Trophic Links of the Spotted Flycatcher, *Muscicapa striata*, in Transformed Forest Ecosystems of North-Eastern Ukraine

ANGELA B. CHAPLYGINA[1], NADIIA O. SAVYNSKA[1]* AND VIKTOR V. BRYGADYRENKO[2]

[1] *Department of Zoology, Faculty of Natural Sciences, 'H.S. Skovoroda' Kharkiv National Pedagogical University, Alchevskyh Street, 29, Kharkiv, 61002, Ukraine*

[2] *Department of Zoology and Ecology, Faculty of Biology, Ecology and Medicine, 'Oles Honchar' Dnipro National University, Gagarin Avenue, 72, Dnipro, 49010, Ukraine*

* *Corresponding author: iturdus@ukr.net*

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Abstract

The diet of the spotted flycatcher, *Muscicapa striata* Pallas, 1764, was studied to reveal its trophic links and subsistence of bird populations in transformed ecosystems of North-Eastern Ukraine. A total of 75 invertebrate taxa were found in the diet. Insects made up 94.8%: imagoes of Diptera (39.8%), Hymenoptera (24.2%), Lepidoptera (17.2%), Odonata (7.9%), Coleoptera (5.1%), etc. Large-sized insects dominated. Qualitative composition of the nestling diet of spotted flycathers was composed of zoophages (31.7%), phytophages (29.4%), saprophages (20.1%), polyphages (12.0%), and necrophages (6.7%). Invertebrate trophic groups were almost equally distributed in the nestling diet according to the number of taken insects as follows: zoophages (22.0%), polyphages (21.0%), phytophages (21.0%), necrophages (20.0%), and saprophages (16.0%). Environmental conditions play an important role affecting the diet structure. The most favourable feeding conditions for the species were found in protected natural areas. The analysis showed that the forage intake of flycatchers was equal in all the sites. The highest invertebrate diversity was found in model site 2 (National Nature Park "Homilshanski Lisy") with its 62 taxa and in model site 4 (National Nature Park "Hetmanskyi") with its 33 taxa. Similarity indices were higher in model site 3 (30) compared to model site 1 (26) showing that birds could switch between different invertebrate species, thus causing the formation of ecological pre-adaptations and further synanthropisation of the species. The highest values of Jaccard and Sørensen indices, 57.5% and 73.0%, respectively, for 23 taxa of invertebrates were revealed in model sites 3 and 4.

Keywords: spotted flycatcher, foraging pattern, transformed areas, invertebrates, diet, trophic links, competition, dendrophilous birds, zoophages, phytophages, saprophages

Introduction

Monitoring of the status of insectivorous passerines under anthropogenic transformation of natural areas is one of the priority tasks in modern ornithology (Assandri et al. 2017). Due to their mobility, birds are recognized as good environmental indicators (Gregory et al. 2003). One of the numerous groups of insectivorous birds in Eurasia is flycatchers (*Muscicapidae*). According to Sangster et al. (2010), judging by sequences of their mitochondrial genes and nuclear loci, they belong to one of the four clades, *Muscicapinae*.

The spotted flycatcher (*Muscicapa striata* Pallas 1764) holds a leading position in communities of forest ecosystems of the temperate climatic zone (Snow and Perrins 1998, Amar et al. 2006, Hernández 2009). In the UK, the foraging success of the spotted flycatcher nestlings is higher in gardens, in contrast to woodlands and agricultural lands (Stevens et al. 2007). The study of feeding ecology of the species sheds light to the possibilities of its conservation as an insectivorous bird and a long-distance migrant with a European protection status (Bern Convention 1979) (Newton 2007, Pons et al. 2016). Given the fact that the environmental conditions are crucial to the successful reproduction and stability of the species populations (Stoate and Szczur 2006, Stevens et al. 2007, Stevens et al. 2008), this issue is gaining particular importance in the North-Eastern Ukraine, a region characterized by intensive transformation of natural communities (Brygadyrenko 2014, 2015).

Knowing patterns of foraging behaviour of insectivorous birds is useful to reduce outbreaks of the arthropods, who are the carriers of germs causing dangerous human diseases (Anderson and Magnarelli 1993, Lommano et al. 2014), being the pests in forest and agriculture (Faly and Brygadyrenko 2014), and to control the number of bird flocks that may be a threat to harvest (Barnard 1980).

