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TROPHIC LINKS OF THE BLACKBIRD (*Turdus merula* Linnaeus, 1758) IN TRANSFORMED FOREST ECOSYSTEMS OF NORTH-EASTERN UKRAINE

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Abstract

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The blackbird (*Turdus merula* Linnaeus, 1758; Passeriformes, Turdidae) diet was studied to contribute to the conservation of the species population in transformed forests of the north-eastern part of Ukraine. Four forest ecosystems were studied: 3 model sites in the oak forests, transformed under intensive recreation pressure, and 1 model site in a pine-oak forest. A total of 44 invertebrate taxa, dominated by Insecta (78.1%, n = 1075), were found. The order Lepidoptera (63.5%) prevailed. In the diet of blackbird nestlings, the highest number of taxa (37.1–52.2%) was represented by phytophages. The phytophagous species also constituted the majority of the consumed prey items (58.8– 72.0%). Environmental conditions provided an important effect on the diet structure. The most favourable foraging conditions for the species were found in protected natural areas. According to the analysis, the blackbird foraging efficiency was similar in all the studied sites. The highest biodiversity indices were found in a protected area of Homilshanski Forests National Nature Park. Results of the research have indicated a crucial role of *T. merula* in the population management of potentially dangerous agricultural pests.

Key words: foraging stereotype, diet; dendrophilous birds, zoophages, phytophages, saprophages.

Introduction

The increasing rate of anthropogenic environmental changes, recorded since the second half of the 20th century, has led to the formation of urban coenoses (Blinkova, Shupova, 2017). To monitor the changes, birds are often used, since their mobility make them convenient indicators of the environment (Gregory et al., 2003; Blair, Johnson, 2008; Bulakhov et al., 2008; Chaplygina et al., 2019). Therefore, studies on the status of insectivorous passerines in the natural communities, exposed to a growing anthropogenic pressure, is one of the main objectives in the contemporary ornithology (Assandri et al., 2017).

The blackbird (*Turdus merula* Linnaeus, 1758) is a common insectivorous bird and a principal contributor to forest ecosystem communities of the temperate climate zone (Amar

et al., 2006; Domokos, Domokos, 2016). It is also a migrant of global conservation concern (Bern Convention) (Newton, 2007) and studies on the foraging ecology of the species will definitely assist to its conservation. It has been already revealed that habitat conditions of *T. merula* are crucial for the successful breeding and stability of its population in forests of Turkey (Karakava, Arican, 2015), Germany (Batary et al., 2014), Sweden (Felton et al., 2016), Romania (Domokos, Domokos, 2016), Spain (Moreno-Rueda, Pizzaro, 2009; Peris, Montelongo, 2014), and countries of Southern Asia (Hamer et al., 2015). The role of artificial light for blackbirds when they search for forage has been also studied (Russ et al., 2015). The letter is especially vital for the north-eastern part of Ukraine, where the natural communities experience strong transformation (Brygadyrenko, 2015; Chaplygina et al., 2016a; Shupova, 2017). In addition, the knowledge of foraging patterns of insectivorous birds is important to prevent outbreaks of the arthropods, being potential carriers of dangerous human diseases (Anderson, Magnarelli, 1993; Lommano et al., 2014), and to mitigate outbreaks of forestry and agricultural pests (Faly, Brygadyrenko, 2014; Chaplygina et al., 2015; Caprio, Rolando, 2017). It also gives an opportunity to control bird flocks which may otherwise destroy part of the harvest (Barnard, 1980; Paralikidis et al., 2009).

Different literary sources discuss a process of the emergence and expansion of synurbanised blackbird populations in European cities (Shukshin, Bokotey, 2016). However, the authors of this paper have found a forest type of the species in the study area. The high number of blackbirds in the forests of North-Eastern Ukraine allows considering it as a subdominant species (Chaplygina, Savinskaya, 2016; Chaplygina, 2018). The timing of this bird migrations (Nadtochiy, Chaplygina, 2010) and the characteristics of their nest locations in Ukraine (Chaplygina, 2009) have been studied as well.

