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Invertebrates in the diet of collared flycatcher (*Ficedula albicollis*) nestlings in transformed forest ecosystems of north-eastern Ukraine

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Abstract

The diet composition of collared flycatcher nestlings, *Ficedula albicollis* (Temminck 1815), in the transformed forests of northeastern Ukraine was investigated to present an argument for conservation management actions that could benefit the species. Food pellets were collected from nestlings in four study sites with differing levels of recreational disturbance over 10 breeding seasons. The invertebrates they contained were identified, divided into trophic groups and compared across sites. A total of 1,160 food pellets were collected, containing 3,253 invertebrates from 294 species. Insects comprised 83% of the prey, with the most abundant orders of Diptera, Coleoptera and Lepidoptera. The smallest diversity of prey species was found in samples from the most disturbed site. The qualitative composition of the prey items showed that zoophages were the most frequent trophic group encountered, followed by phytophages, saprophages, polyphages, and necrophages. However, the order of trophic group frequency varied between sites. Although collared flycatchers forage within a limited area, their diet is characterized by a wide diversity of prey, and they exploit all forest layers.

Keywords: collared flycatcher, diet, trophic links, zoophages, phytophages, saprophages, necrophages, polyphages

Introduction

Trophic links of species are crucial in terms of correction and preservation of ornithofauna in natural and transformed areas alike (Korňan and Adamík 2017). The maintenance of biodiversity requires an understanding of the role of trophic interactions and the potential consequences if links are lost (Teichman et al. 2013). The gaps in knowledge of trophic levels in ecosystems hamper the undestanding and modelling of ecosystem dynamics (Tylianakis et al. 2008). Food chains form a network of trophic interactions important to ecosystem functions and processes. Thus, a direct link between a predator and its prey is mediated by numerous ecological and evolutionary determinants (Kuwae et al. 2012). Moreover, the availability or absence of trophic links depends on different determinants such as morphological and behavioural traits of the species, their phylogenetic limitations and environment (Carnicer et al. 2009). Trophic interactions of the species may be influenced by their functional characteristics at wide spatial scales (Brooks et al. 2012).

The effect of the diet of insectivorous birds on the abundance of arthropods in their habitat has been relatively little studied, though a relationship was found in the Scottish Southern Uplands by Dennis et al. (2008). The significancy of birds for biological control of arthropods of different taxa is also poorly studied (Gámez-Virués et al. 2007). Apart from predation, the structure of invertebrate communities may also be influenced by abiotic factors such as soil moisture (Brygadyrenko 2014). Shifts in the population status of species or species groups can lead to "trophic cascades", when shifts in the size of one population cause shifts in the populations occupying lower levels of the food chain (Polis 1999). Under certain conditions, descent trophic cascades are also known to be formed (Bridgeland et al. 2010).

The availability of feeding stations in a habitat is of primary importance for supporting a state of bird population. Many European countries set up special feeders to provide extra food for birds in the reproduction period (Amrhein 2013). However, these measures are not suitable for all birds species, particularly not for collared flycatchers since these birds have a very specific foraging strategy (catching insects directly in the air) (Davies 1976).

Beak morphology of the collared flycatcher (the speed and power of jaw closure) determines its specialisation in a certain foraging strategy (Corbin et al. 2015). Therefore, due to adaptive behaviour, the collared flycatcher avoids the competition for breeding areas and diet resources (Krist 2004). It all goes to show a wide ecological lability and universatility of these birds. The birds simply do not depend on a particular species of insects (Litt et al. 2014, Schirmel et al. 2016, Hejda et al. 2017). Some studies have identified the role of feed for sympatric species (Drahulian et al. 2018) and specific features of overlapping trophic niches of different birds (Lagar 2016).

The aim of this study was to investigate the diet of the collared flycatcher in forest ecosystems of north-eastern Ukraine and to relate its diet composition to habitat quality and particularly disturbance levels.

This research summarises studies on collared flycatchers, performed for 10 years in transformed forest ecosystems of north-eastern Ukraine (Lezhenina et al. 2009, Chaplygina et al. 2015).

Material and methods

Study area

The research was carried out in the forest-steppe zone of Left-bank Ukraine (the Kharkiv and Sumy regions). Four study sites with different stages of recreational disturbance were selected, which, according to the classification developed by Gensiruk (2002), have a score from 1 (low stage of recreational disturbance) to 5 (high stage of recreational disturbance).

The diet composition of collared flycatcher nestlings was studied in upland oak woodlands of NNP "Homilshanski Forests", the forest park of Kharkiv, pine-oak forests of NNP "Hetmanskyi", and in the site of Vakalivshchyna.

Model site 1 (MS1) is situated far from settlements, on the eastern bedrock bank of the Psel river in the site Vakalivshchyna (51°01'42'' N 34°55'30'' E) at an altitude of 157 m a.s.l. and is represented by an oak forest mixed with maple and lime trees. The crown closure covers ca. 85% (Table 1), and the share of damaged trees does not exceed 10% of their total abundance. The understory and shrub layers are typical for the habitat, without traits of noticeable damage. The grassy cover is mainly undisturbed and typical for the forest type. In some areas, excessive development of forest herbs is observed, due to the fallout of overmature trees. The forest floor is undisturbed and thick. The recreational coefficient of the site was determined by the area of forest paths comprising 5%. Model site 1 is characterized by the 1st stage of recreational disturbance.

Model site 2 (MS2) is located within a recreational zone of the Nature Park "Homilshanski Forests" (49°38′12'' N 36°18′28'' E) at an altitude of 170–190 m a.s.l. in the vicinities of study plots of "H.S. Skovoroda" Kharkiv National Pedagogical University and "V.N. Karazin" Kharkiv National University. These areas suffer from intensive recreation pressure during the bird breeding season. The wood includes damaged and diseased trees (about 35%); the crown closure is about 70%. The understory and shrub layers are available but poorly differentiated. The grassy layer is partly disturbed; projective cover reaches 85% in some areas. The forest floor is relatively little disturbed. Forest paths occupy up to 30% of the site. The model site is characterized by the 3rd stage of recreation disturbance and requires management of recreational pressure.

Table 1. Indices of diet diversity of the collared flycatcher across the four study sites

Indices	MS1	MS2	MS3	MS4
Number of species	89	215	58	87
Total number of specimens	667	1694	408	484
Margalef's index	6.76	28.78	9.48	13.91
Shannon index	2.65	3.93	3.11	3.47
Simpson dominance index	0.93	0.87	0.86	0.82
Simpson diversity index	1.08	1.14	1.16	1.22
Berger-Parker dominance index	0.23	0.12	0.12	0.17
McIntosh dominance index	0.69	0.80	0.77	0.77
McIntosh evenness	0.77	0.84	0.84	0.83
Pielou evenness	0.41	0.51	0.53	0.54

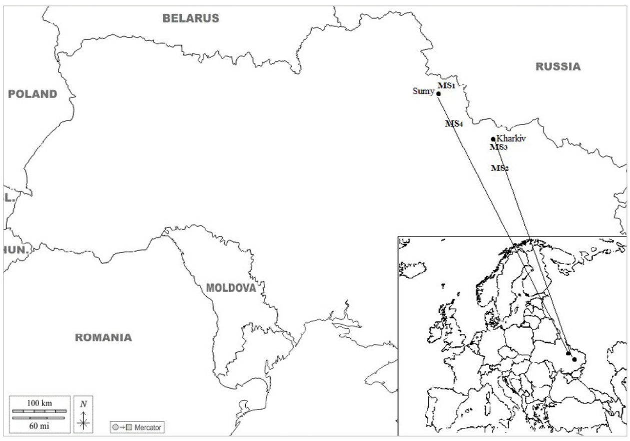

Figure 1. The sites, where the invertebtates from the diet of collared flycatcher nestlings (*Ficedula albicollis*) were collected in transformed forest ecosystems in north-eastern Ukraine: MS1 – Vakalivshchyna, MS2 – NNP Homilshanski Forests, MS3 – the forest park of Kharkiv city, MS4 – NNP Hetmanskyi

Model site 3 (MS3) lies in the forest park of Kharkiv city (50°00'21' N 36°13'45" E) at an altitude of 94–202 m a.s.l. It is a predominantly natural upland oak woodland with a small part of planted species, located in the watershed of the rivers Lopan and Kharkiv. Its crown closure is circa 60%. Species of the forest edge, meadow, riparian-aquatic and ruderal plants are also recorded. There is an extended network of forest paths and roads, which people use for jogging. Increasing recreation pressure leads to the expansion of open glades and increasing density of paths. The maple *Acer negundo* forms dense thickets at the forest edge; in some places, garbage dumps are scattered. The closer to the forest border the more ruderal species can be found. The site has the 4th level of recreational disturbance.