In Western Europe, in recent decades, the number of spotted flycatchers shows a large-scale declining trend, started in the 1980s (Robinson et al. 2016). In the UK, for example, the bird number decreased by 82% (Freeman and Crick 2003, Baillie et al. 2006). In addition, Onishi et al. (2010) has indicated an extension of the species range and the first record of *M. striata* in Japan.

Modern researchers consider trophic features of the species to be determinative in managing and conservation of the bird species diversity in natural and transformed areas (human impact, deforestation, recreation, etc.) (Keith 2015, Luke 2015, Kornan 2017). Potential reasons for decreasing the number of birds during the breeding season are changes in the status of natural associations in their breeding habitats (Kirby et al. 2005, Paker et al. 2014, Hamer et al. 2015). This reduces availability of invertebrates and leads to the loss of feeding resources of flycatchers (Marochkina et al. 2005, Stoate and Szczur 2006, Chaplygina et al. 2015).

European countries propose different tools to improve feeding habitats during the reproductive period including extra feeding of birds with specially equipped mangers (Amrhein 2013). However, they are rather unsuitable for the use in the case of *M. striata* due to a specific pattern of their foraging – hunting in the air (Davies 1976). To support bird numbers and improve their feeding and reproduction conditions, in Central Italy the distribution of marginal vegetation, like shrubs, hedges, isolated trees, are promoted (Morelli 2013). In Southern Africa, suburban water collection tanks are proposed (Suri et al. 2017). In the forest-steppe zone of Ukraine, no special studies on *M. striata* were conducted, therefore, the peculiarities of its diet, as the main reason limiting the size of this species, require careful investigation.

The purpose of this study is to analyze the qualitative and quantitative composition of the diet and foraging pattern of spotted flycatchers to reveal their trophic links and conserve bird populations in transformed ecosystems of North-Eastern Ukraine.

Material and Methods

This research was performed in 2007–2016 in the forest-steppe zone of Left-bank Ukraine in Kharkiv and Sumy Regions. The diet of the spotted flycatcher nestlings was studied in upland oak forests of National Nature Park "Homilshanski Lisy" (NNP "HF"), Zmiiv district, Kharkiv region, in the forest park of Kharkiv (forest park), in pine-oak forests of National Nature Park "Hetmanskyi" (NNP "H"), Okhtyrka district, Sumy region, and in site "Vakalivshchyna", Sumy region. Three model sites, selected in the oak woodlands, had different stages of recreational digression according to the Gensiruk classification (2002). The fourth model site was selected in a pine-oak forest.

Model site 1 (MS1) is located in the oak forest with a mixture of maple and linden trees in site "Vakalivshchyna", on the eastern bedrock bank of the Psel river. This territory is placed far apart from settlements; the crown closure is about 85% (Table 1). The percentage of damaged trees does not exceed 10% of their total number. The undergrowth and shrub layers correspond to the conditions of the habitat and do not have significant damage. The herbaceous cover is mostly undisturbed, corresponds to the type of forest. Here and there, due to the fallout of some overmatured trees, an excessive development of forest grasses is observed. The forest floor is thick and undisturbed. The recreational coefficient of the site was determined by the area of forest paths constituting 5%. Model site 1 can be evaluated in terms of the 1st stage of recreational digression.

