

The diet of the roe deer (*Capreolus capreolus*) in the forest ecosystems of Zhytomirskie Polesie of the Ukraine

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Abstract. The botanical composition of the European roe deer diet in the radioactively contaminated forest ecosystems of Zhytomirskie Polesie of the Ukraine was investigated. Deer were caught monthly over a two-year period on three plots in forest habitats typical for Zhytomirskie Polesie (fresh and moist mixed coniferous forests and mixed broadleaved forests). An analysis of the stomach contents of hunted deer showed that they consumed leafy as well as leafless stems, grasses, fruits and mushrooms depending on the season and availability of forest plants. Each season was characterized by one major dietary component. In the spring, the main component of the deer diet was the stems of woody plants. 44 species of vascular plants (3% of the natural flora of the region) were identified in the roe deer diet including 41 species of *Magnoliophyta*, of which 34 species of *Magnoliopsida* and 7 species of *Liliopsida*, 2 species of *Polypodiophyta* and one species of *Pinophyta*. Species such as aspen (*Populus tremula*), oak (*Quercus robur*), blackberry (*Rubus nessensis*) and bilberry (*Vaccinium myrtillus*) were consumed year-round.

Keywords: foraging ecology, stomach content analysis, diet components

1. Introduction

The European roe deer *Capreolus capreolus* (L.) is a characteristic representative of the even-toed ungulates (order Artiodactyla) occurring in Ukrainian Polesie forests as well as throughout Europe's forests. The species is both an important trophic chain link in forest ecosystems and valuable game animal. According to the most recent available data (Sokolov 1992), European roe deer population in Zhytomyr Polesie consists of 16 thousand females and males.

The European roe deer can be treated as bioindicator of pollution on forest areas, owing to its fairly low allocation capability as well as reliance on same feeding areas (Fruzin-ski et al. 1983; Timofeeva 1985; Sokolov 1992). Intake of pollutants of different kinds, including radionuclides, occurs through food consuming, hence studies on European roe deer diet in terms of its components and structure are practical in view of utilization of roe deer meat (Sokolov 1992).

European roe deer diet represents the diversity of structure and composition as well as shows seasonal differentiation. Roe deer food components include the shoots of trees, shrubs and subshrubs as well as herbs, ferns, lichens, fungi and forest fruits (Cederlud et al. 1980; Timofeeva 1985; Karlen et al. 1991; Sokolov 1992; Petrov 1996; Mihalusev 1997; Krasnov et al. 1998). Roe deer diet composition and structure have not been fully identified, and literature data show some discrepancies. The results of German studies show that the European roe deer consumes about 400 plant species (Mihalusev 1997), the analyses carried out in northern Switzerland pointed out 350 species (Karlen et al. 1991), whereas information on forests of Ukraine, Belarus and European part of Russia indicates about 250 plant species (Danilkin 1993). In subject literature, there can be found certain disparities concerning qualitative composition of roe deer diet. It was reported that in roe deer diet there

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prevail herbaceous plants (up to 75–80 %; Sokolov 1992; Petrov 1996) or else trees and shrubs (up to 60–80%; Timofeeva 1985; Mihalusev 1997). Studies on seasonal changes of roe deer diet are especially interesting. Mihalusev et al. (1997) and Krasnov et al. (1998) report that depending on the year season, in roe deer diet, there prevail different kinds of food, e.g. in the winter, the shoots of pine, aspen, willow and evergreen subshrubs are of major importance, in the spring – willow and aspen shoots with leaves, whereas in the summer roe deer diet is dominated by herbaceous plants and in the fall – by berries and fungi.

The aim of the present study was to determine the structure of European seasonal roe deer diet.

