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Arthropods (Acarina, Coleoptera, Siphonaptera) in nests of hoopoe (*Upupa epops*) in Central Europe

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Abstract: In 1993–1995 and 2009–2011, during investigation of reproduction biology of hoopoe, 63 nests of this species were collected after fledging of the chicks in Slovakia and Austria and their arthropod fauna was analyzed. Altogether 5,481 individuals and 34 species of mesostigmatic mites were found in 82.5% of the nests examined. The nidicolous mite *Androlaelaps casalis* was most abundant and frequent, representing 91.7% of all individuals. The richest in species were saprophilous mites (64.7% of all recorded species), while ectoparasites of the genera *Dermanyssus* and *Ornithonyssus* represented only 0.4% of all mites. Only 8 beetle species represented by 65 individuals were found in 18 nests. The dominant trophical group were carnivores (mainly nidicolous *Gnathoncus buyssoni*) with almost identical representation in (86.2%), followed by a similar representation of necrophags (10.8%). Unlike nests of other birds, the typical nidicolous species *Haploglossa puncticollis* and the fungivors were absent due to the dry character of studied countryside and placement of the nests in boxes situated in vineyard cottages. Only one species of fleas, *Ceratophyllus gallinae* – parasitizing first of all in the passeriform birds and being particularly abundant in the cavity nesting birds was recorded in hoopoe nests.

Key words: *Ceratophyllus gallinae*; beetles; mesostigmatic mites; nidicolous fauna

Introduction

Hoopoe *(Upupa epops* L., 1758) is distributed in warm and moderate areas of Europe, Asia and Africa. It is a migratory species arriving to Central Europe from its wintering places from the last decade of March to the first decade of May. It breads in lowlands and in hilly lands. It builds its nest preferably in tree cavities, but rarely also under tree roots, in woodpiles or stone heaps or in nesting boxes etc. During breading season it uses to have only one clutch, the later clutches are probably supplementary. The clutch size ranges from 4 to 10 eggs. The chicks stay in nests 22–29 days (Hudec & Šťastný 2005). Hoopoe is known as a bird with very special preen gland, what affects plumage and may affect also nest arthropod fauna (Martin-Vivaldi et al. 2009). The existing knowledge of the fauna in hoopoe nests is insufficient and its deepening is important because the parasites occurring in the nests can influence condition and development of chicks and healthy state of adults (Møller et al. 1990; Møller 1997). At the same time, the non-parasitic, seemingly indifferent components of the nests fauna, especially the predaceous mites and beetles can reduce populations of ectoparasites in nests and, indirectly, improve condition of birds. Although the hoopoe occupies an extensive breeding area and belongs to the most garish bird species, only few fragmentary data exist about mesostigmatic mites in its nest. They were recorded at parasitological examination of caught hoopoes and their nests (Shumilo & Lunkashu 1971; Zeman & Jurík 1981). This can be also said about other groups of Acari, like ticks (Nagar et al. 1977; Hajela & Saxena 1982) or feather mites (Gaud 1981; Sohn & Noh 1994), which are often highly specialized to bird hosts.

The knowledge of beetle fauna in the hoopoe nests is relatively rich. A more abundant occurrence of beetles (39 species) in hoopoe nests was recorded by Roubal (1907) and Schaufuss (1908), while other authors recorded 1 to 13 species in its nests. Hicks (1959) published an uncritically compiled review of 58 species really or only allegedly found by earlier authors in hoopoe nests. Most of them are typical inhabitants of nests of many bird species (*Gnathoncus rotundatus*, probably confused with *G. buyssoni*, or *Philonthis subuliformis*), other species listed by Hicks (1959) are known to occur in bird nests occasionally. The published data of fleas in hoopoe nests are also sporadic. Rosický (1957) gives the occurrence of two flea species from the hoopoe nests, viz. *Ceratophyllus gallinae* and *C. garei.*

The aim of this paper is to characterize the fauna of the above arthtropod groups in the nests of hoopoe, its comparison with fauna in nests of other bird species, in particular of the cavity nesting species.