Table 1. Brief characteristics of the ecosystems

Model site	Moisture conditions	Density of tree crown layer, %	Density of bush and sapling layer, %	Density of herbaceous layer, %
1	mesohygrophilous	85 (*Quercus robur* L. – 35, *Fraxinus excelsior* L. – 30, *Tilia cordata* Mill. – 10, *Acer platanoides* L. –10)	55 (*Corylus avellana* L.– 15, *Swida sanguinea* L.– 15, *Euonymus europaeus* L.– 10, *Euonymus verrucosa* Scop. – 10)	15 (*Carex pilosa* Scop. – 10, *Stellaria graminea* L. – 5)
2	mesohygrophilous	70 (*Quercus robur* L. – 30, *Tilia cordata* Mill. – 20, *Acer platanoides* L. – 10, *Fraxinus excelsior* L. – 10)	65 (*Corylus avellana* L.– 20, *Sambucus nigra* L. –15, *Acer campestre* L.– 10, *Crataegus monogyna* Jacq. – 5, *Acer tataricum* L.– 5, *Pyrus communis* L. – 4, *Euonymus europaeus* L.– 3, *Euonymus verrucosa* Scop. – 3)	30 (*Stellaria graminea* L.– 15, *Polygonatum multiflorum* (L.) All. – 4, *Aegopodium podagraria* L. – 3, *Leonurus cardiaca* L. – 3)
3	mesohygrophilous	65 (*Quercus robur* L. – 25, *Fraxinus excelsior* L. –15, *Tilia cordata* Mill. – 15, *Acer platanoides* L. –10)	35 (*Corylus avellana* L.– 10, *Sambucus nigra* L.–10, *Acer campestre* L.–5, *Acer tataricum* L. – 3, Acer negundo L. – 3, *Crataegus monogyna* Jacq. – 3, *Euonymus europaeus* L.– 2, *Pyrus communis* L – 2)	20 (*Aegopodium podagraria* L. – 10, *Stellaria holostea* L. – 6, *Carex pilosa* Scop. – 4)
4	mesoxerophilous	20 (*Pinus sylvestris* L. – 12, *Quercus robur* L. – 5, *Tilia cordata* Mill. – 3)	35 (*Acer tataricum* L.–10, *Pyrus communis* L. – 10, *Sambucus racemosa* L. – 10, *Acer campestre* L. – 5)	45 (*Pteridium aquilinum* (L.) Kuhn. – 15, *Polygonatum odoratum* (Mill.) Druce –10, *Milium effusum* L. – 10, *Convallaria majalis* L. – 10)

Model site 2 (MS2) lies within a recreational zone of National Nature Park "Homilshanski Lisy". It covers vicinities of the study stations of 'H.S. Skovoroda' Kharkiv National Pedagogical University and 'V.N. Karazin' Kharkiv National University. An active recreation is observed there during the bird reproduction season. The wood has damaged and diseased trees (about 35%); the crown closure is ca. 70%. The undergrowth and shrub layer are still present but poorly differentiated. The herbaceous layer is partly disturbed; in places a projective cover reaches 85%. The forest floor is weakly disturbed. The area of forest paths occupies up to 30% of the site. This model site shows evidence of the 3rd stage of recreation digression and requires management of recreational pressure.

Model site 3 (MS3) is located in the forest park of Kharkiv and represented by an upland oak forest in the watersheds of the Lopan and Kharkiv rivers. It has mainly natural features with a small part of planted forest species; the crown closure is ca. 60%. Species of the forest edge, meadow, coastal-aquatic and ruderal plants can be also found there. The forest has an extended network of paths and roads using by people for jogging. Growing recreational pressure increases the size of open glades and density of paths. The maple *Acer negundo* forms dense thickets at the forest edge; garbage dumps can be found here and there. The closer to the forest edge the more ruderal species occurred. The site is characterized by the 4th level of recreational digression.

Model site 4 (MS4) is located in National Nature Park "Hetmanskyi", in a pine forest in the vicinity of villages of Kamianka and Klymetovo in section "Lytovskyi Bir". Oak-pine and maple-linden-oak woodlands near Kamianka are slightly disturbed by people, with diseased trees; the crown closure is ca. 20%. The undergrowth and shrub layer correspond to the habitat conditions, 5–20% of trees have insignificant damages. The herbaceous layer consisted of meadow grasses (5–10%), not typical for this type of the forest. The forest floor is little disturbed. The area of paths is small, up to 10% of the model site. In the site, located in Lytovskyi Bir, the area of paths exceeds 20%. Due to the concentration of recreants in July-August the recreational pressure is increasing but by this period most of birds have already completed their reproduction season. This site characteristically exhibits the evidence of the 3d level of recreational digression.

A total of 26 nests of spotted flycatchers were studied, with 85 nestlings in them. 365 food pellets were collected and 706 specimens of invertebrates were examined: 120 (from 32 nestlings) in oak forest MS2, 92 (from 18 nestlings) in pine-oak forest MS4, 75 (from 15 nestlings) in oak forest MS1, and 78 (from 25 nestlings) in oak forest MS3.

The research was conducted over the period between 25 May and 15 June during the first half of the day. The nestling diet was investigated by applying neck ligatures to 5–8-day old chicks (Mal'chevskij and Kadochnikov 1953). The forage samples were fixed in 70% ethanol and the arthropods were further identified in the laboratory. All invertebrates were identified to species, genus or family (in the event of significant damage) by Viktor M. Gramma through standard methods using guides to insects.