2. Methods

The assessment of species composition in diet of the European roe deer was carried out based on the analysis of its rumen contents. During 2 years of observation, on 3 observation plots with habitats characteristic for Ukrainian Polesie forests (fresh and wet mixed coniferous forest and mixed broadleaved forest), there were obtained 3 roe deer every month. Rumen contents were placed on 3 mm sieves and rinsed with water. Assessments were carried out on fresh material without alcohol treatment so as to avoid sample color changes. A microscope with 10x magnification was used for determination of the smallest undigested food fragments. The importance of each diet component was evaluated based on its mean share in rumen contents per a given season in 2 observation years.

The composition of roe deer diet was determined in line with the methodology by Timofeeva (1985). This author classifies the components occurring in the diet throughout the year as well as those occurring seasonally. Diet components were divided as follows:

- a) crucial, consumed in large amounts, with the share higher than 5%, both seasonally and annually;
- b) secondary, with 1%-5% share;
- c) rare, found in minute amounts or sporadically, with the share in annual diet less than 0.4% and 1% share in seasonal diet.

The results obtained were compared using chi-square test and Ward's method (1963). The latter allowed for clustering plant species annually eaten by the European roe deer.

3. Results

The results obtained confirmed that in Zhytomyr forest ecosystems situated in Ukrainian Polesie, roe deer consume the shoots both with and without leaves, as well as herbaceous plants, berries and fungi. In total, there were determi-

ned 44 species of vascular plants, which constituted 3% of natural flora of the region. In roe deer rumen contents, there were found 2 fern (Polypodiophyta) species, 1 gymnosperm species (Pinophyta) and 41 angiosperm species (Magnoliophyta), including 34 dicotyledons (Magnoliopsida) and 7 monocots (Liliopsida).

In forests of Zhytomyr Polesie in Ukraine, key components of European roe deer diet were angiosperms (Magnoliophyta), which constituted 93% of the total number of plant species determined, and included 18 dicotyledon families (Magnoliopsida) plus 3 monocot families (Liliopsida).

The following species from the willow family (Salicaceae) were determined in undigested food in roe deer rumen: aspen (*Populus tremula* L.), grey willow (*Salix cinerea* L.), rosemary-leaved willow (*Salix rosmarinifolia* L.) and goat willow (*Salix caprea* L.). Under the conditions of the present study, aspen appeared to be most readily consumed tree species (17.3% of mean annual consumption). In the spring, summer and fall, aspen consumption was 16.8%, 19.4% and 28.1%, respectively, whereas in the winter it was decreased to 5%. It is difficult to identify willow species based on undigested food remains, thus willow importance in roe deer diet was for the most part determined at a level of the genus. Willow (*Salix*) species constituted typical food in the winter and their share gradually decreased to minute amounts in the summer (Table 1).

White birch (*Betula pubescens* Ehrh.) and silver birch (*Betula verrucosa* L.) from the birch family (Betulaceae) are plants which determine key features of forest ecosystems in Zhytomyr Polesie. In roe deer rumen analyses carried out in the present study, the content of undigested parts of white and silver birch was assessed jointly. It was found that even though birch species occur commonly in the region, their shoots were consumed only in the fall and winter. Birch share in roe deer diet increases from 3.4% in the fall to 10.6% in the winter. (Table 1). The hazel family (Corylaceae) was represented by common hazel *Corylus avellana* L.) eaten only in the summer (2.6% of seasonal consumption).

Among most often consumed plant species, there was pedunculate oak (*Quercus robur* L.) from the beech family (Fagaceae). In the observed region of Ukraine, pedunculate oak is one of the most important tree species and it constitutes a significant component in roe deer diet all year through (11.1 % share in annual diet). The maximum consumption of oak shoots was observed in the spring (25.1% share in rumen), however, substantial consumption took place also in the fall – 12.9%. As presented in Table 1, during the winter as well as in the summer, oak consumption decreased to 4.6% and 2.0%, respectively. In roe deer diet, oak acorns play also an important role. In the fall, their share in seasonal diet was 21.1%. After snow melting in the spring, roe deer feed on last year acorns (up to 1.7% seasonal consumption).