To-date, some researchers suggest that foraging patterns of the species can determine the management and conservation of the bird diversity in natural and transformed areas (Amrhein, 2013; Korňan, Adamík, 2017; Chaplygina, 2018). Changes in breeding habitats are assumed to be potential causes of the reduction of birds in the nesting season (Kirby et al., 2005; Paker et al., 2014). Consequently, they lead to the decline in invertebrates and the loss of feeding habitats for ground-foraging birds (Chaplygina, Savinskaya, 2016; Chaplygina et al., 2016b; Markova, 2016). One of the ways to support the species number and improve the foraging and distribution conditions are suburban river catchments, proposed in South Africa (Suri et al., 2017).

The author have already studied the blackbirds in the forest-steppe zone of Ukraine in comparison with other thrush species (Chaplygina, 2000). However, the diet of this bird in transformed areas requires more thorough inverstigation as it is the main factor that limits the species number.

The aim of this study is to analyse a qualitative and quantitative diet structure and a foraging pattern of the blackbird to reveal trophic links and enhance the conservation of the species populations in the transformed ecosystems of North-Eastern Ukraine.

Material and methods

The research was carried out over the period 2010–2017, in the forest-steppe zone of Left-bank Ukraine (Kharkiv and Sumy regions). The diet structure of the blackbird nestlings was studied in an upland oak forest of Homilshanski Forests

T a b l e 1. Macrofauna species in the blackbird diet (*Turdus merula* Linnaeus, 1758).

Taxon name			Trophic group	MS1	MS2	MS3	MS4	Total Abs (%)	Notes
Order	Family	Species							
1	2	3	4	5	6	7	8	9	10
Odonata	Gryllidae	*Gryllus* sp.	p		8	11		19 (1.8)	Imag.
Coleoptera	Carabidae	Carabidae sp.	z				3	3 (0.3)	-//-
		Ophonus rufipes (De Geer, 1774)	z	16	18			34 (3.2)	-//-
	Silphidae	Silphidae sp.	n				2	2 (0.2)	-//-
		Nicrophorus vespilloides (Herbst,1783)	n	2	3			5 (0.5)	-//-
		Oeceoptoma thoracica (Linnaeus, 1758)	n		3			3 (0.3)	-//-
	Staphylinidae	Philonthus sp.	z		3			3 (0.3)	-//-
	Scara-baeidae	*Anisoplia austriaca* (Herbst, 1783)	ph	8	2	13	3	26 (2.4)	-//-
		Cetonia aurata (Linnaeus,1758)	ph		8			8 (0.7)	-//-
		Scarabaeidae sp.	ph	20	11	11	5	47 (4.4)	-//-
	Cantharidae	*Rhagonicha fulva* (Scopoli, 1763)	z		5			5 (0.5)	-//-
		Cantharidae sp.	z		7			7 (0.7)	-//-
	Elateridae	*Elater sanguineus* (Linnaeus,1758)	p	13	13			26 (2.4)	-//-
		Athous sp.	p		6		4	10 (0.9)	-//-
		Elateridae sp.	p		2	2	2	6 (0.6)	-//-
	Chrysomelidae	*Chrysomela* sp.	ph	4	3			7 (0.7)	-//-
	Curculionidae	*Polydrusus* sp.	ph				2	2 (0.2)	-//-
		Hypera sp.	ph	7				7 (0.7)	-//-
		Curculionidae sp.	ph				4	4 (0.4)	-//-
Hymenoptera	Tenthredinidae	Tenthredinidae sp.	ph	13	15			28 (2.6)	-//-
	Ichneumonidae	Ichneumonidae sp.	z	10				10 (0.9)	-//-
	Formicidae	*Mirmica* sp.	z	6			2	8 (0.8)	-//-
Lepidoptera		Lepidoptera sp.	ph			7		7 (0.7)	-//-
	Tortricidae	Tortricidae sp.	ph	8	6	12	8	34 (3.2)	5 imag.+ 29 larv
	Pyralidoidea	Pyralidoidea sp.	ph		68			68 (6.3)	62 imag.+ 6 larv
	Nymphalidae	Noctuidae sp.	ph	6	11	14	17	48 (4.5)	37 imag.+ 11 larv
	Geometridae	Geometridae sp.	ph	40	53	87	65	245 (22.8)	32 imag.+ 213 larv
	Pieridae	Pieridae sp.	ph	18	19	23	26	86 (8.0)	5 imag.+ 81 larv
	Lycaenidae	Lycaenidae sp.	ph	15	8			23 (2.1)	23 larv
	Syntomididae	Notodontidae sp.	ph	12	10			22 (2.1)	1 imag.+ 21 larv
Diptera	Tipulidae	Tipula sp.	ph	13	7			20 (1.9)	imag.
	Culicidae	*Culex pipiens* (Linnaeus, 1758)	z		2			2 (0.2)	-//-
	Stratiomyidae	*Sargus cuprarius* (Linnaeus, 1758)	s	4	1			5 (0.5)	-//-
	Syrphidae	*Chrysotoxum festivum* (Linnaeus, 1758)	z		6			6 (0.6)	-//-
	Muscidae	Muscidae sp.	s			3		3 (0.3)	-//-
	Calliphoridae	Calliphoridae sp.	z		1			1 (0.1)	-//-
Araneae	Araneae	Aranea sp.	z	11	9			20 (0.2)	5 imag.+15 juv.
Julida	Julidae	Rossiulus kessleri (Lohmander, 1927)	s		1	7	9	17 (1.6)	imag.
Isopoda	Oniscoidea	*Oniscus asellus* (Linnaeus,1758)	s	6	5	22	23	56 (5.2)	-//-
	Asellidae	*Asellus aquaticus* (Linnaeus,1758)	s	13	5		8	26 (2.4)	-//-
Lumbriculida	Arionidae	*Arion subfuscus* (Draparnaud, 1805)	s		12			12 (1.1)	-//-
	Lumbricidae	*Dendrodrilus rubidus* (Eisen, 1874).	s	12	6	6		24 (2.2)	-//-
		Lumbricus terrestris (Linnaeus, 1758)	s	22	16	14	13	65 (6.1)	-//-
		Apporectodea rosea (Savigny 1826)	s		15			15 (1.4)	-//-
		Total		279	368	232	196	1075 (100)	