Statistical processing was performed with the aid of Statistica 8.0 software package (StatSoft 2007). Similarity coefficients in invertebrate species composition found in the bird diets from different sites were calculated by formulas of Jaccard ($C_j = 100 \times j / (a + b - j)$) and Sørensen ($C_s = 100 \times 2j / (a + b)$), 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 ranged from 0 (no similarity between compared parameters) to 1 (complete similarity).

Results

A total of 75 taxa of invertebrates were found in the diet of spotted flycatchers (Table 2). 94.8% ($n = 706$) of them were representatives of the class Insecta. A major part of forage consisted of flying insects, primarily imagoes of Diptera (39.8%), Hymenoptera (24.2%), Lepidoptera (17.2%), Odonata (7.9%), and Coleoptera (5.1%). All the other orders made up less than 5.0% (Figure 1 A, B). Among Diptera, such rather large objects as imagoes of Sarcophagidae (16.1%) and Tabanidae (6.6%) are worth mentioning chased by birds on open forest glades. The bird feeding abilities are primarily connected with their foraging strategy by swooping from a perch for short distances to snap a flying insect. Catching adult representatives of Sarcophagidae, spotted flycatchers control their numbers in the wild, since only flycatchers (*Ficedulla, Muscicapa*) due to their quick reflexes, can hunt flies of this family.

Among Hymenoptera, adult Formicidae played a significant role (22.7%) in the diet of spotted flycatchers; the birds caught them on trunks and skeletal branches of trees. Among ants ($n = 150$), *L. alienus* (54.7%), *P. coarctata* (18.7%), and *T. caespitum* (12.0%) predominated as prey.

Representatives of Lepidoptera took a secondary part in the diet, though being the main forage of nestlings during the first four days of their life, because in this period adult birds mainly bring caterpillars of Noctuidae (7.2%), Pyralidae (1.5%) and other families of Lepidoptera. The proportion of Lepidoptera imagoes in the diet is insignificant due to the fact that the rapid swoops from the perch are poorly coordinated with a trembling flight of butterflies moving in a zigzag and their manner of sloping up and down during their chase. Failures during hunting of birds fix their negative attitude towards such hardly accessible prey. This results in frequent ignoring of adult butterflies by spotted flycatchers.

Feeding frequency of nestlings depends on the number of prey items brought by an adult bird for one flight. Spotted flycatchers belong to the insectivorous birds that do not gather many insects in the bill. In this event, everything depends on the size of the prey, and the latter may be different at different hours of the day when the illumination of hunting areas changes. A distant manoeuvrable swoop into the air from the perch requires more energy as opposed to picking insects off twigs of trees and shrubs. The maximum number of prey specimens found in the forage sample is 6, but most of birds return to their nest after catching only one prey item.

Table 2. Macrofauna in the diet of spotted flycatchers (*Muscicapa striata* Pallas, 1764). Trophic macrofauna groups: ph – phytophages, z – zoophages, p – polyphages, s – saprophages, n – necrophages. MS1-MS4 – model sites, described in Materials and methods