Material and methods

Hoopoe nests were collected in 1993–1995 and 2009–2011, after fledging of the chicks. Altogether 63 nests were obtained in the following sites: Slovakia – Očová (48°35′21″ N, 19°18′59″ E, 3 nests), Ohrady (47°59′13″ N, 17°40′50″ E, 1

Springer

nest) all from tree cavity, Kamenica nad Hronom (47°49′38″ N, 18°44′52″ E, 1 nest); Austria – Illmitz (47°46′32″ N, 16°45′59″ E, 2 nests), Zőbing (48°29′27″ N, 15°41′34″ E, 3 nests), Kammern (48°29′56″ N, 15°42′42″ E, 1 nest), Gneixendorf (48°26′23″ N, 15°37′08″ E, 6 nests), Gedersdorf (48°25′59″ N, 15°41′14″ E, 15 nests), Rohrendorf (48°25′10″ N, 15°39′30″ E, 6 nests), Feuersbrunn (48°26′23″ N, 15°47′17″ E, 7 nests), Gösing (48°28′28″ N, 15°48′48″ E, 3 nests), Lengenfeld (48°28′18″ N, 15°23′56″ E, 10 nests), Langenlois (48°28′20″ N, 15°41′28″ E, 2 nests), Strass im Strassertale (48°28′21″ N, 15°44′05″ E, 2 nests), Engabrunn (48°26′58″ N, 15°45′44″ E, 1 nest), all from the nest boxes. The boxes (60 × 35 × 25 cm) were made of wooden, brown lacquered boards. They were placed into abandoned closed wooden cottages (2 × 2 to 3 × 3 m) that earlier served, in the vineyards, to store the tools. The color of external side of cottage wall was indefinitely dark. The boxes were attached to the inside side of cottage walls, in which fly-in opening of 6 cm in diameter was drilled. They were situated 50 to 100 cm above the ground. The placement of boxes in cottages considerably reduced the humidity in them. The bottom of boxes was lined with a 2–3 cm thick layer of sawdust and pieces of bark.

The mites, beetles and fleas were extracted from the nests by means of Tulgren's funells. The mites and fleas were mounted into permanent slides. The beetles are preserved in ethanol. The whole material is deposed in the collections of the Institute of Zoology of Slovak Academy of Sciences in Bratislava (Slovakia). The quantitative characteristics of occurrence of parasites are used in the sense of Margolis et al. (1982).

In order to obtain data on food offer for hoopoes in the Austrian localities, the insects were pitfall-trapped in immediate surrounding of the cottages with nests. Always places with three degrees of herbage vegetation coverage (without vegetation, with coverage of about 50% and 100%) were selected. The Carabid assemblages were also used to characterize the environmental conditions in the area studied. The assemblages were characterized by two semiquantitative variables (Šustek 2004): index of vegetation preference ranging from 1 to 4, where 1 means absolute predominance of heliophilous species of open landscape, while 4 means absolute predominace of forests species requiring shadowing by closed tree vegetation and index of humidity preference ranging from 1 to 8, where 1 means absolute predominance of strongly xerophilous species, while 8 means absolute predominace of extremely hygrophilous species living in swampy habitats.

Results

A total of 5,481 individuals belonging to 34 species of mesostigmatic mites were collected in hoopoe nests. Mites were present in 52 nests (prevalence 82.5%, mean intensity 105.4, relative density 87), their abundance fluctuated between 1 and 2,379 individuals in one nest. The most frequent species were *Androlaelaps casalis* (it occurred in 61.9% of nests), *Parasitus fimetorum* (20.6%), *Halolaelaps leptoscutatus* (17.5%), *Proctolaelaps scolyti* (14.3%), *Glyptholaspis confusa* and *Macrocheles muscaedomesticae* (each 11.1%). In other mite species found, the percentage of nests infested was lower than 10. *Androlaelaps casalis* had the highest relative density (79.8) and dominace (91.7%).The quantitative representation of other mite species was almost negligible except for *Parasitus fimetorum* (Table 1).

There are the following main features characteristic of mesostigmatic mites in the studied nests of hoopoe, ordered according to the level of importance: (1) high proportion of *Androlaelaps casalis*, a nidicolous species with a special relation to nests of birds; (2) high proportion of males and developmental stages in population of *A. casalis* (each 28.6%); (3) saprophilous species as the richest group in species (64.7% of all recorded species), with 16 coprophiles (47.1%), 4 necrophiles (11.8%) and 2 edaphic humicoles (5.9%); 4) ectoparasites of the genera *Dermanyssus* and *Ornithonyssus* represent only marginal quantitative component of acarocoenoses studied (0.4% of all individuals); (5) negligible quantity (excluding *A. casalis*) and low species diversity of true nidicolous species (e.g., absence of *Hypoaspis lubrica* which is common in various bird's nests, especially those situated in the nest boxes); (6) high proportion of macrochelids and parasitids (each 20.6% of all species) with well developed phoretic behaviour among the mites (Table 1).