Table 1. The structure of the composition of the diet of the roe deer in the forests of Zhytomirskie Polesie of Ukraine

| The composition of the diet | Share (%) | | | | |
|---|----------------|--------|--------|--------|--------|
| | average annual | spring | summer | autumn | winter |
| Shoots <i>Quercus robur</i> L. | 11.1 | 25.1 | 2.0 | 12.9 | 4.6 |
| Shoots <i>Populus tremula</i> L. | 17.3 | 16.8 | 19.4 | 28.1 | 5 |
| Shoots <i>Rubus nessensis</i> W. Hall. | 11.9 | 7.3 | 15.6 | 12.7 | 11.9 |
| <i>Vaccinium myrtillus</i> L. | 7.9 | 9.8 | 5.2 | 4.7 | 11.9 |
| Acorns <i>Quercus robur</i> L. | 5.7 | 1.7 | - | 21.1 | + |
| <i>Sorbus aucuparia</i> L. | 6.17 | 0.1 | 24.08 | 0.5 | - |
| <i>Vaccinium vitis-idaea</i> L.) | 4.7 | 7 | - | + | 11.9 |
| <i>Calluna vulgaris</i> (L.) Hull. | 3.9 | 5.5 | - | 2.3 | 7.9 |
| Shoots <i>Salix</i> | 3.8 | 2.8 | + | 1.6 | 10.6 |
| <i>Urtica dioica</i> L. | 4.1 | 0.01 | 16.2 | + | - |
| <i>Betula</i> | 3.5 | - | - | 3.4 | 10.6 |
| <i>Deschampsia caespitosa</i> (L.) P.B. | 2.7 | 8.3 | 2.6 | - | - |
| <i>Ajuga reptans</i> L. | 3.1 | - | - | - | 12.4 |
| <i>Vaccinium uliginosum</i> L. | 1.15 | 4.6 | - | - | - |
| <i>Tilia cordata</i> Mill. | 2.7 | - | 9.8 | 0.9 | + |
| Shoots <i>Pinus sylvestris</i> L. | 2.2 | + | - | + | 8.7 |
| <i>Rubus idaeus</i> L. | 1.3 | - | - | 5.2 | - |
| Other species together | 7.9 | 11.0 | 5.1 | 6.5 | 4.4 |

Scots pine (*Pinus sylvestris* L.), is the most common species in Zhytomyr Polesie forests (similarly to birch species it determines forest ecosystem features in the region). Considerable amounts of young shoots of pine undergrowth were consumed in the winter (8.7% share in seasonal diet), whereas in the spring and fall, pine shoots were rarely found in roe deer rumen contents. The annual share of pine in roe deer diet was 2.2%.

An important component of summer roe deer diet is lime (*Tilia cordata* L.) from the family Malvaceae Juss. The share of lime shoots in roe deer diet was 9.8% in the summer and negligible in the fall and winter (0.9% and 0.02%, respectively). The shoots of Norway maple (*Acer platanoides* L.) from the family Sapindaceae Juss. were found in rumens of roe deer obtained in the summer (1.9% share). In other seasons of the year, Norway maple was basically not consumed.

The rose family (Rosaceae), which comprises the biggest number of species in Ukrainian flora, was also represented most abundantly (7 species) in European roe deer diet. In rumen contents, there were found the shoots of blackberry (*Rubus nessensis* W. Hall.), raspberry (*Rubus idaeus* L.) and rowan (*Sorbus aucuparia* L.). Blackberry is one of the basic components of roe deer diet, consumed in considerable amounts all year through. On average, the share of blackberry shoots in annual roe deer diet was 11.9%. Blackberry

share was the largest in the summer (15.6%), and gradually decreased in the following seasons (Table 1). Raspberry was consumed only in the fall (5.2% of fall diet). Then in the spring, minor amounts of water avens (*Geum rivale* L.) and woodland strawberry (*Fragaria vesca* L.) were observed in examined rumen contents.