Order	Family	Species	Trophic group	MS1	MS2	MS4	MS3	Total	Notes
Odonata	Libellulidae	*Sympetrum* sp.	z	1	2	1	0	4	imago
	Coenagrionidae	Coenagrionidae sp.	z	2	1	0	0	3	–"–
	Aeschnidae	Aeschnidae sp.	z	0	5	5	2	12	–"–
	Gomphidae	*Gomphus vulgatissimus* (Linnaeus, 1758)	z	0	3	1	0	4	–"–
	Cordulidae	*Somatochlora metallica* (Van der Linden, 1825)	z	3	2	0	0	5	–"–
	Libellulidae	Libellulidae sp.	z	0	11	3	5	19	–"–
		Libellula quadrimaculata Linnaeus, 1758	z	0	6	0	0	6	–"–
Orthoptera	Gryllidae	*Modicogryllus frontalis* (Fieber, 1844)	p	0	2	0	0	2	–"–
		Gryllus sp.	p	0	1	0	0	1	–"–
	Acrididae	*Chorthippus brunneus* (Thunberg, 1815)	ph	0	2	0	0	2	–"–
Psocoptera	–	Psocoptera sp	s	0	2	1	1	4	–"–
Hemiptera	Cicadidae	Cicadidae sp.	ph	0	2	0	0	2	larva
	Miridae	*Megacoelum* sp.	z	0	1	0	0	1	imago
	Pentatomidae	*Palomena prasina* (Linnaeus, 1761)	ph	0	1	0	0	1	–"–
Coleoptera	Carabidae	Carabidae sp.	z	0	1	0	0	1	larva
	Silphidae	Silphidae sp.	n	0	1	2	1	4	imago
		Silpha sp.	n	3	0	0	0	3	2 imagoes + 1 larva
		Nicrophorus sp.	n	0	1	0	0	1	imago
	Scarabaeidae	*Hoplia parvula* Krynicky, 1832	ph	0	1	1	3	5	–"–
		Phyllopertha horticola (Linnaeus, 1758)	ph	0	3	3	2	8	6 imagoes + 2 larvae
		Serica brunnea (Linnaeus, 1758)	ph	0	1	1	0	2	imago
		Scarabaeidae sp.	ph	0	1	0	0	1	–"–
	Buprestidae	*Eurythyrea quercus* (Herbst, 1780)	ph	0	1	0	0	1	–"–
	Alleculidae	*Pseudocistela ceramboides* (Linnaeus, 1761)	s	0	1	1	0	2	–"–
	Rhipiphoridae	*Metoecus paradoxus* (Linnaeus, 1761)	z	2	0	0	0	2	–"–
	Chrysomelidae	Chrysomelidae sp.	ph	0	1	0	1	2	–"–
	Byturidae	Byturidae sp.	ph	2	0	0	0	2	–"–
Neuroptera	Chrysopidae	*Chrysopa* sp.	z	0	2	0	0	2	–"–
	Coniopterigidae	Coniopterigidae sp.	z	0	1	0	0	1	–"–
Hymenoptera	Tenthredinidae	Tenthredinidae sp.	hp	0	1	1	1	3	larva
	Xiphydriidae	*Xiphydria* sp.	ph	0	1	0	0	1	imago
	Ichneumonidae	Ichneumonidae sp.	z	0	0	0	4	4	–"–
	Vespidae	Vespidae sp.	z	0	0	1	0	1	–"–
	Sphecidae	Sphecidae sp.	z	0	2	0	0	2	–"–
	Braconidae	Braconidae sp.	z	0	1	0	0	1	–"–
	Formicidae	*Tetramorium caespitum* (Linnaeus, 1758)	p	4	6	3	5	18	–"–
		Lasius niger (Linnaeus, 1758)	p	0	1	0	1	2	–"–
		Lasius sp.	p	2	3	2	3	10	–"–
		Lasius alienus (Forster, 1850)	p	22	20	25	15	82	–"–
		Formica cunicularia Latreille, 1798	p	0	4	1	1	6	–"–
		Myrmica sp.	p	1	1	1	1	4	–"–
Raphidioptera	Rhaphidiidae	*Rhaphidia flavipes* (Stein, 1863)	z	0	1	0	0	1	–"–
Trichoptera	Limnophilidae	Limnophilidae sp.	s	0	1	0	0	1	–"–
	Phryganeidae	*Phryganea grandis* Linnaeus, 1758	s	0	10	0	0	10	–"–
	–	Trichoptera sp.	z	5	3	2	0	10	–"–
Lepidoptera	Cossidae	*Phragmataecia castaneae* (Hubner, 1790)	ph	0	1	0	0	1	–"–
	Tortricidae	Tortricidae sp.	ph	5	6	4	3	18	–"–
	Nymphalidae	Nymphalidae sp.	ph	2	4	0	0	6	–"–
	Noctuidae	Noctuidae sp.	ph	2	18	16	12	48	–"–
	Geometridae	Geometridae sp.	ph	0	0	4	0	4	–"–
	Pieridae	Pieridae sp.	ph	0	2	0	0	2	–"–
	Pyralidae	Pyralidae sp.	ph	3	3	2	2	10	–"–
	Limacodidae	*Apoda limacodes* (Hufnagel, 1766)	ph	0	4	0	0	4	–"–

Table 2. (*Continued*)

