Трансформация экосистем
Ecosystem Transformation

ISSN 2619-094X Print
ISSN 2619-0931 Online
www.ecosysttrans.com

Article

Beetles (Coleoptera) in nests of the European pied flycatcher *Ficedula hypoleuca* (Pallas, 1764) in the southeast of the Ladoga area (Republic of Karelia)

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Received: 06.01.2022
Revised: 22.02.2022
Accepted: 11.03.2022
Published online: 12.05.2022

DOI: 10.23859/estr-220106
UDC 574.43; 574.38

Translated by S.V. Nikolaeva

Abstract. Invertebrates collected in the Republic of Karelia in 2016 from nests of the pied flycatcher *Ficedula hypoleuca* (Pallas, 1764) are analyzed and 516 specimens of invertebrates are identified. The vast majority of these invertebrates are Hymenoptera (ants of the genus *Camponotus*) – 46.6% and various beetles (Coleoptera) – 46.37%. An annotated list of 38 species of beetle from 22 families is presented. The beetle fauna of the studied European pied flycatcher nests is mixed and includes both nidicolous species and free-living species that are not directly related to nest microcenoses. The rare beetles species *Melandrya dubia* (Schaller, 1783) and *Otho sphondyloides* (Germar, 1818), were found.

Keywords: consortium, nidicolous, nidocenoses, diet, Russia, beetles, birds, rare species.

To cite this article. Sazhnev, A.S. et al., 2022. Beetles (Coleoptera) in nests of the European pied flycatcher *Ficedula hypoleuca* (Pallas, 1764) in the southeast of the Ladoga area (Republic of Karelia). *Ecosystem Transformation* **5** (2), 35–41. https://doi.org/10.23859/estr-220106

Introduction

The functional structure of microcenoses, or microbiotopes of nests (nidocenoses), allows them to be considered as biocenotic systems organized as consortia (Krivokhatsky, 1989). The main factor in the emergence and enrichment of the species diversity of nesting microcenoses (including parasites) is the host species, which acts as the core of the consortium. Nidicoles and other nest dwellers (consorts) act as consumers of topical (spatial) and trophic (food) resources provided by the host species and its activity. The same nesting microcenoses are often used repeatedly by birds (particularly hole nesters). Over time, the volume of substrate increases in the nest, creating conditions for expansion of microbiotic connections of nidicoles. Also, food residues of

the diet of adult birds and nestlings accumulate in the substrate (for insectivorous species these are invertebrate remains). An example of such interspecies relationships, considered in this work, is the hole-nesting species, the pied flycatcher *Ficedula hypoleuca* (Pallas, 1764) and its nesting invertebrates, in particular Coleoptera.

There are few works on non-parasitic inhabitants of the nests of *Ficedula hypoleuca*; regarding beetles, there are a few records of nidicolous Staphylinidae from the nests of various flycatchers (Lundyshev and Orlov, 2016), Histeridae, etc. (Lezhenina et al., 2009). Most of the works containing information about beetles are on the feeding of nestlings (Bel'skii and Bel'skaya, 2009a, b; Lezhenina et al., 2011; Lundberg and Alatalo, 1992; Silverin and Andersson, 1984).

Materials and methods

The material was collected in 2016 at the Mayachino Station (Republic of Karelia) of the Institute of Biology of the Karelian Scientific Center of the Russian Academy of Sciences. The station is located on the southeastern coast of Lake Ladoga in the Olonets District of the Republic of Karelia (N 60°46′ E 32°48′). To attract hole-nesting birds, wooden nestboxes with an entry hole diameter of 30–34 mm and bottom dimensions of 10×10, 10×12, or 12×12 cm were used (Blagosklonov, 1991). The bulk of artificial nesting sites (AN) were placed in lines along roads, quarterly clearings and drainage ditches in biotopes characteristic of the region. ANs were hung at a height of 1.5–1.7 m from the ground in mature pine and spruce forests, in pine-deciduous and deciduous-spruce forests, in black alder forests, as well as in young pine-deciduous forests and maturing forest stands. The distance between neighboring nesting sites varied from 20 to 100 m and averaged about 40 m. A detailed description of the study area was previously published (Artemyev, 2008).