Model site 4 (MS4) is situated in NNP Hetmanskyi (50°23'10" N 34°55'34" E), in a pine forest near Kamianka and Klymetovo villages, in the area called "Lytovskyi Bir" at an altitude of up to 215 m a.s.l. Oak-pine and maple-lime-oak woodlands near Kamianka are little disturbed by people, with diseased trees; the crown closure is ca. 20%. The understory and shrub layer are typical for the habitat; 5–20% of trees have insignificant damages. The grassy layer includes meadow grasses (5–10%), not typical for this type of forest. The forest floor is relatively little disturbed. The area of paths is not large, up to 10% of the model site. In the section, lying in Lytovskyi Bir, the area of paths exceeds 20%. Although in July-August the recreational pressure is increasing due to a high number of visitors, most birds have already finished their breeding season by the time. The site has the 3rd level of recreational disturbance.

Methods

Artificial nestboxes were set across the study areas and inspected annually. A total of 67 collared flycatcher nests with 452 nestlings were sampled resulting in 1,160 food pellets collected over the ten years (Supplementary Table 1).

To obtain the food pellets, neck ligatures were applied to 5–8-day old chicks during the first half of the day, with dates spanning 25 May to 15 June (Malchevskiy and Kadochnikov 1953). Neck bandages were applied to all chicks in the nest for up to 1 hour. The food was removed immediately after having fed the chicks, in case of close observation of the nest, or after 15–30 minutes if the process was not controlled. The samples were fixed in a 70% solution of ethanol, and the arthropods were subsequently identified in the laboratory. All invertebrates were identified to species, genus, or family (in case of significant damage) by standard methods using microscopes, reference books and material as required.

3,253 specimens of invertebrates were studied: 1,694 (from 27 nestlings) in the oak forest MS2, 484 (from 18 nestlings) in the pine-oak forest MS4, 667 (from 22 nestlings) in the oak forest MS1, and 408 (from 20 nestlings) in the oak forest MS3.

Statistical analysis

Statistical analysis of the data obtained was performed with the aid of Statistica 8.0 software package (StatSoft 2007).

Similarity coefficients in the species composition of invertebrates found in the diet at different sites were calculated using the similarity indices (Sörensen Index). The formula to find the Jaccard Index:

$$C_j = \frac{100 - j}{a + b - j}$$

The formula to find the Sörensen Index:

$$C_s = \frac{100 - 2j}{a + b} ,$$

where:
j is the number of invertebrate species found in both groups,
a is the number of species in the first group,
b is the number of species in the second group.

These coefficients had values from 0 (no similarity between compared parameters) to 1 (complete similarity). The similarity of bird communities and their consorts was studied using cluster analysis in OriginPro 9.0 graphing and data analysis app (OriginLab 2015).

Pielou's evenness (Pielou 1975) was calculated using the formula:

$$E = \frac{H}{\log S} ,$$

where
H' is the Shannon index;
S is the number of species.

Margalef's species richness index (Margalef, 1969) was calculated by the formula:

$$DMg = \frac{S - 1}{\log N}$$

The formula to find the McIntosh dominance index (MacArthur 1955) is the following:

$$DMc = \frac{S - \sqrt{\sum N_i^2}}{S - \sqrt{S}} ,$$

where:
S is the number of the species registered in the site,
N is the total number of all the species registered in the site,
N_i is the number of pairs of each species.

The Shannon diversity index, or the Shannon-Wiener Index (Shannon and Weaver 1964) was found by the formula:

$$H' = \sum p_i \log 2 p_i ,$$

where
p_i is the assessment of the value of each species (abundance).

The Simpson dominance index (Simpson 1949) was calculated as per the formula below:

$$U_s = \frac{1}{\sum \frac{P_i(N_i - 1)}{N - 1}} ,$$

where:
N_i is the number of individuals that belong to i-species,
N is the total number of individuals in the studied sample.

The Simpson diversity index (Simpson 1949) was found using the formula:

$$D_p = \Sigma_{p_i} 2 \ ,$$

where p_i is a relative abundance of each species.

The Berger-Parker dominance index (Margalef 1969) was found using the formula:

$$DBP = \frac{n_{\max}}{N} \ ,$$

where:
N is the number of species in the plot,
$n_{\max}$ is the number of individuals of the most widespread species.

To determine the distance of searching for food for chicks, hourly visual observations through binoculars were made at each site for every pair of birds.

Results

Trophic links, revealed in the diet of the collared flycatcher, included invertebrates that belong to 294 taxa ($n = 3253$) of two phyla: Arthropoda (99.4%) and Mollusca (0.6%) (Supplementary Table 1s). The basis of these trophic links consists of representatives of the phylum Arthropoda (248 species): classes Insecta – 83.3%, Arachnida – 13.7%, Malacostraca – 2.0% and Diplopoda – 1.0%. The most numerous insects are distributed across 100 families and 15 orders, the dominant orders among them are Diptera – 23.0%; Coleoptera – 23.0%; Lepidoptera – 13.0% and Hymenoptera – 12.0%. The highest number of invertebrates was recorded in MS2 (87.3%, $n = 1694$) and MS3 (81.3%; $n = 408$), with a somewhat smaller number in MS1 (73.6%; $n = 667$) and MS4 (70.4%; $n = 484$). Thus, MS1 shows a typical distribution, where 9 of 15 recorded insect orders were found, with the quantitative dominance as follows: Lepidoptera (52.8%; $n = 352$), Hymenoptera (20.5%, $n = 137$) and Coleoptera (11.7%, $n = 78$). This site is also characterized by low biodiversity indices: Margalef's i. is 6.8; the Shannon i. is 2.7 (Table 1).

In oak woodlands (MS1–MS3), the flycatchers use a vertical examination strategy of the trees, thoroughly scanning trunks, and undergrowth in a radius up to 50 m from the nest. In an overmature oak woodland (MS1), the subpopulation of flycatchers is the oldest, formed by a dense location of breeding flycatcher colonies. As a result, the birds have adapted to feed chicks with the most mass diet items – caterpillars of Lepidoptera (Tortricidae, Noctuidae, Geometridae).

Among 10 orders of insects, recorded in MS4, the representatives of Coleoptera (32.0%; $n = 484$), Hymenoptera (26.8%) and Lepidoptera (11.8%) dominated. Diversity indices at MS4 are the second highest (Margalef – 13.9; Shannon – 3.5), with higher values registered only in MS2.

In MS4, the birds inspect a considerable area of the pine forest and collect prey within a radius of 120–150 m from the nest, thus spending much more energy. In a pure pine forest of NNP Hetmanskyi the collared flycatchers flew to collect prey to the site with well-developed deciduous undergrowth, covering a distance up to 350 ± 25.7 m ($n = 30$).