The beetles were represented only by 65 individuals belonging to 8 species. The dominant (36.9%) species was *Gnathoncus buyssoni*, an obligatory nidicolous carnivore occurring in nests of many bird species (Hicks 1959; Mazur 1981), especially in the cavity and box nesting birds. It was present in 15.9% of nests and in the positive nests it was represented by 1 to 8 individuals (in average 2.4) and in all nests by 0.41 individuals. The next dominant species was *Philonthus sordidus*, a frequent facultatively nidicol. Out of the mites and flea larvae, the first instars of larvae of *Fannia* sp. numerously represented in the nests could serve as a rich food basis for them. In some nests, 1–3 individuals of *Trox scaber* or *T. hispidus* occurred in 2009. Both species are necrophagous and eat dry detritus of animal origin (Tesař 1957). Representation of other beetles was negligible, but their food preference was in direct connection with the nest material, rests of foods, excrement and organic detritus in the nests. There were no species whose occurrence might be considered as occasional in the nest or no species, which could use the nests as a temporal cover.

The representation of trophic groups of beetles (Fig. 1) was characterized by a high predominance (86.2%) of carnivores followed by necrophags (10.8%) and negligible representation of saprophags and algivores. There were not recorded any fungivores and detritophags, which are a frequent component of nests fauna of other beetles. Not only the dry microclimate in interior of the cottages, in which the boxes were placed, but the close surrounding of nest was also very dry, as indicated by carabid assemblages (Table 2). There predominated the xerophilous species (especially *Broscus cephalotes* L., 1785, *Ophonus azureus* F., 1775, *Microlestes minutulus* Goeze, 1777) over the mesohygrophilous ones. Major part of the assemblage consisted of heliophilous species (typically *Bembidion lampros* Herbst, 1784), while the eurytopic species (e.g., *Ca-*

Table 1. Representation of mesostigmatic mites in hoopoe nests.