Pied flycatcher was the most numerous bird among the inhabitants of the AN – in 2016 this species occupied 74 out of 329 surveyed nesting sites. To collect entomological material, bird nests from the AN within 1–7 days after fledging (from June 21 to July 20) were placed in two sealed plastic bags for storage and transportation (2–3 days), which was considered an integral sample. Invertebrates were sampled from the nesting material manually and using a thermal extractor (extraction for 5–10 days). A total of 36 samples were processed. The samples included invertebrates without taking into account parasitic elements (these were selected separately). Some material in the samples was represented by chitinous remains; therefore, in some cases, the identification was only possible to subfamily or genus; for whole specimens, the identification was based on the details of the external morphology and structure of the male genitalia. Identifications were made by the first author. The material is kept in alcohol in the collection of invertebrates at the I.D. Papanin Institute for Biology of Inland Waters, Russian Academy of Sciences, Borok (Borok, Russia).

Results and discussion

During the research, 516 specimens of invertebrates were found (Table 1), the vast majority of which were Hymenoptera (mainly ants of the genus *Camponotus*) – 46.6% and various Coleoptera – 46.37%, some of which were identified to species, others, due to incomplete preservation or complexity of identification, to genus and /or family.

Table 1. Number of invertebrates specimens (N) and their percentage (%) in nests of pied flycatcher (Republic of Karelia). Dominant taxa are highlighted in bold.

Taxon	N	%
Diplopoda	2	0.38
Araneae	1	0.19
Plecoptera	1	0.19
Homoptera	1	0.19
Heteroptera	4	0.76
Coleoptera	**238**	**46.37**
Lepidoptera	25	4.75
Hymenoptera	**241**	**46.60**
Diptera	3	0.57
Total	*516*	*100*

Ants are part of the pied flycatcher's dietary spectrum and, although not a preferred prey item, they sometimes form a significant part of the diet of adults and are found in the diet of nestlings (Cramp and Perrins, 1993; Lundberg and Alatalo, 1992; Silverin and Andersson, 1984). It has been established that forest areas inhabited by ants are more attractive for nesting and hatching of pied flycatcher chicks (Maslov et al., 2016), which may be due to the abundance and availability of ants as a food source when other invertebrates are lacking. This indirectly explains the significant proportion of ants (mainly head capsules) in the nesting material from our study.

Among beetles, taxa of 22 families were identified (Table 2); 38 taxa have been identified to species. The most frequently represented beetles in the collections, with the percentage of the total number of beetles, are: dendro- and chortobiont Elateridae (22.69%), herpetobionts from the family Carabidae (17.23%), horto-anthobionts Cantharidae (15.97%), and the nidicolous zoophage *Gnathoncus buyssoni* (family Histeridae) (14.71%); the latter is directly associated with nests. The first three groups of species characterize the diet of the flycatcher, and only *G. buyssoni* (along with other nidicolous species) is a true element of the consortium.

Among the recorded species, groups were distinguished based on characteristics of biology and quality of preservation: FE – nutrients not associated with nesting microcenoses (they were present in the samples mainly in the form of residues); AS – random species that could have entered the nests by accident or used them as a shelter (mainly represented by whole, but more often dead, individuals); FN – facultative nidicoles directly or indirectly associated with nests – predators, saprophages and mycetophages (found alive).

Note that the beetle fauna of the studied nests of the pied flycatcher is of a mixed nature: in addition to nidicole elements (zoophages of the families Histeridae, some Staphylinidae, saprophages of the families Dermestidae and Anobiidae), it contains free-living species that are not directly associated with nesting microcenoses and to a greater extent reflect food relations of the species-edificator of the consortium. Two species, *Anisotoma humeralis* and *Cyllodes ater*, were classified as facultative nidicoles as mycetophages associated with plasmodia of myxomycetes and agaric xylotrophic fungi, the mycelium of which can develop in nesting litter. Some species present in the nesting material are associated with water bodies: these are representatives of the amphibiotic family Scirtidae, as well as *Galerucella nymphaeae*, feeding on the aquatic plants *Nymphaea* and *Nuphar* – their presence reflects the width of the trophic niche of the flycatcher.