The highest diversity of trophic links in the diet of the collared flycatcher nestlings was found in MS2, where high values of all biodiversity indices were apparent: Margalef – 28.8; Shannon – 3.9 (Table 1). In this site, Hymenoptera (20.5%; $n = 347$), Lepidoptera (22.5%, $n = 381$) and Coleoptera (20.5%, $n = 347$) dominated (Figure 2).

MS3 showed lesser diversity of insects in the diet – 8 orders, with the dominance of larvae of Lepidoptera (31.2%; $n = 127$), larvae of Diptera (24.6%, $n = 100$) and Hymenoptera (18.6%, $n = 76$). A smaller taxonomic difference in this site is confirmed by the McIntosh index for it: 108.7. However, the values of other indices are variable. Thus, Margalef's index of 9.5 is almost 1.5 times higher than in MS1 (Table 1).

The analysis of similarity of species diversity within the prey items showed the highest similarity between the oak woodlands MS1 and MS2 (56 taxa, the Sörensen similarity index is 0.6) (Table 2).

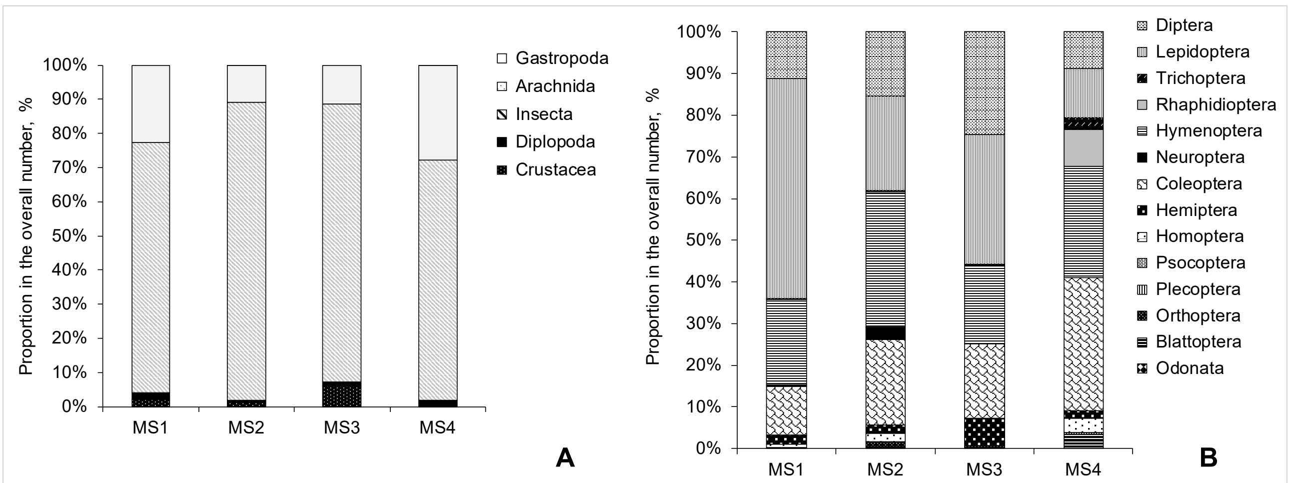

Figure 2. Diversity of trophic links in the collared flycatcher: A – main groups of invertebrates; B – main orders of insects

The highest number of similar taxa consumed by birds in these sites belonged to the order Lepidoptera (Tortricidae, Noctuidae, Geometridae) and different spider species (*Aranea* sp.). The taxonomic diversity increases as follows: MS3 (58 species) → MS4 (87) → MS1 (89) → MS2 (215) (Figure 3A). The qualitative data support the diversity indices, i.e., the similarity of trophic links increases in the line of forest biogeocoenoses: MS3 → MS4 → MS1 → MS2. Thus, trophic links of the collared flycatcher in the oak woodland of the 4th stage of recreational disturbance were the most diverse, whereas in the natural protected areas they were the most similar (Figure 3).

Table 2. Invertebrate similarity in the collared flycatcher diet across the four study sites

Pair of model sites	Number of invertebrate species	Similarity indices	
		Jaccard I.	Sörensen I.
MS2–MS1	56	0.3	0.6
MS2–MS4	48	0.2	0.3
MS2–MS3	44	0.2	0.3
MS1–MS4	44	0.3	0.5
MS1–MS3	31	0.3	0.4
MS4–MS3	24	0.2	0.3

According to the invertebrate qualitative structure, the trophic links of the collared flycatcher nestlings showed almost equal proportion of zoophagous and phytophagous species in all the sites, which matches the finding of Stanchynskyi (1931) regarding proportions in biogeocoenoses. Thus, zoophages dominated from 34.4% ($n = 89$) in MS1 and 35.8% ($n = 87$) in MS4 to 36.7% ($n = 215$) in MS2. In MS3, the nestling diet was dominated by phytophages (32.1%; $n = 58$), whereas zoophages ranked second (30.9%). The third place was occupied by saprophages: from 14.5 (MS2) to 16.0, 16.8 and 17.8% (MS1, MS3 and MS4) (Figure 4A).

In all the sites, zoophages dominate according to qualitative proportion in trophic links of the collared flycatcher: from 37.5% ($n = 408$) in MS3 to 49.0 ($n = 667$), 50.2 ($n = 1694$), 53.6% ($n = 484$) in MS1, MS2 and MS4, respectively. The proportion of phytophages was smaller,

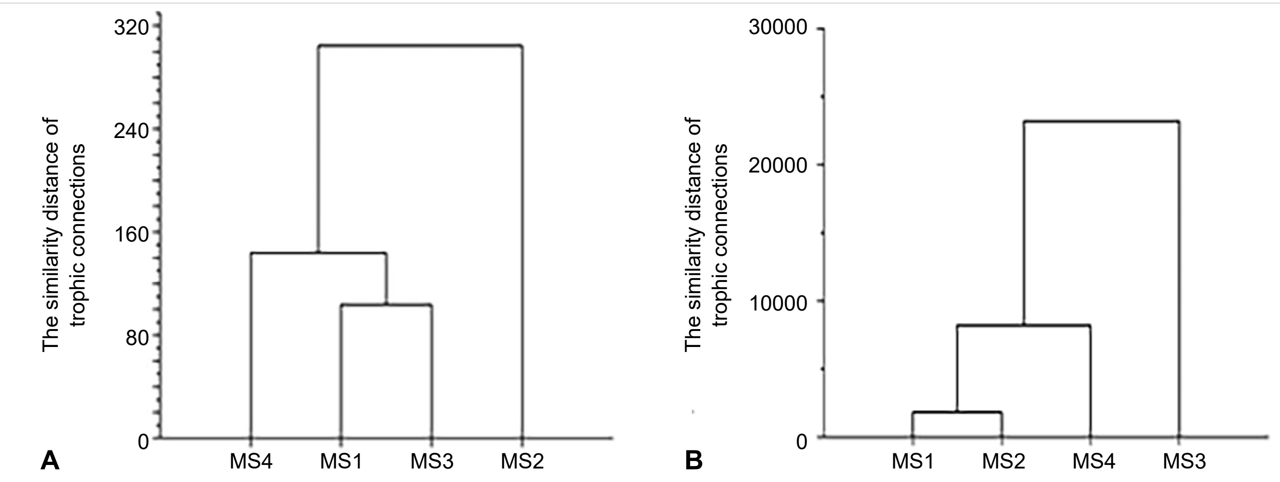

Figure 3. Similarity of trophic links of the collared flycatcher in the studied sites (A – by the qualitative structure of diet; B – by diversity indices)

