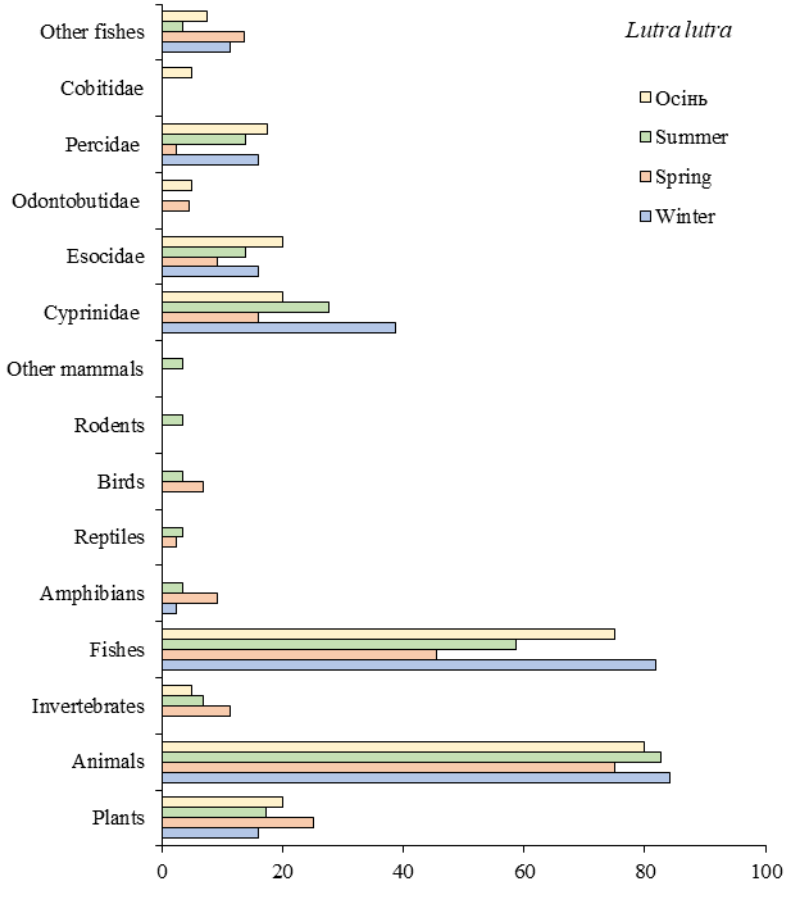

Fig. 5. Seasonal variation of the diet of the otter in the western regions of Ukraine.

Рис. 5. Сезонна мінливість раціону видри річкової на території західних областей України.

Discussion

Based on the obtained results, the regularity of changes in the composition of the diet of predatory mammals depending on the season is the following. Each species adapts to changes in the environment differently. However, they all change or supplement their diet with additional objects in one way or another. In addition, the seasonal variation of food is closely related to species.

In winter, the stone marten mainly feeds on plants (69.2%), and the weasel feeds on animals (75%). During this period, the fox and pine marten consume food of plant and animal origin with almost the same frequency. In winter, the fox enriches its diet with invertebrates, fish, domestic mammals, and ungulates in small quantities. Although, the main type of food during this period is rodents (19%) and birds (16.6%). Rodents are also the basis of the weasel's winter diet (50%), in addition to them, the predator consumes amphibians during this period.

Both species of marten also consume rodents and birds in the winter period. However, the pine marten hunts birds more often (17.4 %), and no common vole was found among rodents (13 %) in the winter period. The stone marten rarely hunts birds in winter, and the basis of its diet is rodents (23.1%), namely the common vole (11.5%). Since, during this period, the share of voles in the fox's diet is also quite high (10.4%), competitive relations between these species may intensify during the winter. As for the weasel, we found only 3 food objects. However, a small number of samples were analysed during the winter period, which gives us a superficial idea of the predator's diet during this period.

The spring period is characterised by a sharp decrease in objects of plant origin in the diet of all predators considered. This is most clearly manifested in the trophic behaviour of the stone marten. In spring, this predator consumes the largest share of animal food (80%). The share of animals in the pine marten's diet also increases, but this species actively hunts invertebrates during this period (37.1%). Birds were not detected in the diet of the pine marten in the spring period, but they are present in the diet of the weasel in this period (5.9%). In the diet of the stone marten, domestic mammals appear (10%), and the share of birds also increases (10%), while the share of birds in other predators decreases, and is completely absent in the pine marten.

Almost half of the summer diet of all studied species consists of plant objects. All these predators are characterised by the consumption of a large number of invertebrates during this period, with the lowest share of them in the diet of the stone marten (5.6%), whose main food in the summer is plants (55.6%), rodents (22.2%), and birds (16.7%). During this period, the share of the latter decreases in other species. Reptiles, as in the spring period, are an additional source of food for the fox and pine marten (in spring also for weasels).

In autumn, plant components make up more than half of the diet of these predators. This period is characterised by the highest share of juicy fruits throughout the year, except for the weasel, in the diet of which plants are rarely found during this period (21.4%). The basis of the diet of this species during this period is mammals (64.3%). In the autumn period, the share of rodents (15.5%) and birds (8.3%) in the fox's diet increases. Due to a large number of food objects, in particular of plant origin, such species as the fox, stone marten, and pine marten show greater tolerance to each other [Petrov *et al.* 2016].

Inedible objects were recorded in the food samples of the fox and pine marten. The largest number of them was registered in the summer period (in 8 samples, although all these samples were collected in one place) and absent in the winter period, for the marten. As for the fox, there are no non-food items in its diet only in the summer period, which can be explained by the large amount of available food.

Conclusions

1. The seasonal change of food objects is closely related to the species of the predator.

2. In the winter period, the stone marten mainly feeds on plants (69.2%), and the weasel feeds on animals (75%), mainly rodents. During this period, the fox enriches its diet with invertebrates, fish, domestic mammals, and ungulates. The two marten species also consume rodents and birds

during the winter period. However, the pine marten hunts birds more often during this period (17.4%). The stone marten rarely hunts birds in winter, and the basis of its diet is rodents (23.1%).

3. The spring period is characterised by a sharp decrease in objects of plant origin in the diet of all predators considered. This is the most apparent in the trophic behaviour of the stone marten.

4. Almost half of the summer diet of all species considered consists of plant objects and a large number of invertebrates, the lowest share of which is in the diet of the stone marten (5.6%). The main food of this species in summer is plants (55.6%), rodents (22.2%), and birds (16.7%).

5. In autumn, more than half of the diet of these predators consists of plant components. This period is characterised by the highest share of juicy fruits throughout the year, except for the weasel, in the diet of which plants are rarely found during this period (21.4%).

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