	Gelechiidae	Gelechiidae sp.	ph	2	0	0	0	2	–"–
	–	Lepidoptera sp.	ph	0	8	7	5	20	5 imagoes + 15 larvae
	Tipulidae	*Tipula* sp.	s	2	2	2	4	10	imago
	Culicidae	*Culex pipiens* Linnaeus, 1758	s	0	0	0	6	6	–"–
	Stratiomyidae	*Chloromyia formosa* (Scopoli, 1763)	s	8	12	8	4	32	–"–
		Stratiomyidae sp.	s	0	2	0	0	2	–"–
	Tabanidae	*Tabanus bovinus* Linnaeus, 1758	z	1	1	0	0	2	–"–
		Tabanus sp.	z	0	0	4	0	4	–"–
		Tabanidae sp.	z	0	8	12	14	34	–"–
	Asilidae	Asilidae sp.	z	0	5	4	0	9	–"–
Diptera		*Syrphus* sp.	z	2	2	0	0	4	–"–
	Syrphidae	*Syritta pipiens* (Linnaeus, 1758)	s	0	2	0	0	2	–"–
		Eristalis tenax (Linnaeus, 1758)	s	2	8	6	0	16	–"–
		Eristalis sp.	s	0	4	0	0	4	–"–
	Muscidae	Muscidae sp.	s	0	0	0	4	4	–"–
	Sarcophagidae	Sarcophagidae sp.	n	15	45	31	17	108	86 imagoes + 22 pupae
	Tachinidae	Tachinidae sp.	n	3	7	8	6	24	imago
	–	Diptera sp.	s	3	3	0	0	6	–"–
Arachneae	Salticidae	Salticidae sp.	z	4	8	5	5	22	–"–
Julida	Julidae	*Rossiulus kessleri* (Lochmander, 1927)	s	0	0	0	1	1	–"–
Isopoda	Porcellionidae	*Porcellio scaber* Latreille, 1804	s	0	4	0	10	14	–"–
–	–	Total	–	111	275	176	144	706	–"–

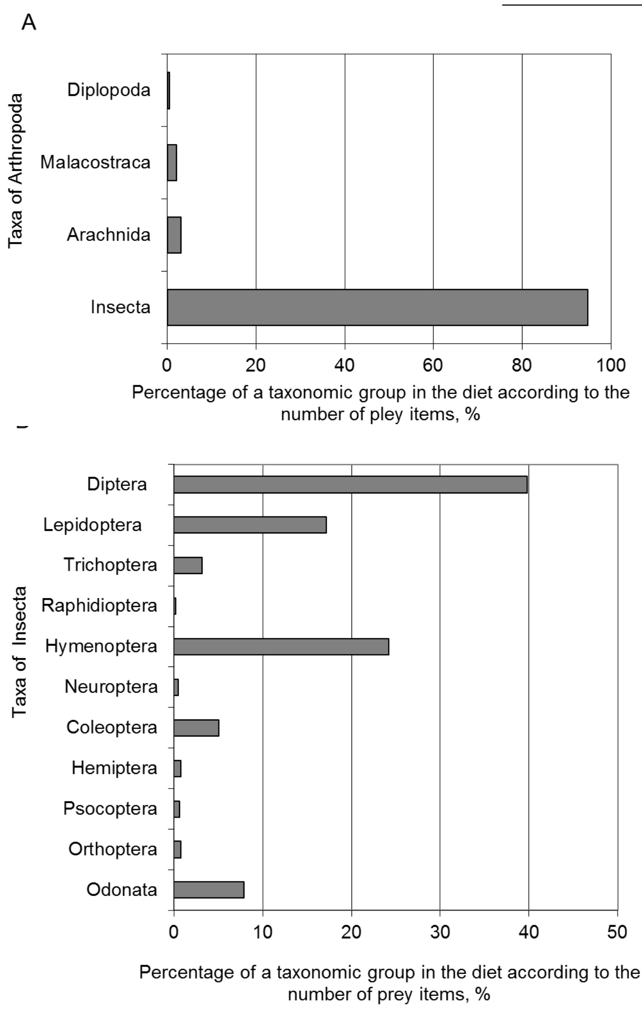

Figure 1. Diversity of trophic links of spotted flycatchers (A – main groups of invertebrates; B – main orders of insects)

The weight of food pellets significantly varies during the period of feeding chicks, averagely equalling to 0.18 g (min. 0.05, max. 0.50). The body length of prey items ranges widely (2.4–36.6 mm, on average 9.1 ± 0.34 mm); a food pellet length varies within narrower limits (5.3–23.6 mm, on average 13.4 ± 0.45 mm).