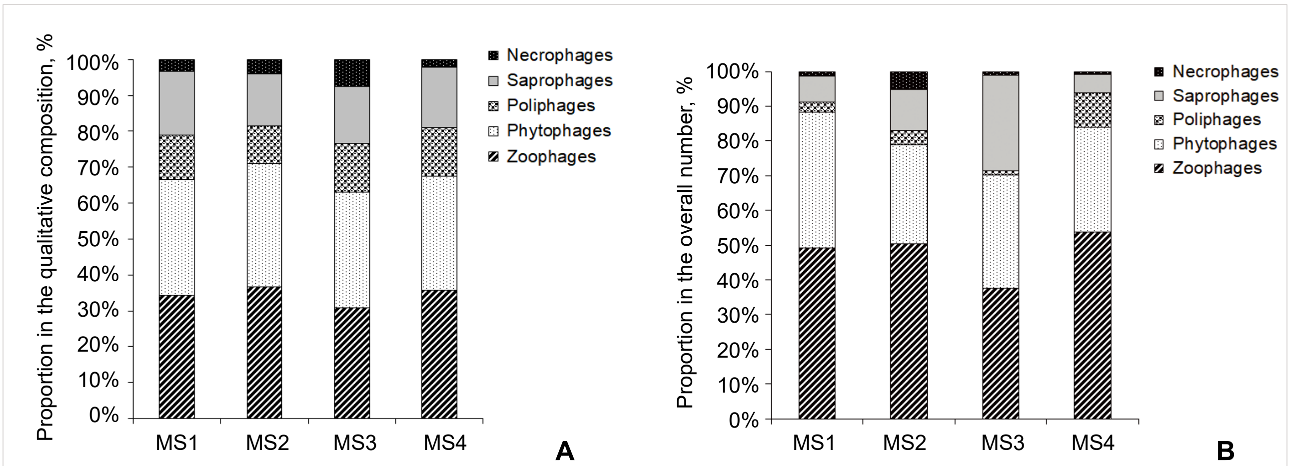

Figure 4. Distrubution of trophic groups in the diet of collared flycatcher nestlings across the four study sites: A – proportion in the qualitative composition, B – proportion in the overall number

but they ranked second in all the sites. The third place was occupied by saprophages: from 7.5% (MS1) and 11.8% (MS2) to 27.4% (MS3). In MS4, the third place is occupied by polyphages (9.9%), in MS2 they were the rarest. Necrophages prevailed in MS2 – 5.3% (Figure 4B).

Discussion

Qualitative and quantitative composition of the diet may affect breeding success in different species (Inozemtsev and Frenkina 1985). Insufficient feeding of nestlings often occurs in pine forests with less suitable prey and can lead to nestling starvation. The nests of collared flycatchers, left by fledgelings, often contained food remains of Elytra and even whole representatives of Diptera from the family Tabanidae, the order Coleoptera, superclass Myriapoda, etc. The weight of such food remains varied between 3–7 g per nest. Their number per nest ranged from 6 to 22 items, weight from 0.3 to 0.5 g each. Their formation has a biological value: firstly, the digestive tract of chicks is not clogged with not really usable and low-calorie diet, secondly, remains or "leftovers of bird meal" are a primary source of an autonomous trophic link. In fact, there forms a tiny model of the functioning heterotrophic consortium of flycatchers in forests biogeocoenoses that has been operated since the birds occupied their nests and until the end of the vegetation season (Chaplygina et al. 2015).

Comparative analysis of the collared flycatcher diet by trophic groups indicates that a dominant role is played by zoophages (106 species, 37.2%) and phytophages (96 species, 33.7%). 56 species are divided between phytosaprophages (16.1%) and necrophages (3.4%). 27 species (9.6%) are classified by us as polyphages. In general, in all the model sites, the trophic links of the collared flycatchers were quantitatively dominated by zoophages (49.0%; $n = 3{,}253$); phytophages were subdominants (32.0%), much smaller number of saprophages (12.0%), polyphages (4.0%) and necrophages (3.0%) were recorded. The dominance of zoophages among prey items is indicative of their high number in forest climax biogeocoenoses of Left-bank Ukraine.

Among trophic links, the zoophages are represented by different arthropods: insects, spiders, centipedes. Spiders are often found in the flycatcher diet (Lezhenina et al. 2009) and often are dominant in it (Polchaninova and Prisada 1994), belonging to consumers of the 2nd, 3rd, and higher orders in the flycatcher consortium. Most of the spiders in food samples of the flycatchers are immature. The family Linyphiidae is represented by the highest number of species, and the highest percentage by abundance are from the family Theridiidae. The family Clubionidae also constitutes an integral part. According to a catching strategy, cobweb spiders dominate, according to their habitat preference as dendrobionts.

Among zoophagous insects, the flycatcher diet includes representatives of such orders as Odonata, some Orthoptera, some Hemiptera-Heteroptera: *Pentatoma rufipes* (Linnaeus, 1758), *Nabis ferus* (Linnaeus, 1758), *Himacerus apterus* (Fabricius, 1798), *Zicrona caerulea* (Linnaeus, 1758), and some families of Coleoptera: Carabidae, Histeridae, Staphylinidae, Cantharidae, Melyridae, Elateridae (*Elater balteatus* (Reitter, 1918)), Coccinellidae, Rhypophoridae). The latter family is represented by a rare species of Metoecus paradoxus (Linnaeus, 1761). As for the Chrysopidae, our samples also included *Chrysoperla carnea* (Stephens, 1836), which, in fact, is the only species of the family. Imagoes of this species are pollenophages (feed on pollen and nectar of plants), and larvae are zoophages feeding on ground beetles.

A rare species of Mecoptera was recorded such as *Bittacus italicus* (Müller, 1786) (Tokarskyi et al. 2013). The Rhaphidioptera were represented by a forest species of *Rhaphidia flavipes* (Stein., 1863), which larvae are often recorded in the nest litter of closed-nesting birds. The larvae of the first age feed on the ground beetles and later attack the larvae of bark beetles and other inhabitants of tree trunks.

Links of the collared flycatcher nestlings with Hymenoptera were rather poor with small numbers of several parasite insects recorded from Ichneumonidae, Braconidae, Aphidiidae known as parasites of ground beetles and chalcids (Chalcidoidae). However, two species of ants (Formicidae), such as *Lasius niger* (Linnaeus, 1758) and *L. alienus* (Förster, 1850), were highly represented in the nestling diet. Some zoophages are associated with particular forest stands and are indicators of particular biogeocoenoses. For example, deciduous trees may be inhabited with mirid bugs, while some ladybirds prefer coniferous trees and asilid larvae prefer the ground or rotten wood. Between the different study sites, the proportion of insects and spiders in each trophic links of the collared flycatcher were at similar levels (Figure 2A).

Saprophages (phytosaprophages, necrophages, corpophages, ceratophages) belong to decomposers in the bird trophic consortium. Phytosaprophages and detritophages are consumers of organic matter of plant origin. They include Julidae from Myriapoda and Oniscoidea from Malacostraca. Among arthropods, saprophages include Collembola, among insects Psocoptera, which are found in the nest litter. Saprophages also include *Liposcelis divinatorius* (Müller, 1776). The order Coleoptera is regarded as the richest in saprophagous families, genera and species. Most of them are found in the diet of nestlings and the nest litter. Some of them are larvae of Lucanidae and Scarabaeidae as well as larvae of Helodidae, Ptinidae, Anobiidae, Cryptophagidae, Lathriidae, Oedemeridae, Mordellidae, Melandryidae, Alleculidae, Tenebrionidae, Eucnemidae, Lagriidae and Cerambycidae. A characteristic feature of saprophages is their dominance in climax mature forests. Diptera in the nestling diet are represented by saprophages from the families Sciaridae, Lauxoniidae, Muscidae, Stratyomiidae: predominantely *Chloromyia* and some Syrphidae (for example, *Eristalis tenax* (Linnaeus, 1758)). Larvae of the latter prefer catchpits and are considered as indicators of polluted water bodies. Muscidae are more typical for transformed areas. Among arthropods, saprophages include such crustacean species as slaters (Oniscoidea). Conventional saprophages and detritophages are Chironomidae, whose larvae inhabit freshwater bodies, feed on bacteria, detritus and algae. During the period of swarming, they copulate making an original "wedding dance" during which they are caught by flycatchers and other birds. Detritophages include representatives of the order Trichoptera, the family Phriganeidae. Their larvae live in reed stalks, feed on detritus and form diet resources of benthos fish species. The imagoes live several days and are regularly eaten by birds.