Family / Species	E	Σ(♀)	Σ(mars)	Σ(s)	Σ(n)	D (%)	I	R	P (%)
Macrochelidae									
Glyptholaspis confusa (Foà, 1900)	3b	10	1	1	12	0.22	1.71	0.19	11.11
Macrocheles glaber (J. Müller, 1860)	3b	8	–	–	8	0.15	1.60	0.13	7.94
Macrocheles matrius (Hull, 1925)	2b	32	19	6	57	1.04	11.40	0.90	7.94
Macrocheles merdarius (Berlese, 1889)	3b	1	–	–	1	0.02	1.00	0.02	1.59
Macrocheles muscaedomesticae (Scopoli, 1772)	3b	14	3	–	17	0.31	2.43	0.30	11.11
Macrocheles penicilliger (Berlese, 1904)	3c	7	3	–	10	0.18	1.67	0.16	9.52
Macrocheles trogicolis Mašán, 1994	3c	1	–	–	1	0.02	1.00	0.02	1.59
Hypoaspididae									
Hypoaspis tuberculata Mašán, 1992	3f	1	1	–	2	0.04	2.00	0.03	1.59
Laelapidae									
Androlaelaps casalis (Berlese, 1887)	2a	2,147	1,439	1,438	5,024	91.66	128.82	79.75	61.90
Haemogamasidae									
Eulaelaps stabularis Vitzthum, 1925	1b	8	1	–	9	0.16	2.25	0.14	6.35
Macronyssidae									
Ornithonyssus sylviarum (Canestrini et Fanzago, 1877)	1a	5	–	–	5	0.09	1.00	0.08	7.94
Dermanyssidae									
Dermanyssus hirundinis (Hermann, 1804)	1a	11	4	2	17	0.31	5.67	0.30	4.76
Phytoseiidae									
Amblyseius alpinus Schweizer, 1922	3a	2	–	–	2	0.04	2.00	0.03	1.59
Blattisocius keegani Fox, 1947	3e	1	–	–	1	0.02	1.00	0.02	1.59
Ameroseiidae									
Ameroseiella apodius (Karg, 1971)	3b	4	3	–	7	0.13	1.75	0.11	6.35
Proctolaelaps pygmaeus (J. Müller, 1860)	3a	4	–	1	5	0.09	5.00	0.08	1.59
Proctolaelaps scolyti Evans, 1958	3d	36	1	2	39	0.71	4.33	0.62	14.29
Halolaelapidae									
Halolaelaps leptoscutatus Karg, 1971	3b	11	3	33	47	0.86	4.27	0.75	17.46
Halolaelaps octoclavatus (Vitzthum, 1920)	3b	–	–	5	5	0.09	2.50	0.08	3.17
Halolaelaps sexclavatus (Oudemans, 1902)	3b	–	1	2	3	0.05	3.00	0.05	1.59
Halolaelaps sp.		1	–	–	1	0.02	1.00	0.02	1.59
Rhodacaridae									
Cornodendrolaelaps presepum (Berlese, 1918)	3b	3	1	1	5	0.09	1.00	0.08	7.94
Dendrolaelaps brevipilis (Leitner, 1949)	3b	1	–	1	2	0.04	2.00	0.03	1.59
Dendrolaelaps sp.		–	–	1	1	0.02	1.00	0.02	1.59
Parasitidae									
Cornigamasus lunaris (Berlese, 1882)	3b	–	–	1	1	0.02	1.00	0.02	1.59
Gamasodes spiniger (Trägardh, 1910)	3b	–	–	4	4	0.07	1.00	0.06	6.35
Parasitus coleoptratorum (L., 1758)	3b	–	–	2	2	0.04	1.00	0.03	3.17
Parasitus fimetorum (Berlese, 1903)	3b	26	16	115	157	2.86	12.08	2.49	20.63
Poecilochirus carabi G. & R. Canestrini, 1882	3c	–	1	–	1	0.02	1.00	0.02	1.59
Trachygamasus ambulacralis Willmann, 1949	3b	–	–	4	4	0.07	4.00	0.06	1.59
Vulgarogamasus remberti (Oudemans, 1912)	2b	–	–	2	2	0.04	2.00	0.03	1.59
Trachytidae									
Uroseius acuminatus (C.L. Koch, 1897)	3c	–	–	3	3	0.05	1.50	0.05	3.17
Uroseius infirmus (Berlese, 1887)	2a	1	–	–	1	0.02	1.00	0.02	1.59
Trematuridae									
Nenteria slovaca Mašán, 1999	3b	2	2	21	25	0.46	12.50	0.40	3.17
Total		2,337	1,499	1,645	5,481	100.00	105.40	87.00	82.54

Explanations: D – dominance; I – mean intensity; R – relative density; P – prevalence; s – subadults; E – ecological groups: 1 – parasite (a – associate of birds' hosts, b – associate of mammals' hosts); 2 – nidicol (a – associate of birds' nests, b – associate of mammals' nests); 3 – free living species (a – edaphic humicole, b – associate of coprophilic substrates, c – associate of necrophilic substrates, d – wood-colonizing species, e – associate of grain and food stores, f – myrmecophile).

lathus fuscipes Goeze, 1777) were little represented even in the plots with vegetation coverage of 50 or 100%. The contribution of frequent ploughing of some parts of the study area to its dry character is also indicated by differences in number of species or individuals and in humidity preference index between plots with sparse vegetation and those with vegetation coverage of about 50–100% (Table 3).

In the hoopoe nests we found 105 males and 136 females of the flea *Ceratophyllus gallinae* (Schrank, 1803). It was recorded in 17 nests (prevalence 27%, mean intensity 14.2, relative density 3.8), number of individuals ranged from 1 to 69.

Discussion

The arthropod fauna in nests can be influenced by different factors. Out of the properties and behavior of the birds it can be also influenced by the character of the nests itself or of the nest box (Weselowski & Stanska 2001; Lambrechts et al. 2010). Mesostigmatic mites in bird nests are a relatively frequent object of different coenological studies, less frequent are investigation focused on collecting the ectoparasitic mites directly from plumage of the caught host birds. The mite communities in bird nests have not been intentionally studied. There are only two original papers mentioning

Table 2. Survey of beetles species in hoopoe nests.