The mean annual consumption of rowan shoots was 6.2%, but in the summer it reached 24.1%. In the fall, in roe deer rumens, there were observed fruits of European crab apple (*Malus sylvestris* Mill.) and common pear (*Pyrus communis* L.)—2.9 and 1.4% of seasonal diet composition, respectively.

In European roe deer diet, the heather family (Ericaceae) was represented among others by bilberry (*Vaccinium myrtillus* L.), lingonberry (*V. vitis-idaea* L.), bog bilberry (*V. uliginosum* L.) and bog cranberry (*V. oxycoccus* L.). These species are dominant or sub-dominant in mixed coniferous and broadleaved forest of Ukrainian Zhytomyr Polesie. Bilberry is one of the basic components in roe deer diet all year through, and its consumption was comparatively similar during all seasons of the year, ranging from 4.7% in the fall to 11.9% in the winter (Table 1). Lingonberry shoots constituted typical winter-spring food, and their contents in roe deer rumens were the largest in the winter (11.9%). Bog bilberry belonged to the group of spring diet components (4.6% share

in seasonal diet), and was not consumed in the summer and very rarely in the fall and winter. Other representatives of the heather family in roe deer diet were: common heather (*Calluna vulgaris* (L.) Hill) and wild rosemary (*Ledum palustre* L.). Common heather dominates or subdominates in many post-fire forest areas, and wild rosemary occurs in bog pine forests as well as in oligo-mesotrophic swamps. The results of roe deer rumen analyses showed that the common heather was the basic diet component during the winter and spring (7.9% and 5.5%, respectively), whereas in the fall its consumption decreased to 2.3%, and in the summer it did not occur in roe deer diet. Wild rosemary was not observed in roe deer diet in the summer and fall and consumed in the winter and spring (1.7% and 2.0% of seasonal consumption, respectively).

Perennial plants from the figwort family (Scrophulariaceae) – germander speedwell (*Veronica chamaedrys* L.) and common speedwell (*V. officinalis* L.), were found in roe deer rumen contents in the spring and summer. Their share in the diet was not higher than 0.1%, therefore these species were classified as rare components of roe deer diet. Low amounts of perennial herbs such as wood anemone (*Anemone nemorosa* L.) (2.7% of seasonal consumption) and liverleaf (*Hepatica nobilis* Mill.) from the buttercup family (Ranunculaceae) were observed only in the spring.

Considerable amount of common nettle (*Urtica dioica* L.) from the nettle family (Urticaceae) was consumed during the summer (16.2% of seasonal consumption). Conversely, in the spring and summer, this plant species was rarely observed in roe deer rumen contents. In winter roe deer diet (only), there was observed bugleweed (*Ajuga reptans* L.) from the mint family (Labiatae) (12.4% of seasonal consumption).

Other plant species observed in roe deer rumen contents did not exceed 1% share, therefore were classified as rare or incidental components the diet analyzed. These were as follows: hazelwort (*Asarum europaeum* L.) from the birthwort

family (Aristolochiaceae), greater stitchwort (*Stellaria holostea* L.) from the carnation family (Caryophyllaceae), dyer's greenweed (*Genista tinctoria* L.) from the legume family (Fabaceae), marsh willowherb (*Epilobium palustre* L.) from the willowherb family (Onagraceae), guelder-rose (*Viburnum opulus* L.) from the moschatel family (Adoxaceae). The above species are either perennial herbs (hazelwort, greater stitchwort, marsh willowherb) or brush (guelder-rose) or else subshrub (dyer's greenweed).

Among 7 undigested monocot plant species found in roe deer rumen, only tufted hairgrass (*Deschampsia caespitosa* (L.) P.B.) from the family of true grasses was important roe deer diet component. This species was consumed in the spring to a big extent (8.3%), and in the summer its amounts in the diet were lower (2.6%). Other grass species were rarely found: purple moor-grass (*Molinia caerulea* (L.) Moench) and species from the bentgrass genus (*Agrostis* L.) (possible to determine only to the level of the genus). There were also observed minute amounts of: compact rush (*Juncus conglomeratus* L.), hairy wood-rush (*Luzula pilosa* (L.) Willd.) from the rush family (Juncaceae) and 2 sedge species, i.e. *Carex brizoides* Juslen ex L.) from the sedge family (*Carex ericetorum* Poll.). Generally, the share of monocots was no more than 1%.