Polyphages are insects feeding on both vegetation and animal diet. They rank fourth in a system of forest coenoses after zoophages, phytophages and saprophages in a diet of chicks and adults as well. They include Blattoptera, some mirid bugs Miridae, Lygaeidae, Pyrrhocoridae, Pentatomidae. Among Orthoptera, they include Tettigonidae, Gryllidae. Among Carabidae, such genera as *Harpalus*, *Amara*, *Ophonus* are polyphagous.

From the order Coleoptera, polyphages include the families Elateridae and Eucnenidae. Two rare species of polyphages are worth mentioning: *Rhysodes sulcatus* (Fabricius, 1787) from Rhysodidae and *Eucinetus haemorrhous* (Duft., 1825) from Eucinetidae.

Conclusions

Although the feeding range of collared flycatchers is limited to a relatively small radius around the nest site, they consume a diverse spectrum of prey and exploit all forest layers. The analysis of food pellets has shown that insects comprised 83% of prey, with Diptera, Coleoptera and Lepidoptera as the most abundant orders. The analysis of prey similarity and diversity found the greatest similarity between the two oak forests in MS1 and MS2.

In the study sites of north-eastern Ukraine, we found collared flycatchers to have trophic links with 294 taxa of invertebrates, acting as consumers of the 2nd order. Their diet is dominated by zoophages, both in qualitative and quantitative composition.

While foraging, the birds generally use bare branches and trunks in the middle structural layer of the woodland as perches, making aerial forays towards the ground to take prey. This foraging behaviour means that they can exploit a wide range of habitats from gardens and parks to forest plantations, providing there is a mix of forest stand and open space and sufficient prey. The level of anxiety affects indirectly. The smallest diversity of prey species was found in samples from the most disturbed area, where Lepidoptera caterpillars, Diptera and Hymenoptera larvae predominated.

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Supplement

Table 1s. Trophic links of the collared flycatcher in the transformed forest ecosystems of north-eastern Ukraine

Taxon name			Trophic group	MS1	MS2	MS3	MS4	Total	Notes
Order	Family	Species							
Entomobryo-morpha	Entomobryidae	Entomobryidae sp.	s				1	1	imag.
Odonata	Libellulidae	Libellulidae sp.	z		1			1	-‘-
	Lestidae	Lestes sp.	z		1			1	-‘-
Dictyoptera	Ectobiidae	*Ectobius lapponicus* (Linnaeus, 1758)	p		3	2	10	15	-‘-
		Ectobius sylvestris (Poda, 1761)	p		1			1	-‘-
Orthoptera	Tettigoniidae	*Tettigonia viridissima* (Linnaeus, 1758)	p		2 larv.			2	2 larv.
		Tettigonia sp.	p		1 larv.	1 larv.		2	2 larv.
		Leptophyes albovittata (Kollar, 1833)	p		4 larv.			4	4 larv.
		Phaneroptera falcata (Poda, 1761)	p		1, 3 larv.			4	1 imag. + 3 larv.
	Gryllidae	Gryllus sp.	p		2 larv.			2	2 larv.
Plecoptera	Perlidae	Perlidae sp.	s				1	1	imag.
Psocoptera	Liposcelididae	Liposcelis sp.	s		1			1	-‘-
Hemiptera	Cicadidae	Cicadidae sp.	ph		2 larv.			2	2 larv.
		Cicadatra atra (Oliver, 1790)	ph		1			1	imag.
	Delphacidae	Delphacidae sp.	ph		1			1	-‘-
	Cixiidae	Cixiidae sp.	ph		1			1	-‘-
	Cicadellidae	Cicadellidae sp.	ph	3, 1 larv.	12, 9 larv.		12	37	27 imag. + 10 larv.
		Idiocerus sp.	ph		1			1	imag.
		Deltocephalus pulicaris (Fallen, 1806)	ph		1			1	-‘-
	Issidae	*Issus muscaeformis* (Schrank, 1781)	ph		1			1	-‘-
	Aphrophoridae	Aphrophora sp.	ph	1				1	-‘-
	Aphididae	Aphididae sp.	ph		1			1	-‘-
	Nabidae	*Nabis ferus* (Linnaeus, 1758)	z	1	1	2		4	-‘-
		Himacerus apterus (Fabricius, 1798)	z	1 larv.	1	2		4	3 imag. + 1 larv.
	Anthocoridae	Anthocoris sp.	z			1		1	imag.
	Miridae	Miridae sp.	ph	1, 1 larv.	3, 5 larv.	2	2, 1 larv.	15	8 imag. + 7 larv.
		Calocoris sp.	p	1				1	imag.
		Myrmecophyes alboornatus (Stal, 1858)	p	1				1	-‘-
		Deraeocoris olivaceus (Fabricius, 1777)	z	1	1	1		3	-‘-
		Deraeocoris ventralis (Reuter, 1904)	z		4			4	-‘-
		Megacoelum infusum (Herrich-Schaeffer, 1839)	z			5		5	-‘-
		Liocoris tripustulatus (Fabricius, 1781)	ph			1		1	-‘-
		Cyllecoris flavoquadrimaculatus (De Geer, 1773)	z			1		1	-‘-
		Miris striatus (Linnaeus, 1758)	z			5		5	-‘-
		Polymerus sp.	ph		1			1	-‘-
		Leptopterna ferrugata (Fallen, 1807)	ph	1				1	-‘-
		Stenodema sp.	ph	1				1	-‘-
		Poeciloscytus sp.	ph		1			1	-‘-
	Reduviidae	*Empicoris culiciformis* (De Geer, 1773)	z	1				1	-‘-
		Reduviidae sp.	z		1	1		2	-‘-
	Lygaeidae	Lygaeidae sp.	ph		4			4	-‘-
	Acanthosoma-tidae	Elasmostethus sp.	ph		1			1	-‘-
		Elasmucha sp.	ph		1			1	-‘-
	Rhopalidae	*Chorosoma schillingi* (Schilling, 1829)	ph		1			1	-‘-
	Coreidae	*Nemocoris falleni* (F. Sahlberg, 1848)	ph				1	1	-‘-
		Coreidae sp.					1	1	-‘-
	Pentatomidae	*Palomena prasina* (Linnaeus, 1761)	p				1 larv.	1	1 imag. + 1 larv.
		Pentatoma rufipes (Linnaeus, 1758)	p		2	1 larv.		3	2 imag. + 1 larv.
		Pentatomidae sp.	ph		1, 1 larv.			2	1 imag. + 1 larv.
		Eurydema oleracea (Linnaeus, 1758)	ph	1 larv.				1	1 larv.
Coleoptera	Carabidae	Carabidae sp.	p	1, 2 larv.	1, 7 larv.	9		20	11 imag. + 9 larv.
		Bembidion sp.	z				1	1	imag.
		Harpalus sp.	p				1	1	-‘-
		Pterostichus sp.	z				6	6	-‘-
	Silphidae	Silphidae sp.	n		2, 5 larv.	5 larv.		12	2 imag. + 10 larv.
		Silpha sp.	n		1, 12 larv.	2		15	3 imag. + 14 larv.
		Nicrophorus sp.	n		2			2	imag.
		Dendroxena quadripunctata (Scopoli, 1772)	n		12, 15 larv.			27	12 imag. + 15 larv.
	Staphylinidae	Philonthus sp.	z		1			1	imag.
		Oxyporus sp.	ph				1	1	-‘-
		Oxyporus rufus (Linnaeus, 1758)	ph		2 larv.	2 larv.		4	4 larv.
		Staphylinidae sp.	z	1		2 larv.		3	2 larv.
	Scarabaeidae	*Oryctes nasicornis* (Linnaeus, 1758)	s		1 pupa			1	1 pupa
		Anomala dubia (Scopoli, 1763)	ph		3			3	imag.
		Phyllopertha horticola (Linnaeus, 1758)	ph		5, 3 larv.		4	12	9 imag. + 3 larv.
	Rutelidae	*Anisoplia segetum* (Herbst, 1783)	ph		2			2	imag.
	Melolonthidae	*Hoplia parvula* (Krynicky, 1832)	ph		7			7	-‘-
	Dermestidae	*Dermestes lardarius* (Linnaeus, 1758)	n		5			5	-‘-
		Dermestidae sp.	n		1 larv.			1	1 larv.
	Cantharidae	*Malthinus flaveolus* (Herbst, 1786)	z				1	1	imag.