Notes: macrofauna trophic groups: ph – phytophages; z – zoophages; p – polyphages; s – saprophages; n – necrophages; MS1–MS4 – model sites; described in Materials and methods; imag. – imagoes; larv. – larvae; juv. – juveniles (immature specimens).

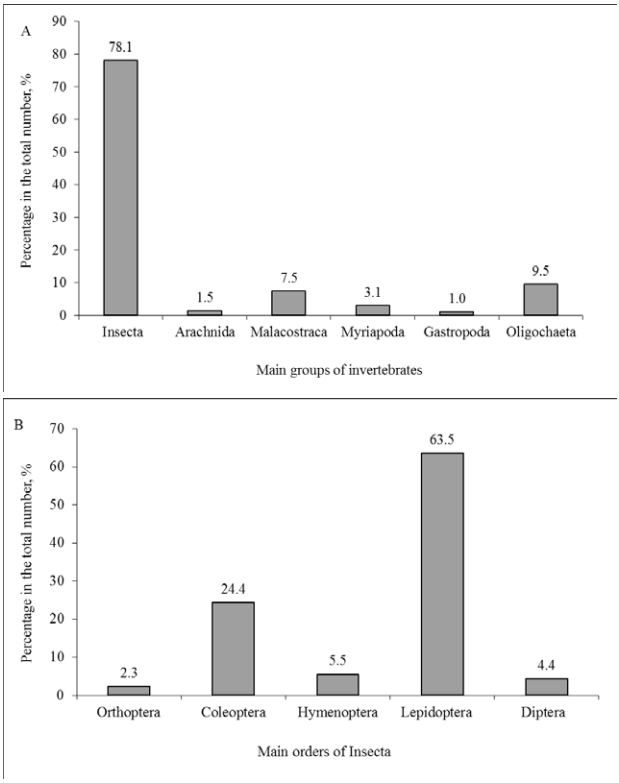

Fig. 1. Diversity of the blackbird trophic links: A – main groups of invertebrates; B – main orders of insects.

National Nature Park (Zmiiv District), in a forest park of Kharkiv, in a pine-oak forest of Hetmanskyi National Nature Park (Okhtyrka District), and in Vakalivshchyna Area (Sumy Region). According to Gensiruk's classification (2002), three model sites, selected in the oak forests, were characterized by different stages of recreational digression (transformed as a result of heavy recreation pressure). The fourth model site was located in a pine-oak forest.