The nests of the pied flycatcher are complex supraterral perennial nesting microcenoses (Sazhnev and Matyukhin, 2020) closed to the free access of most beetles, which almost excludes their accidental entry into the tree hollow. However, some free-living species of beetles could enter nests not only with food for nestlings, but also independently in search of shelter in rainy weather; in the study area, ground beetles, as well as representatives of other groups of invertebrates (ants, spiders, flies, lepidopterans and centipedes), entered both empty nestboxes and those inhabited by birds.

The presence of millipedes (Diplopoda) and herpetobiont Carabidae in the material from the nests indicates both their possible inclusion in the diet of the birds, and the use of ANs by these invertebrates as shelters from adverse weather. The majority of Coleoptera in collections from nesting pied flycatchers is species capable of active flight, living in tree canopies, in shrub and grass layers, or found on flowering vegetation.

According to the previous publications, beetles make up from 4.4 to 19.7% of the diet of pied flycatcher nestlings (Bel'skii and Bels'kaya, 2009b; Lundberg and Alatalo, 1992) and are represented by both flying and flightless forms. At the same time, the composition of the food directly depends on the location of the nest and the characteristics of the populated microbiotope; in particular, in samples from nests located closer to the littoral zone, the predominance of coastal invertebrates is noted (Bakkal, 1997), which characterizes the pied flycatcher as a species that is flexible in its choice of food. In our studies, eurytopic and forest species predominate among the beetles.

Records of note for the regional fauna include the rare species *Melandrya dubia, Schizotus pectinicornis* and *Otho sphondyloides*, as well as *Ptinus fur*, cryptogenic for Europe.

Conclusions

The fauna of bird nests in its broadest sense consists of both taxa that are part of a heterotrophic consortium and are associated with the edificator species by trophic and topical relationships, as well as random species that enter nests from surrounding biotopes. Coleoptera (which accounted for 46.37% of all invertebrates in our studies) from the nests of *Ficedula hypoleuca* to a great extent reflect the food preferences of nestlings and adults of the pied flycatcher, and also give an idea of the species composition of invertebrates (including rare species) in the vicinity of the nesting areas. Most (84.13%) of the beetles in the nests of the flycatcher are represented by food remains and random species; 15.87% of the beetles found were classified as facultative nidicoles.

Table 2. Number of beetles specimens (N) and their percentage (%) in nests of pied flycatcher (Republic of Karelia). FE – feeding element, AS – accidental species, FN – facultative nidicole.

Taxon	Group	N	%
Family Carabidae		**41**	**17.23**
Carabidae spp.	FE	31	13.03
Agonum sp.	FE	3	1.26
Harpalus rubripes (Duftschmid, 1812)	FE/AS	1	0.42
Poecilus sp.	FE	1	0.42
Pterostichus sp.	FE	1	0.42
Pterostichus aethiops (Panzer, 1796)	FE/AS	1	0.42
Pterostichus oblongopunctatus (Fabricius, 1787)	FE/AS	3	1.26
Family Silphidae		**1**	**0.42**
Phosphuga atrata (Linnaeus, 1758)	FN	1	0.42
Family Staphylinidae		**11**	**4.62**
Staphylininae sp.	FE/AS	1	0.42
Aleocharinae sp.	FN	2	0.84
Aleochara sp.	FN	7	2.94
Philonthus sp.	FN	1	0.42
Family Histeridae		**35**	**14.71**
Gnathoncus buyssoni (Auzat, 1917)	FN	35	14.71
Family Leiodidae		**1**	**0.42**
Anisotoma humeralis (Fabricius, 1792)	FN	1	0.42
Family Scarabaeidae		**2**	**0.84**
Aphodius depressus (Kugelann, 1792)	FE	1	0.42
Phyllopertha horticola (Linnaeus, 1758)	FE	1	0.42
Family Elateridae		**54**	**22.69**
Elateridae spp.	FE/AS	8	3.36
Agriotes sp.	FE/AS	2	0.84
Ampedus balteatus (Linnaeus, 1758)	FE/AS	3	1.26
Athous subfuscus (O.F. Müller, 1764)	FE/AS	6	2.52
Dalopius marginatus (Linnaeus, 1758)	FE/AS	7	2.94
Denticollis linearis (Linnaeus, 1758)	FE/AS	21	8.82
Ectinus aterrimus (Linnaeus, 1761)	FE/AS	1	0.42
Hemicrepidius hirtus (Herbst, 1784)	FE	2	0.84
Melanotus castanipes (Paykull, 1800)	FE	2	0.84
Selatosomus cruciatus (Linnaeus, 1758)	FE	1	0.42
Selatosomus latus (Fabricius, 1801)	FE	1	0.42