Order	Family	Taxon name Species	Trophic group	MS1	MS2	MS3	MS4	Total	Notes
		Malthinus sp.	z	2	3		2	7	-‘-
		Cantharis fusca (Linnaeus, 1758)	z				1	1	-‘-
		Cantharis lateralis (Linnaeus, 1758)	z				1	1	-‘-
		Cantharis livida (Linnaeus, 1758)	z	2	1			3	-‘-
		Rhagonycha testacea (Linnaeus, 1758)	z	2			8	10	-‘-
		Rhagonicha fulva (Scopoli, 1763)	z			1		1	-‘-
		Rhagonicha sp.	z	1				1	-‘-
		Malthodes sp.	z	1	1		1 larv.	3	2 imag. + 1 larv.
		Cantharidae sp.	z	3 larv.				3	3 larv.
		Podabrus alpinus (Paykull, 1798)	z	1				1	imag.
	Melyridae	Malachius sp.	z				1	1	-‘-
		Ebaeus pedicularis (Fabricius, 1777)	z		1			1	-‘-
		Dasytes niger (Linnaeus, 1761)	z				1	1	-‘-
		Dasytes sp.	z		6	2		8	-‘-
	Anobiidae	*Ptinus rufipes* (Oliver, 1790)	s	2	1			3	-‘-
		Ptinus fur (Linnaeus, 1758)	s	1				1	-‘-
		Ptinus sp.	s		1			1	-‘-
	Elateridae	*Agriotes gurgistanus* (Faldermann, 1835)	p		1			1	-‘-
		Agriotes ustulatus (Schaller, 1783)	p		8			8	-‘-
		Agriotes sp.	p	4	2, 1 larv.		7	14	13 imag. + 1 larv.
		Elater sp.	z		2		3	5	imag.
		Athous sp.	p	2	5		8	15	-‘-
		Melanotus sp.	p		6		2	8	-‘-
		Cardiophorus sp.	p		9	1		10	-‘-
		Selatosomus latus (Fabricius, 1801)	p		1 larv.			1	1 imag. + 1 larv.
		Selatosomus sp.	p				6	6	imag.
		Prosternon tesselatum (Linnaeus, 1758)	p			1	9	10	-‘-
		Elateridae sp.	p	3	2		2	7	-‘-
	Eucnemidae	*Dirrhagus attenuatus* (Maeklin, 1845)	p		1			1	-‘-
		Eucnemidae sp.	p	2	6		1	9	-‘-
	Buprestidae	Acmaeodera sp.	ph		1			1	-‘-
		Buprestidae sp.	ph		1 larv.	3 larv.		4	4 larv.
	Nitidulidae	Meligethes sp.	ph	7			5, 9 larv.	21	14 imag. + 9 larv.
	Coccinellidae	*Adalia decimpunctata* (Linnaeus, 1758)	z		2			2	imag.
		Synharmonia conglobata (Linnaeus, 1758)	z		2			2	-‘-
		Coccinula sinuatomarginata (Faldermann, 1837)	z		1			1	-‘-
		Coccinella undecimpunctata (Linnaeus, 1758)	z				1	1	-‘-
		Calvia quatuordecimguttata (Linnaeus, 1758)	z		9			9	-‘-
		Calvia decimguttata (Linnaeus, 1767)	z		1	2		3	-‘-
		Calvia quindecimguttata (Fabricius, 1777)	z		1			1	-‘-
		Neomysia oblongoguttata (Linnaeus, 1758)	z				1	1	-‘-
		Hyppodamia variegata (Goeze, 1777)	z		1			1	-‘-
		Anatis ocellata (Linnaeus, 1758)	z		1			1	-‘-
		Harmonia quadripunctata (Pontoppidan, 1763)	z		1			1	-‘-
		Coccinellidae sp.	z		4 larv.		2 larv.	6	6 larv.
	Oedemeridae	*Oedemera podagrariae* (Linnaeus, 1767)	s		1			1	imag.
		Oedemera femorata (Scopoli, 1763)	s				1	1	-‘-
		Chrysanthia viridissima (Linnaeus, 1758)	s				2	2	-‘-
	Mordellidae	*Mordellochroa abdominalis* (Fabricius, 1775)	s			1		1	-‘-
	Melandryidae	Melandryidae sp.	s	1				1	-‘-
		Eustrophus dermestoides (Fabricius, 1793)	s		49			49	-‘-
	Tenebrionidae	*Lagria hirta* (Linnaeus, 1758)	p	1	2		4	7	-‘-
		Allecula morio (Fabricius, 1787)	s		2			2	-‘-
		Prionychus ater (Fabricius, 1775)	s			1	1	2	-‘-
		Alleculinae sp.	s	3 larv.	4			7	4 imag. + 3 larv.
		Pseudocistela ceramboides (Linnaeus, 1761)	s	2	2	4	5	13	imag.
		Cylindronotus gilvipes (Menetries, 1849)	s		5, 1 larv.	3		9	8 imag. + 1 larv.
		Tenebrionidae sp.	s			1, 2 larv.		3	1 imag. + 2 larv.
	Rhipiphoridae	*Metoecus paradoxus* (Linnaeus, 1761)	z		11			11	imag.
		Metoecus sp.	z		2			2	-‘-
	Cerambicidae	Cerambycidae sp.	ph	2	4, 1 larv.			7	6 imag. + 1 larv.
		Pseudovadonia livida (Fabricius, 1776)	ph	1	1		2	4	imag.
		Anisorus quercus (Götz, 1783)	ph	1	3			4	-‘-
		Stenocorus meridianus (Linnaeus, 1758)	ph		1			1	-‘-
		Stenocorus sp.	ph	1				1	-‘-
		Dinodera collaris (Linnaeus, 1758)	ph	1	1			2	-‘-
		Leiopus nebulosus (Linnaeus, 1758)	ph		1, 1 juv.			2	1 imag. + 1 juv.
		Leiopus sp.	ph		1			1	imag.
		Acanthocinus aedilis (Linnaeus, 1758)	ph			1		1	-‘-
		Tetrops praeustus (Linnaeus, 1758)	ph		1			1	-‘-
	Chrysomelidae	Chrysomela sp.	ph				5 larv.	5	5 larv.
		Melasoma sp.	ph		2 larv.			2	5 larv.
		Melasoma vigintipunctata (Scopoli, 1763)	ph		13	1	2, 1 pupa	17	16 imag. + 1 pupa
		Chalcoides sp.	ph	2	1			3	imag.
		Cryptocephalus sp.	ph		2			2	-‘-
		Entomoscelis sp.	ph	2 larv.				2	2 larv.
		Chrysomelidae sp.	ph	4, 2 larv.	3, 2 pupa, 4 larv.	1, 3 larv.	2 larv.	21	8 imag. + 11 larv. + 2 pupa