Model site 1 (MS1) is situated far from settlements, on the eastern bedrock bank of the Psel River in Vakalivshchyna Area and is represented by an oak forest mixed with some maple and linden trees. The crown closure makes up circa 85% (Table 1), and the proportion of damaged trees does not exceed 10% of their total number. The understory and shrub layers, without traits of noticeable damage, are typical for the habitat. The grassy cover is mainly undisturbed and typical for this 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, based on the area of forest paths, comprised 5%. Model site 1 has the 1st stage of recreational digression.

Model site 2 (MS2) is located within a recreational zone of Homilshanski Forests National Nature Park, in the vicinities of research sites of H. S. Skovoroda Kharkiv National Pedagogical University and Karazin Kharkiv National University. This area is exposed to intensive recreation pressure during the bird breeding season. The forest 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 places. The forest floor is slightly disturbed. Forest paths cover up to 30% of the site. This model site has the 3d stage of recreation digression, and the management of recreation pressure is required.

Model site 3 (MS3) is in the forest park of Kharkiv City. It is a predominantly natural upland oak forest with a small admixture of artificially planted species, located in the interfluve of the Lopan and Kharkiv rivers. The crown closure is circa 60%. The species, typical for the forest edge, as well as meadow, riparian, aquatic, and ruderal plants are recorded. There is an extended network of forest paths and roads, used for jogging. Increased recreation pressure leads to the expansion of open glades and the increasing density of paths. The maple *Acer negundo* forms dense thickets at the forest edge; in some places, garbage dumps can be found. The number of ruderal species increases as approaching the forest border. The site has the 4th level of recreational digression.

Model site 4 (MS4) is situated in Hetmanskyi National Nature Park, in a pine forest near the villages of Kamianka and Klymetovo, in the area called "Lytovskyi Bir". The oak-pine and maple-linden-oak woodlands near Kamianka have slight signs of human-caused disturbance; diseased trees are found; the crown closure is circa 20%. The understory and shrub layer are typical for the habitat; 5–20% of the trees have insignificant damages. The grassy layer

includes meadow grasses (5–10%) that is not typical for this type of the forest. The forest floor is slightly disturbed. The area of paths is not extensive and covers up to 10% of the model site. In the section, lying in Lytovskyi Bir, the area of paths exceeds 20%. In July-August, the recreation pressure increases due to a high number of visitors. However, most bird species finish the breeding season before that time. The site has the 3d level of recreational digression.

A total of 48 blackbird nests with 154 nestlings were inspected and 768 food pellets were collected. Of 1,075 invertebrate specimens, found in the model sites, 279 (taken from 42 nestlings) were in the oak forest MS2, 368 (from 50 nestlings) in the pine-oak forest MS4, 232 (from 34 nestlings) in the oak forest MS1, and 196 (from 28 nestlings) in the oak forest MS3.

The research was carried out from May 25th to June 15th (period 2010–2017) in the first half of the day. The nestling diet was investigated by applying neck ligatures to 5- to 8-day-old chicks (Mal'chevskij, Kadochnikov, 1953). The forage samples were fixed in a 70% solution of ethanol, and the arthropods were further identified in the laboratory. All the invertebrates were identified to the species, genus or family (in case of significant damage) by Associate Professor PhD Viktor Gramma by standard methods, using reference books.