The structure of roe deer diet composition changed depending on food availability (Fig.1). For example, during the winter, there considerably decreased the consumption of oak and aspen shoots, and there increased the consumption of pine, birch and willow shoots. Analogous changes were observed in the spring, when young oak and aspen shoots became more attractive as roe deer food when compared to those of willow or pine. In the fall, rowan, aspen and oak shoots along with oak acorns were most attractive food.

In European roe deer diet, there were also observed specific seasonal components. In the spring, in roe deer rumens there were found winter varieties of agricultural crops cultivated

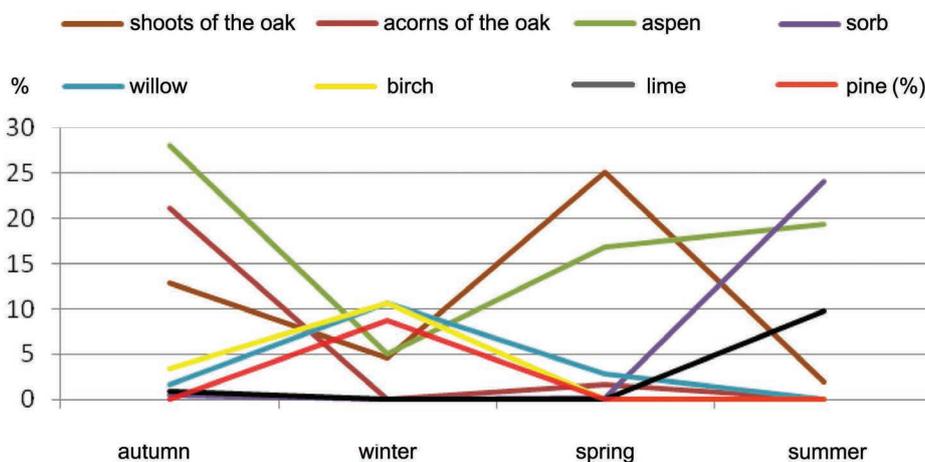


Figure 1. Changes in the share of individual species of tree plants in the diet of roe deer depending on the season

on the fields located next to the forests observed, and in the fall – fungal fruit bodies (1.4%). Fungi were also sporadically found in rumen samples obtained in the winter-spring period.

Roe deer also fed on ferns represented by 2 species from the wood ferns family (Dryopteridaceae): narrow buckler-fern (*Dryopteris carthusiana* (Vill.) H.P. Fuchs) and male fern (*D. filix-mas* (L.) Schott.). These species are herbaceous perennials developing on wet sites. Both of them were classified as rare diet components (0.1%–0.3% share in annual diet), which are consumed in the winter.

The analysis of the diet of the European roe deer inhabiting forest ecosystems situated in Ukrainian Zhytomyr Polesie indicates that only 15 plant species can be included to the group of basic diet components, the consumption of which is more than 5%. Under the conditions of this study, the share of these plant species in the mean annual diet was 89%. Among these only 4 species (oak, aspen, blackberry and bilberry) were consumed all year round, and their share

in the mean annual diet was 53%. Other plant species described can be classified as basic seasonal diet components.

The share of basic diet components (more than 5% consumed) in spring diet was 60.8%. These were: lingonberry, common heather and hairgrass. Basic component share in roe deer summer diet was comparatively low – 42.2%. Beside plant species mentioned above, in the summer, there were also consumed: rowan, nettle and lime shoots. The share of basic components (including raspberry) in fall roe deer diet was 79.5%. Winter diet was most diverse, and although the share of basic components was only 33.4 %, there were found seasonal components such as: lingonberry, common heather, willow and pine shoots as well as bugleweed.