The nestling diet of spotted flycatchers was dominated by quite large items (often more than 30 mm) at the imago stage. In most cases, the prey size does not depend on the age of nestlings. However, parent birds soften large chitinized items with their bills and tear off the wings of butterflies and moths. Spotted flycatchers hunt on rather large prey items to save energy, because catching of insects in flight requires energy-consumptive foraging manoeuvres. The vast majority of specimens belong to flying insects. This coincides with the fact that, according to our data, the proportion of spotted flycatcher's foraging manoeuvres in the air makes up 96.2%.

In all the studied model sites the nestling diet of spotted flycatchers was characterized by the prevalence of zoophages (31.7%), being consumers of the 2nd and 3^{d} orders. Smaller proportions of phytophagous (29.4%), saprophagous (20.1%), polyphagous (12.0%), and necrophagous (6.7%) insects were found (Figure 2A).

According to the number of taken prey items, the diet of spotted flycatchers almost equally represented various trophic groups. Zoophages dominated (22%; *n* = 706). Polyphages and phytophages ranked the second place (21% each), and then followed by necrophages (20.0%) and saprophages (16%) (Figure 2B).

Environmental conditions play an important role affecting the structure of bird forage. Equal forage intake of flycatchers within all the investigated sites should

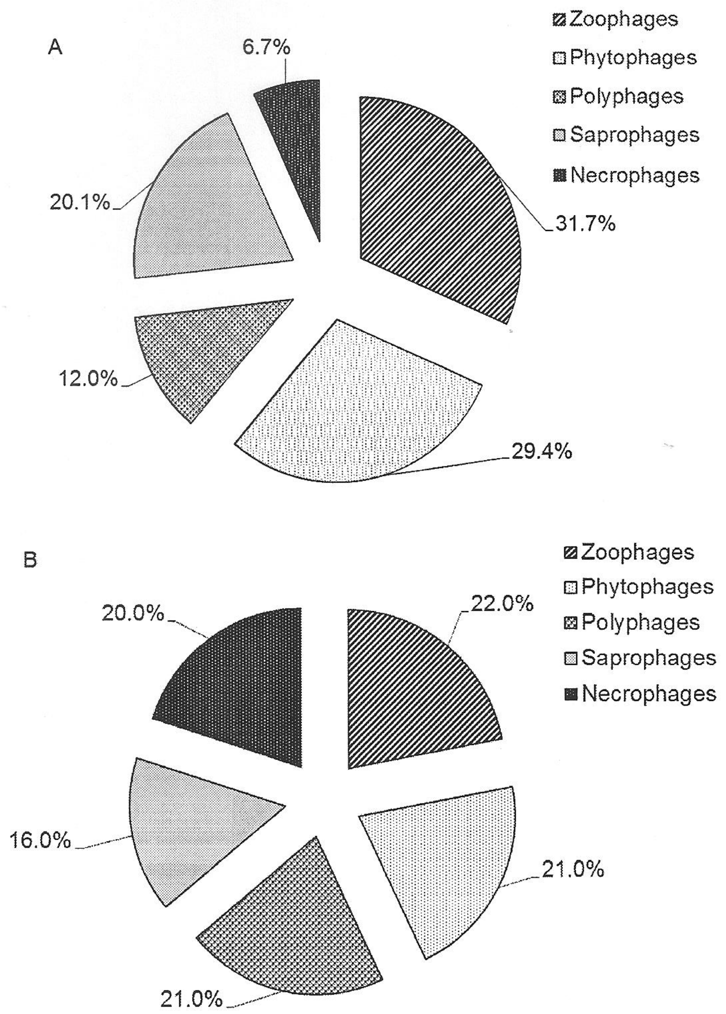

Figure 2. Distribution of prey items of spotted flycatchers per trophic groups in all model sites (A – percentage according to the number of species, B – percentage according to the number of prey items)

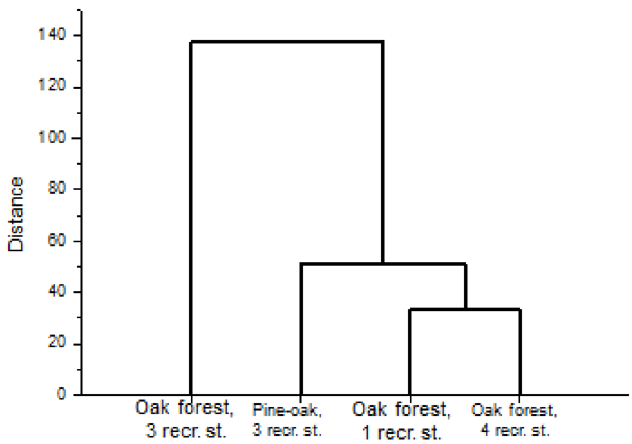

Figure 3. Similarity of trophic links of spotted flycatchers in different model sites of North-Eastern Ukraine