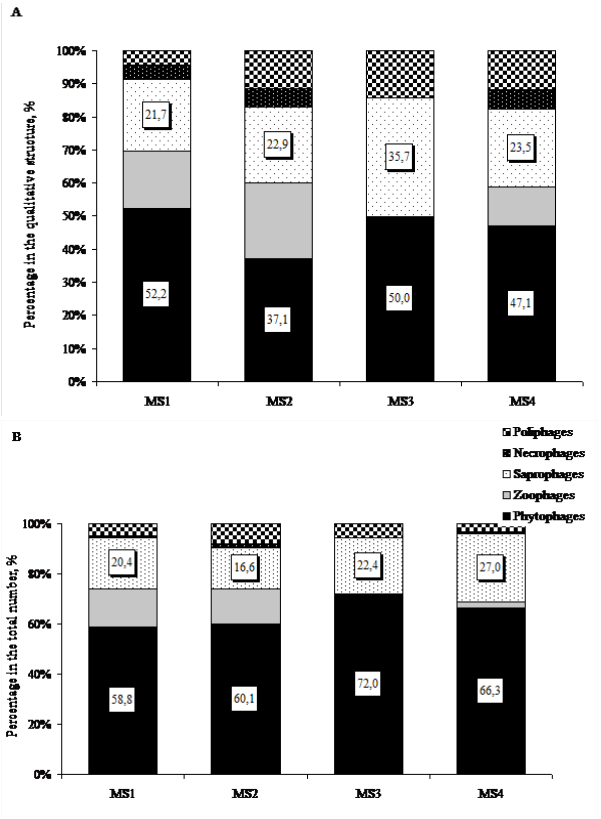

Fig. 2. Distribution of blackbird trophic groups in the model sites: *A*– percentage in the qualitative structure, *B* – percentage in the total number.

Statistical treatment of the data was performed in the programme Statistica 8.0 (StatSoft Inc., USA). Similarity coefficients in the species composition of the invertebrates, found in the diet in different sites, were calculated using the formulas of Jaccard ($C_j = 100 \times j / (a + b - j)$) and Sorensen ($C_s = 100 \times 2j / (a + b)$), where j – the number of invertebrate species found in both groups, a – the number of species in the first group, b – the number of species in the second group. These coefficients ranged from 0 (no similarity between compared parameters) to 1 (complete similarity).

Results

The blackbird (*Turdus merula* L.) belongs to the birds, collecting forage in the above-ground layer and, ethologically, is associated with the forest areas rich in herpetobionts. All the birds feed on the ground surface, not pulling invertebrates out of the ground but finding their prey under fallen leaves, stirring the litter, which provides a positive effect on the ground-forming processes. Thus, the species prefer habitats with fallen leaves and well-developed ground litter, upper layers of which are difficult to transform. The birds are often found in the

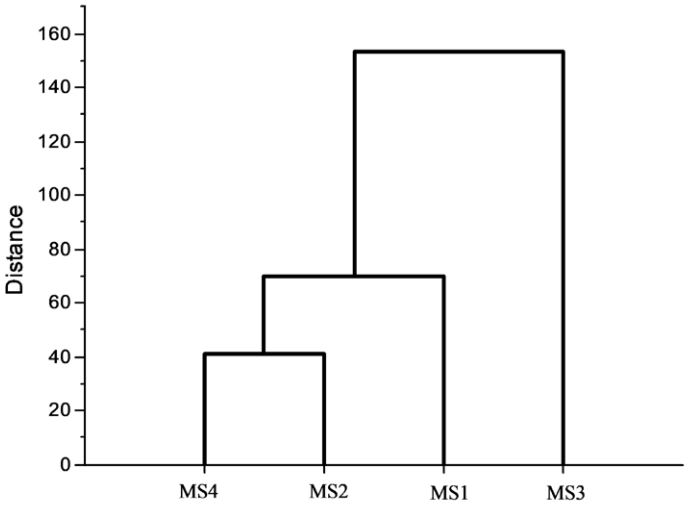

Fig. 3. The similarity of the blackbird trophic links in the studied sites of North-Eastern Ukraine.

T a b l e 2. Indices of diet diversity of the blackbird in model sites of North-Eastern Ukraine.

Parameters	MS1	MS2	MS3	MS4
Number of species	23	35	14	17
Total number of specimens	279	368	232	196
Margalef index	3.91	5.75	2.39	3.03
Menhinnik index	1.38	1.82	0.92	1.21
Shannon index	2.96	3.05	2.17	2.25
Simpson dominance index	0.92	0.91	0.94	0.92
Simpson diversity index	1.09	1.10	1.06	1.09
Berger-Parker dominance index	0.14	0.18	0.38	0.33
McIntosh diversity index	69.25	100.60	98.37	78.66
McIntosh dominance index	0.80	0.77	0.62	0.64
McIntosh evenness	0.95	0.87	0.79	0.79
Pielow evenness	0.66	0.60	0.57	0.55

T a b l e 3. Invertebrate similarity in the blackbird diet in model sites of North-Eastern Ukraine.