Ogólnie, udział podstawowych pokarmów wynosił 84,4% w diecie wiosennej, 94,9% – w letniej, 93,5 % – w jesiennej i 95,6 % – w diecie zimowej.

In the 6-month periods of spring-summer and fall-winter, there were observed comparable shares of: aspen, blackber-

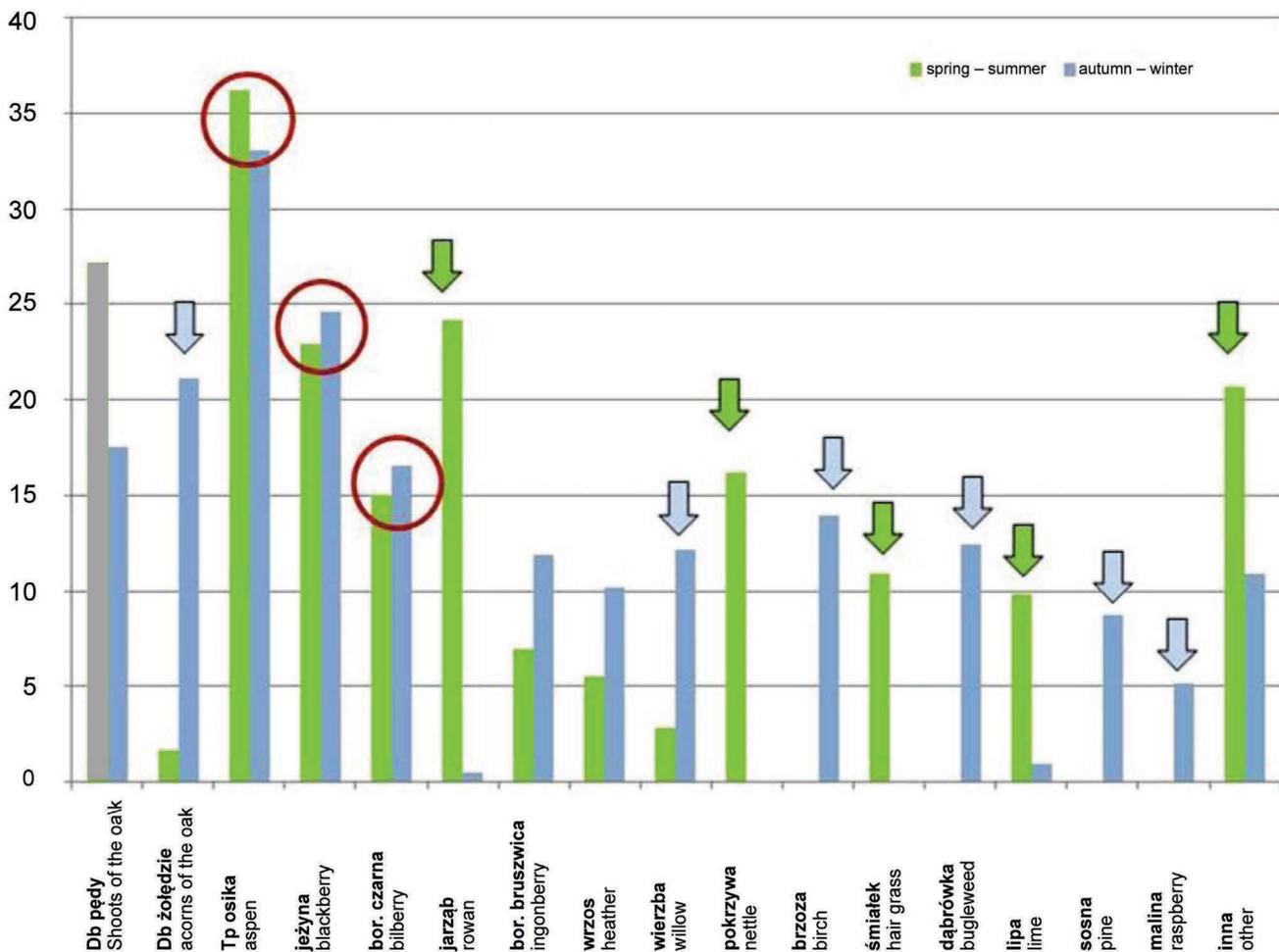


Figure 2. The variation in composition of roe deer during spring – summer season and autumn – winter season. Circles indicated a similar share