Taxon name			Trophic group	MS1	MS2	MS3	MS4	Total	Notes
Order	Family	Species							
	Curculionidae	Otiorhynchus sp.	ph		1			1	imag.
		Omias concinnus (C. H. Boheman in C. J. Schönherr, 1834)	ph		3			3	-‘-
		Omias sp.	ph		2			2	-‘-
		Mylacus sp.	ph			1		1	-‘-
		Cionus sp.			1			1	-‘-
		Curculionidae sp.	ph		1			1	-‘-
		Scolytus sp.	ph		1			1	-‘-
		Xyleborus monographus (Fabricius, 1792)	ph		2			2	-‘-
		Xyleborus dispar (Fabricius, 1792)	ph	1	1	1		3	-‘-
Neuroptera	Chrysopidae	Chrysopidae sp.	z		27			27	-‘-
		Chrysopa sp.	z		3, 12 larv.			15	3 imag. + 12 larv.
	Hemerobiidae	Hemerobius sp.	z	2				2	imag.
		Neuroptera sp.	z		1 larv.			1	1 larv.
Hymenoptera	Tenthredinidae	Tenthredinidae sp.	ph	4, 1 larv.	6, 8 larv.	1, 13 larv., 1 cocoon	31, 37 larv.	102	42 imag. + 59 larv. + 1 co-coon
		Tenthredo sp.	ph		2			2	imag.
	Diprionidae	*Diprion pini* (Linnaeus, 1758)	ph				1	1	-‘-
	Siricidae	Sirex sp.	ph				1	1	-‘-
	Ichneumonidae	Ichneumonidae sp.	z	4	12		4	20	-‘-
	Chalcididae	Chalcididae sp.	z	1			1	2	-‘-
	Pompilidae	Pompilidae sp.	z		1			1	-‘-
	Vespidae	Vespidae sp.	z	2				2	-‘-
		Eumeninae sp.	z	13				13	-‘-
	Sphecidae	Sphecidae sp.	z		1			1	-‘-
	Halictidae	Halictus sp.	ph	1	2			3	-‘-
	Apidae	Xylocopa sp.	ph		1			1	-‘-
	Megachilidae	Megachilidae sp.	ph	1				1	-‘-
	Formicidae	*Tetramorium caespitum* (Linnaeus, 1758)	p		4, 12 ♀			16	-‘-
		Lasius niger (Linnaeus, 1758)	p	1	3	1	11	16	-‘-
		Lasius fuliginosus (Latreille, 1798)	p		3			3	-‘-
		Lasius sp.	p	60	204	41	1	306	-‘-
		Lasius alienus (Förster, 1850)	p	3, 5 ♀, 3 ♂	148, 42 ♀, 3 ♂	3, 1 ♀	3	211	-‘-
		Formica cunicularia (Latreille, 1798)	p		1			1	-‘-
		Ponera coarctata (Latreille, 1802)	p		10			10	-‘-
		Myrmica sp.	p	1	2	2		5	-‘-
		Myrmicinae sp.	p		1 ♀		1	2	-‘-
		Hymenoptera sp.	z			2		2	-‘-
Raphidioptera	Raphidiidae	*Dichrostigma flavipes* (Stein, 1863)	z		5		23	28	-‘-
		Raphidia sp.	z		1 larv.		7	8	7 imag. + 1 larv.
Trichoptera		Trichoptera sp.	s	1	2	1	9, 2 larv.	15	13 imag. + 2 larv.
	Phryganeidae	*Phryganea grandis* (Linnaeus, 1758)	s		1			1	imag.
Lepidoptera		Lepidoptera sp.	ph	26, 1 pupa, 6 larv.	10, 20 larv.	2, 6 larv.	5, 1 pupa, 5 larv.	82	43 imag. + 2 pupa + 37 larv.
	Tineidae	Tineidae sp.	n	1				1	imag.
	Tortricidae	Tortricidae sp.	ph	89, 13 pupa, 33 larv.	64, 2 pupa, 15 larv.	18, 1 pupa, 31 larv.		266	171 imag. + 16 pupa + 79 larv.
		Tortrix viridana (Linnaeus, 1758)	ph		4			4	imag.
	Lasiocampidae	Lasiocampidae sp.	ph		1		2	3	-‘-
	Nymphalidae	*Vanessa cardui* (Linnaeus, 1758)	ph		1			1	-‘-
		Melitaea sp.	ph				1	1	-‘-
		Nympalidae sp.	ph		5, 1 larv.	1 larv.	3, 3 larv.	13	8 imag. + 5 larv.
	Erebidae	Erebidae sp.	ph		1, 1 larv.			2	1 imag. + 1 larv.
	Noctuidae	Noctuidae sp.	ph	5, 55 larv.	44, 4 pupa, 108 larv.	6, 36 larv.	3, 1 larv.	262	58 imag. + 4 pupa + 200 larv.
	Geometridae	Geometridae sp.	ph	1, 21 larv.	10, 15 larv.	5 larv.	1, 3 larv.	56	12 imag. + 44 larv.
	Pieridae	Pieridae sp.	ph	2	1		5	8	imag.
	Pyralidae	Pyralidae sp.	ph				4	4	-‘-
	Erebidae	*Amata phegea* (Linnaeus, 1758)	ph				2	2	-‘-
		Amata sp.	ph				1	1	-‘-
	Gelechiidae	Gelechiidae sp.	ph		10, 2 larv.			12	10 imag. + 2 larv.
	Notodontidae	Notodontidae sp.	ph	1 larv.				1	1 larv.
	Hesperiidae	Hesperiidae sp.	ph	1				1	imag.
		Microlepidoptera sp.	ph	3	26			29	-‘-
Mecoptera	Panorpidae	*Panorpa communis* (Linnaeus, 1758)	z	1				1	-‘-
Diptera	Tipulidae	Tipula sp.	ph	4	5	1	3	13	-‘-
		Ctenophora sp.	ph	1				1	-‘-
	Chironomidae	Chironomidae sp.	s	6	2	42, 1 larv.		51	50 imag. + 1 larv.
	Culicidae	*Culex pipiens* (Linnaeus, 1758)	z	10	4	10	4	28	imag.
	Sciaridae	Sciaridae sp.	s		4			4	-‘-
	Rhagionidae	Rhagio sp.	z		1			1	-‘-
	Stratiomyidae	*Sargus cuprarius* (Linnaeus, 1758)	s		2			2	-‘-
		Chloromyia formosa (Scopoli, 1763)	s		13			13	-‘-
		Chloromyia sp.	s		8			8	-‘-
		Stratiomys sp.	s		4			4	-‘-