Pair of model sites	Number of invertebrate species	Similarity index	
		Jaccard	Sorensen
MS1 – MS2	20	52.6	69.0
MS3 – MS4	10	47.6	64.5
MS1 – MS4	10	33.3	50.0
MS2 – MS3	12	32.4	49.0
MS1 – MS3	9	32.1	48.6
MS2 – MS4	12	30.0	46.2

areas with a pronounced microrelief of depressions, ground hills and other roughness. These conditions lead to a sharp soil moisture gradient. While feeding, a blackbird moves quickly, usually making 28.5 ± 2.5 (10–40) hops and 6.7 ± 0.8 (2–10) pecks per minute. The duration of a visual inspection of prey is 1–6 sec.

Trophic links of the blackbird with 44 taxa of invertebrates were revealed (Table 1). Representatives of Insecta (78.1%; n = 1075; of them Lepidoptera caterpillars - 61.5%; n=840) constituted an absolute majority, while Oligochaeta (9.7%) and Malacostraca (7.6%) were found in smaller percentages. Other invertebrate groups (1.0 –3.1%) were insignificant (Figs 1a, b). The birds pick up Lepidoptera caterpillars from grassy vegetation or from the ground surface, when the latter descend to the ground for pupation or fall on the grass due to the strong wind.

The diet of the blackbird nestlings in all the model sites was dominated by phytophages: from 37.1% (MS2) and 47.1% (MS4) to 52.2% (MS1) and 59.0% (MS3) in the total number of the species consumed (Fig. 2a). Phytophages also prevailed among prey items: 58.8% (MS1), 60.1% (MS2), 66.3% (MS4) and 72.0% (MS3) (Fig. 2b). In the breeding season, the blackbirds eradicate phytophages of forest plantations, in particular, larvae of Lepidoptera and Diptera, beetles from the families Curculionidae, Scarabaeidae, etc. Irrespective of the availability of saprophages (Oligochaeta) in their diet, the blackbirds definitely belong to valuable insectivorous birds.

The highest biodiversity indices were revealed in trophic links of the blackbird nestlings in the oak forest with the 3^{d} stage of recreational digression (Fig. 3). However, with the increase of the environment transformation degree in the oak forests with the 1st and 5th stages of recreational digression, the indices show a decreasing trend. McIntosh's and Pielow's evenness indices indicate similar use of prey items in different model sites (Table 2), thus confirming the absence of specificity in the blackbird diet (Aleksandrova, 1959). Shannon diversity index grows from 2.17 (MS3) and 2.25 (MS4) to 2.96 (MS1) and 3.05 (MS2).

Therefore, the blackbirds demonstrate the highest diet similarity in the natural protected areas of the oak forest with the 3^{d} stage of recreational digression (MS2) and in the pine-oak forest with the 3^{d} stage of recreational digression (MS4). Trophic links of the blackbird in MS3 were significantly different (Table 3).

Discussion

In general, the blackbirds play a significant role in the studied ecosystems, regulating the number of invertebrates (Bulakhov et al., 2008). If compare different species for one nesting cycle (averagely, 5 chicks), the song thrushes consume 13,850 g of biological production, the blackbirds – 18,360 g, and the fieldfares – 21,450 g (the impact of adult birds on the biomass of biocoenoses was not taken into consideration) (Chaplygina, 2000).

The blackbirds have no special diet preferences (Alexandrova, 1959) that makes them quite plastic for the occupation of anthropogenic landscapes (Chaplygina, 2000; 2018). However, we have found a foraging pattern, dominated by representatives of three groups: earthworms, caterpillars and gastropods (Berezantseva, 1997; Baranovsky, 2008). There are also myriapods (Myriapoda), mentioned in the studies of our Belarusian colleagues, as well as click beetles (Elateridae) (Abramova, Haiduk, 2017). During the migration to wintering

grounds, the birds eat fruits of *Cornus sanguinea* L., *Sambucus nigra* L. and *Rubus* sp. Their preference for the dogwood fruit is probably associated with a high content of lipids that is crucial before the long-distance migration (Hernández, 2009).

Conclusion

The blackbird diet in human-transformed areas is quite diverse and dominated by Lepidoptera caterpillars, Oligochaeta, and Mollusca. It allows the birds to change the composition of their prey species, depending on the dominance of insects in each particular model site. Further studies on the diet of other insectivorous avian species in these model sites will enhance the identification of functional characteristics of trophic networks in natural and transformed areas, a special role in which is played by polyphagous species with a wide diet range, such as the blackbird.

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