ry and bilberry. On the other hand, considerable differences between the two periods concerned: oak acorns, willow (for the most part consumed only in the fall and winter) as well as birch, bugleweed, pine and raspberry (consumed only in the fall and winter), also nettle and hairgrass (consumed only in spring and summer).

The analysis of roe deer diet in view of forest layers indicated that this animal species feeds on the shoots of trees from 10 genera, brushes from 4 genera, subshrubs from 6 genera and on 1 species of woody plant. At the same time, the European roe deer consumes phytomass of perennial plants from 17 genera as well as fungi and fruits of 3 tree species. The mean percentage annual shares of woody shoots and fruits/berries along with fungi and perennial plant phytomass were 78:8:20, respectively. In the group of consumed shoots, tree shoots constituted 37%, brush shoots - 19%, and underbrush shoots - 16%. The share of woody and herbaceous plants significantly changed seasonally during the year. In the spring, herbs constituted 15%, in the summer - 19%, in the winter - 13%, and in the fall - only 0.6%. Under the conditions of the present stud, neither forest fruits nor fungi were observed in roe deer diet in the summer and winter.

The results of chi-square test showed significant differences in the shares of plant species consumed by the roe deer: oak and (p = 0.0041) oak and blackberry (p = 0.0007). Due to seasonality of roe deer feeding habits, differences

between other plant species observed were not subject to the statistical analyses carried out.

Similarities between the shares of different plant species in roe deer diet are presented in Figure 3. At the distance 3, there can be distinguished three groups of roe deer food. In the first group, there are the shoots of oak, aspen and blackberry, in the second - oak acorns, bilberry and a number of plant species from forest groundcover, and in the third - other determined plant species with lower than 5% share in roe deer diet. The latter is diversified in terms of taste - from pine and willow shoots to nettle and raspberry.

The majority of plants consumed by the European roe deer inhabiting Zhytomyr Polesie forests are mesophyte species (90%). Mesohigrophyte species (3.8% of the mean annual consumption) were represented by *Ledum palustre* L., *Vaccinium uliginosum* L., *Vaccinium oxycoccus* L. and *Juncus conglomeratus* L.) (średnioroczego składu pokarmu). Most plant species (80%) grow on mesotrophic soils, and are characteristic for mixed coniferous and broadleaved forests. Summer roe deer diet comprised 78.5% plants of this kind and fall diet - 91.1%. In the spring and winter, the share of these species decreased to 67.1% and 52.1%, respectively. About 10% of plant species consumed were oligo-mesotrophic (pine, Marsh Labrador tea, bog bilberry, compact rush), which were consumed especially in the winter (annually: 20.9% and 40.4% of seasonal winter diet). The share of oligotrophic