Taxon name			Trophic group	MS1	MS2	MS3	MS4	Total	Notes
Order	Family	Species							
		Odontomyia sp.	s		1			1	-'-
		Nemotelus sp.	s		1			1	-'-
		Pachygaster sp.	s		2			2	-'-
		Geosorgus sp.	s		18			18	-'-
	Tabanidae	Tabanidae sp.	z		2			2	-'-
		Tabanus sudeticus (Zeller, 1842)	z		2			2	-'-
		Tabanus sp.	z	1	13		3	17	-'-
	Bombyliidae	*Hemipenthes morio* (Linnaeus, 1758)	z		2			2	-'-
		Bombylius sp.	z		1			1	-'-
		Villa sp.	z		2			2	-'-
	Asilidae	Dioctria sp.	z		5			5	-'-
		Choerades sp.	z		1			1	-'-
		Neoitamus sp.	z		5			5	-'-
		Machimus sp.	z		2			2	-'-
		Asilidae sp.	z	1	5		1	7	-'-
	Syrphidae	*Chrysotoxum festivum* (Linnaeus, 1758)	z		1			1	-'-
		Chrysotoxum sp.	z		1			1	-'-
		Eupeodes corollae (Fabricius, 1794)	z		1			1	-'-
		Syrphus ribesii (Linnaeus, 1758)	z		2			2	-'-
		Syrphus virtipennis (Meigen, 1822)	z		2			2	-'-
		Syrphus sp.	z		2		4	6	-'-
		Episyrphus balteatus (De Geer, 1776)	z		1			1	-'-
		Merodon sp.	ph		1			1	-'-
		Syritta pipiens (Linnaeus, 1758)	s				1	1	-'-
		Eristalis tenax (Linnaeus, 1758)	s	2	1		1	4	-'-
		Eristalis sp.	s		1		2	3	-'-
		Syrphidae sp.	z	3	18, 1 larv.	1	1	24	23 imag. + 1 larv.
	Tephritidae	Trypetinae sp.	ph	1		1		2	imag.
		Tephritidae sp.	ph		1			1	-'-
	Ulidiidae	*Otites formosa* (Panzer, 1798)	ph		1			1	-'-
	Lauxaniidae	Lauxaniidae sp.	ph		1, 1 larv.			2	1 imag. + 1 larv.
	Pallopteridae	*Palloptera ambusta* (Meigen, 1826)	ph		1			1	imag.
	Opomyzidae	*Opomyza florum* (Fabricius, 1794)	ph		2			2	-'-
	Pipunculidae	Pipunculidae sp.	z		1			1	-'-
	Psilidae	Psilidae sp.	ph		1			1	-'-
	Phoridae	Phoridae sp.	s	1				1	-'-
	Muscidae	Muscidae sp.	s	3, 1 larv.			1	5	4 imag. + 1 larv.
	Calliphoridae	*Pollenia rudis* (Fabricius, 1794)	z		2			2	imag.
		Lucilia caesar (Linnaeus, 1758)	n		1			1	-'-
	Sarcophagidae	Sarcophaga sp.	n	2			1	3	-'-
		Sarcophagidae sp.	n	7	22, 5 pupa, 6 larv.	3	4	47	36 imag. + 5 pupa + 6 larv.
	Tachinidae	Tachinidae sp.	z	4	19		3	26	imag.
	Hippoboscidae	Hippoboscidae sp.	z		1			1	-'-
		Diptera sp.	s	6	18, 2 pupa, 6 larv.	11, 1 pupa, 12 larv.	1	57	36 imag. + 3 pupa + 18 larv.
Araneae	Tetragnathidae	Tetragnathidae sp.	z	9, 14 juv.	17, 22 juv.		61, 21 juv.	144	87 imag. + 57 juv.
	Araneidae	Araneidae sp.	z		5, 2 juv.			7	5 imag. + 2 juv.
		Araniella cucurbitina (Clerck, 1757)	z	5	2	2	2	11	imag.
	Lycosidae	Lycosidae sp.	z	1, 3 juv.	9, 5 juv.		1 juv.	19	10 imag. + 9 juv.
		Pardosa lugubris (Walckenaer, 1802)	z	7	6		4	17	imag.
		Trochosa terricola (Thorell, 1856)	z	4	6	2	2	14	-'-
	Pisauridae	Pisauridae sp.	z	4	6			10	-'-
	Agelenidae	Agelenidae sp.	z	6, 1 juv., 1 larv.	5, 2 juv.		4, 2 juv.	21	15 imag. + 5 juv. + 1 larv.
	Theridiidae	*Enoplognatha ovata* (Clerck, 1757)	z	5	6	3	3	17	imag.
	Clubionidae	Clubionidae sp.	z	5	9			14	-'-
	Gnaphosidae	Gnaphosidae sp.	z	7	5			12	-'-
	Zoridae	Zoridae sp.	z	5	5			10	-'-
	Philodromidae	Philodromidae sp.	z	1, 2 juv.	6, 3 juv.	4 juv.	1 juv.	17	7 imag. + 10 juv.
		Philodromus cespitum (Walckenaer, 1802)	z	6	6	5	6	23	imag.
		Philodromus rufus (Walckenaer, 1826)	z	5	4	6	5	20	-'-
		Tibellus sp.	z	3, 1 juv.	2, 5 juv.	5, 1 cocoon, 3 juv.	3 juv.	23	10 imag. + 1 cocoon + 12 juv.
	Thomisidae	Thomisidae sp.	z	2, 3 juv, 1 larv.	7, 4 juv.	3 juv.	2 juv.	22	9 imag. + 12 juv. + 1 larv.
		Cozyptila blackwalli (Simon, 1875)	z	5	5	2	3	15	imag.
		Synema globosum (Fabricius, 1775)	z	4	8	3	2	17	-'-
		Xysticus lanio (C. L. Koch, 1835)	z	6	6	2	3	17	-'-
		Xysticus ulmi (Hahn, 1831)	z	5	10	2	2	19	-'-
	Salticidae	Salticidae sp.	z	4, 3 juv.	5, 6 juv.	3	3	24	15 imag. + 9 juv.
Trombidiformes	Trombidiidae	Trombidiidae sp.	z		2			2	imag.
Ixodida		Ixodida sp.	z	23			2	25	-'-
Lithobiomorpha	Lithobiidae	Lithobius sp.	z		1			1	-'-
Polydesmida	Polydesmidae	*Polydesmus complanatus* (Linnaeus, 1761)	s		1			1	-'-

Taxon name			Trophic group	MS1	MS2	MS3	MS4	Total	Notes
Order	Family	Species							
Julida	Julidae	Julus sp.	s				4	4	-‘-
		Rossiulus kessleri (Lochmander, 1927)	s	3	4	3	5	15	-‘-
		Megaphyllum sp.	s	7, 1 larv.	1	5		14	13 imag. + 1 larv.
Isopoda	Armadillidiidae	*Armadillidium vulgare* (Latreille, 1804)	s		14			14	imag.
	Porcellionidae	*Porcellio scaber* (Latreille, 1804)	s	4, 6 larv.	5, 3 larv.	11, 13 larv.		42	20 imag. + 22 larv.
		Porcellio sp.	s	3				3	imag.
Pulmonata	Succineidae	Succinea sp.	ph		1		1	2	-‘-
Total				667*	1694**	408***	484****	3253	2465 imag. + 635 larv. + 117 juv. + 34 pupa + 2 cocoon

Notes: the trophic groups of macrofauna: ph – phytophages, z – zoophages, p – polyphages, s – saprophages, n – necrophages; MS1–MS4 – the model sites described in “Materials and methods”; imag. – imagoes; larv. – larvae; juv. – immature specimen(s).
The material was collected in different periods:
* MS1 in the year 2011 – 40 food pellets, in 2012 – 51 food pellets, in 2014 – 105 food pellets, in 2015 – 48 food pellets;
** MS2 in 2009 – 72 food pellets, in 2010 – 83 food pellets, in 2011 – 84 food pellets, in 2012 – 9 food pellets, in 2013 – 128 food pellets, in 2014 – 121 food pellets, in 2015 – 51 food pellets;
*** MS3 in 2011 – 42 food pellets, in 2012 – 9 food pellets, in 2014 – 46 food pellets, in 2015 – 42 food pellets;
**** MS4 in 2014 – 191 food pellets, in 2015 – 38 food pellets.