Taxon	Group	N	%
Family Buprestidae		**1**	**0.42**
Eurythyrea sp.	FE	1	0.42
Family Scirtidae		**8**	**3.36**
Contacyphon coarctatus Paykull, 1799	FE/AS	2	0.84
Microcara testacea (Linnaeus, 1767)	FE/AS	6	2.52
Family Dermestidae		**3**	**1.26**
Dermestidae sp. (larva)	FN	3	1.26
Family Cantharidae		**38**	**15.97**
Cantharis spp.	FE	23	9.66
Cantharis nigricans (O.F. Müller, 1776)	FE/AS	1	0.42
Rhagonycha fulva (Scopoli, 1763)	FE/AS	12	5.04
Rhagonycha sp.	FE	1	0.42
Rhagonycha atra (Linnaeus, 1767)	FE/AS	1	0.42
Family Anobiidae		**2**	**0.84**
Dorcatoma sp.	FN	1	0.42
Ptinus fur (Linnaeus, 1758)	FN	1	0.42
Family Melandryidae		**7**	**2.94**
Melandrya dubia (Schaller, 1783)	FE/AS	7	2.94
Family Eucnemidae		**1**	**0.42**
Otho sphondyloides (Germar, 1818)	FE/AS	1	0.42
Family Nitidulidae		**1**	**0.42**
Cyllodes ater (Herbst, 1792)	FN	1	0.42
Family Coccinellidae		**10**	**4.20**
Coccinellidae sp.	FE	1	0.42
Anatis ocellata (Linnaeus, 1758)	FE/AS	6	2.52
Coccinella septempunctata Linnaeus, 1758	FE/AS	1	0.42
Hippodamia tredecimpunctata (Linnaeus, 1758)	FE/AS	1	0.42
Oenopia conglobata (Linnaeus, 1758)	FE/AS	1	0.42
Family Pyrochroidae		**1**	**0.42**
Schizotus pectinicornis (Linnaeus, 1758)	FE/AS	1	0.42
Family Tenebrionidae		**4**	**1.68**
Tenebrionidae sp. 1	FE	1	0.42
Tenebrionidae sp. 2	FE	1	0.42
Scaphidema metallicum (Fabricius, 1793)	FE/AS	2	0.84
Family Chrysomelidae		**3**	**1.26**
Chrysomelidae sp. (larva)	FE	2	0.84

Taxon	Group	N	%
Galerucella nymphaeae (Linnaeus, 1758)	FE/AS	1	0.42
Family Cerambycidae		**4**	**1.68**
Cerambycidae sp.	AS	2	0.84
Alosterna tabacicolor (DeGeer, 1775)	FE/AS	1	0.42
Stictoleptura variicornis (Dalman, 1817)	FE	1	0.42
Family Rhynchitidae		**1**	**0.42**
Deporaus betulae (Linnaeus, 1758)	FE/AS	1	0.42
Family Curculionidae		**9**	**3.78**
Brachyderini spp.	FE/AS	2	0.84
Cossoninae sp.	FE/AS	1	0.42
Hylobius pinastri Gyllenhaal, 1813	FE/AS	2	0.84
Otiorhynchus scaber (Linnaeus, 1758)	FE/AS	3	1.26
Phyllobius sp.	FE/AS	1	0.42
Total		238	100

Acknowledgments

The authors are grateful to A.S. Prosvirov (Lomonosov Moscow State University, Moscow) for the help in identifying the representatives of the Elateridae family. Special thanks go to V.O. Kozminykh (Perm State Humanitarian Pedagogical University, Perm) for invaluable comments in identifying the species of the Histeridae family.

Funding

The work of A.V. Artemiev was carried out within the framework of the state task of the Institute of Biophysics KarRC RAS No. FMEN-2022-0003. The work of A.S. Sazhnev was held as part of the implementation of the state task of the Ministry of Science and Higher Education of the Russian Federation No. 121051100109-1.

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