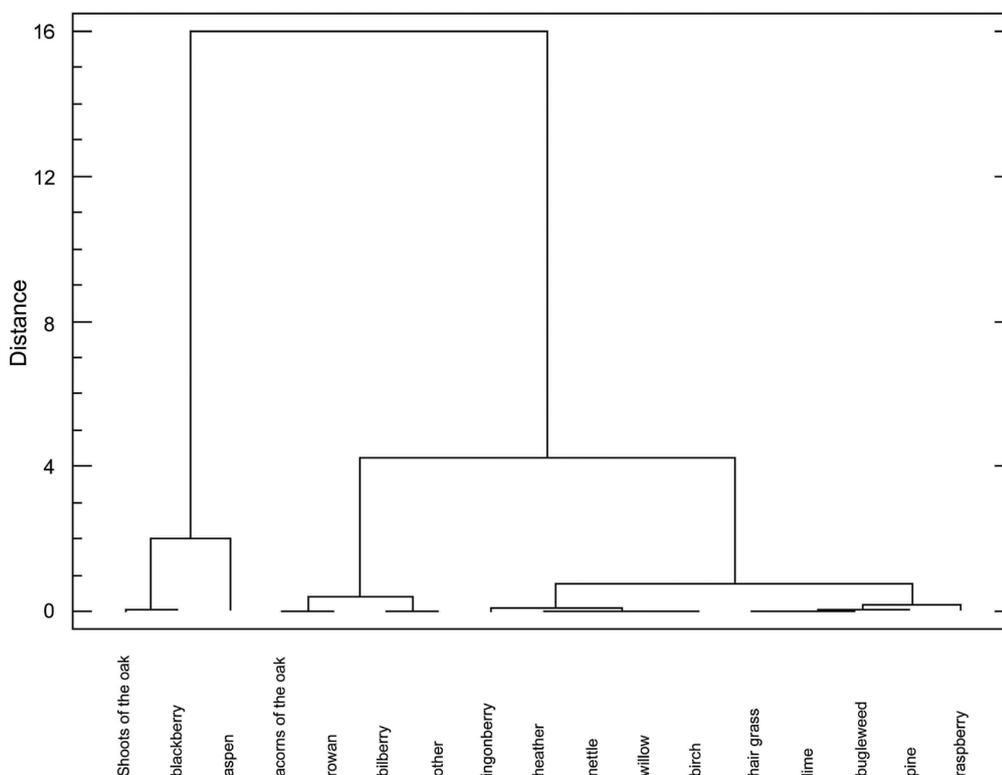


Figure 3. The dendrogram of frequency of particular plant species selection by roe deer during the year

species such as common heather, sedges and forest cranberry was 7.5% of all consumed plant species. Megatrophic species were represented by raspberry and nettle.

The results on botanical composition of the diet consumed by the European roe deer inhabiting Zhytomyr Polesie region (with a certain level of radioactive contamination) are comparable with those obtained by Petrov (1996) and Mihalusev et al. (1997) in neighboring (also contaminated) regions of Kiyev-Chernikov Polesie and Belarusian Polesie. This can be attributed to similar habitat and climatic conditions in these areas. In natural conditions of forests in other parts of Europe, roe deer diet is different, e.g. in eastern parts of the Urals and Central Chernozemic economic region in Russia, there is observed dominance of herbal plants (54%) in roe deer diet, in Austrian forests – prevail ferns, and in Sweden – fungi (Cederlud et al. 1980; Fruzinski et al. 1983; Tataruch et al. 1990; Sokolov 1992; Danilkin 1993).

4. Conclusions

1. European roe deer diet is composed of 44 vascular plant species. This animal species feeds on woody shoots, herbs, forest fruits as well ferns and fungi. All through the year, basic components of roe deer diet are: aspen (*Populus tremula*), pedunculate oak (*Quercus robur*), blackberry (*Rubus nessesensis*) and bilberry (*Vaccinium myrtillus*).

2. Seasonal diet differentiation occurs in the case of consumption of oak acorns and willow (eaten in the fall and winter), birch, bugleweed, pine and raspberry (consumed only in the fall-winter period) as well as nettle and hairgrass (consumed only in the spring-summer period).

3. The composition of winter roe deer diet is most diverse. Even though the share of basic diet components is relatively low (33.4 %), large amounts of seasonal diet components are consumed: lingonberry, common heather, bugleweed as well as the shoots of Scots pine, willow and birch.

Conflict of interests

No potential conflicts are declared

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Author's contribution

V.K. – conception, results and conclusions; Z.S. – literature review, field works; S.B., W.S. – result analyses, conclusions and discussion; I.G. – field works.