Table 3. Similarity of invertebrates in the diet of spotted flycatchers in different landscapes

Pair of model sites	Number of invertebrate species	Similarity index	
		Jaccard	Sorensen
MS2 – MS4	30	46.2	63.2
MS2 – MS3	26	39.4	56.5
MS3 – MS4	23	57.5	73.0
MS1 – MS2	21	31.3	47.7
MS1 – MS4	16	37.2	54.2
MS1 – MS3	13	30.2	23.2

be noted. The most favourable foraging conditions for flycatchers were found in protected natural areas. The highest taxa diversity was found in model sites 2 and 4: 62 and 33 taxa, respectively. It should be noted that the taxa diversity in the nestling diet in model site 3 was higher compared to model site 1 showing that birds could switch among different invertebrate species thus causing the formation of ecological pre-adaptations and further synanthropization of the species (Table 1).

The similarity analysis of the prey species found in the nestling diet shows the highest similarity between the natural protected areas of oak forests MS2 and MS1 for 30 species of invertebrates. The Jaccard and Sørensen indices constitute 46.2 and 63.2, respectively (Table 3). According to similarity indices, the most similar is the food of nestlings in MS3 and MS4 (the highest values of Jaccard and Sørensen indices for 23 taxa of invertebrates were 57.5 and 73.0, respectively.

The Shannon diversity index in the diet of spotted flycatchers increases from 2.86 (MS1) and 2.95 (MS4) to 3.07 (MS3) and 3.56 (MS2). Taking into account the obtained results the similarity is shown as a dendrogram (Figure 3).

Discussion

Spotted flycatchers dominate in light sparse forests with a loose understory and open glades. The selection of nesting areas depends on the availability of open space under the crown and absence of dense understory. The canopy structure of trees and shrubs does not influence the nesting site choosing. Birds hunt sitting on branches in the outer part of the tree crown or on short broken branches near the trunk (Davies 1977, Peck 1989). Due to their foraging pattern – catching of invertebrates in the air – the spotted flycatchers mitigate trophic competition with other insectivorous birds. In all model sites, investigated in this study, Diptera (39.8%) and Hymenoptera (24.2%), and in Nature Reserve “Les na Vorskle” Diptera and Lepidoptera prevailed in the species diet (Berezantseva 1998). Alternative foraging activity was rarely used (Davies 1976, Randler 2010). Findings of other authors (Marochkina et al. 2005, Markova 2016a, 2016b) indicate that these birds can switch to aquatic representatives of the order Coleoptera. During a prolonged spring flood the spotted flycatchers hover over the water surface in a trembling flight, then make a rapid swoop and snap invertebrates that are close to the water surface. Trophic links of spotted flycatchers are similar to those of collared flycatchers, which are also characterized by the prevalence of zoophages in their diet (Chaplygina et al. 2015).

When flying to wintering areas, the birds eat fruits of *Cornus sanguinea* L., *Sambucus nigra* L. and *Rubus* sp. The dominance of Dogwood fruit in their diet is probably explained by the high content of lipids necessary for birds before the long-distance flight (Hernandez 2009).

The equal use of prey items in different model sites of the North-Eastern Ukraine and the lack of any certain regularity in the consumption of representatives from various trophic groups enable spotted flycatchers to live in anthropogenically transformed areas. The number of spotted flycatchers and other insectivorous birds can be increased by placing artificial nests. This biotechnological method allows supporting organic farming and contributes to higher biodiversity, for instance, in vineyards (Caprio and Rolando 2017). Spotted flycatchers positively react to the cement-sawdust nests, placed by us in the recreational zone of National Nature Park “Homilshanski Lisy” (Chaplygina and Savynska 2012).

Conclusion

The diet of spotted flycatchers in anthropogenically transformed sites is quite diverse. This allows birds to change the species composition of their prey depending on the dominance of insects in a particular model site. Investigation of the diet of other species of insectivorous birds in the same model sites will help to identify differentiation characteristics of trophic niches of various insectivorous bird species. The development of similar studies will assist in the determination of functioning features of trophic networks in natural and anthropogenically transformed territories, where a special role in the network regulation is played by polyphages with a wide range of prey, such as spotted flycatchers.

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