Family / Species	RN	TR	Σ	D (%)	P (%)	M	IO
Hydrophilidae							
Cercyon menalocephalus (L., 1758)	T	S	1	1.54	1.59	0.02	1.00
Histeridae							
Gnathoncus buyssoni Auzat, 1917	N	C	24	36.91	15.87	0.38	2.40
Staphylinidae							
Philonthus sordidus (Gravenhorst, 1822)	T	C	3	4.62	1.59	0.05	3.00
Philonthus subuliformis (Gravenhorst, 1802)	T	C	13	20.00	11.11	0.21	1.86
Philonthus sp. larvae	T	C	16	24.62	4.76	0.25	5.33
Atheta sp. (defectious specimen)	T	A	1	1.54	1.59	0.02	1.00
Trogidae							
Trox scaber (L, 1767)	T	N	4	6.15	3.17	0.06	2.00
Trox hispidus (Pontopidan, 1763)	T	N	2	3.08	3.17	0.03	1.00
Dermestidae							
Dermestes sp. larva	T	N	1	1.54	1.59	0.02	1.00
Total			65	100.00			

Explanations: RN – Relation to nests: (N – nidicolous, T – trophic); TR – trophical relation: (A – algivorous, C – carnivorous, N – necrophagous, S – saprophagous); P – presence; M – average number of individuals in all nests; D – dominance; IO – average number of individuals per positive nests.

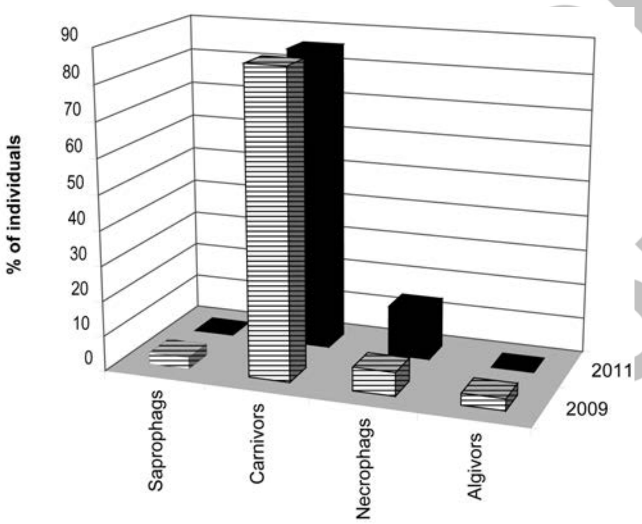

Fig. 1. Representation of trophic groups of beetles in hoopoe nests in Austria in 2009 and 2011.

Table 3. Some community parameters of carabid assemblages in vicinity of hoopoe nests in Austrian localities.

Parameter	Coverage in %		
	≈ 0	≈ 50	≈ 100
Number of species	17	24	28
Number of individuals	137	187	235
Index of vegetation cover preference	1.00	1.05	1. 05
Index of humidity preference	3.28	3.37	3.36

mesostigmatic mites in connection with hoopoe. Shumilo & Lunkashu (1971) examined 15 caught hoopoes in Republic of Moldova and Ukraine, but only on two of them (13.3%) they recorded occurrence of two females of *Ornithonyssus sylviarum*. Zeman & Jurík (1981) studied fauna and ecology of gamasoid mites in nests of cavity nesting birds in Czechoslovakia. They found three individuals of nidicolous *Macrocheles matrius* in one examined nest of hoopoe.

The existing knowledge about taxocoenoses on mesostigmate mites in bird nests in natural tree cavities or in boxes shows that they are characterized by the following structural features: (1) eudominance of nidicolous mites, first of all of *A. casalis* and *H. lubrica*; (2) low quantitative representation of haematophagous ectoparasites of birds of the genera *Dermanyssus* and *Ornithonyssus*; (3) a higher proportion of facultative ectoparasites of small mammals, which get into the nests through dormice and bats; (4) a higher proportion of saprophilous species, usually very active phoretically, and a reduced proportion of free living and often well moveable edaphic species; (5) presence of subcorticolous species or species living in decaying wood (Piryanik & Akimov 1964; Borisova 1972, 1977; Mrciak & Sixl 1979; Zeman & Jurík 1981; Ambros et al. 1992).

In the nests analyze, absence of the nidicolous mite *H. lubrica* is remarkable. This species is frequently and abundantly found in nests in tree cavities and boxes. When comparing our results with the above scheme, the increased species diversity of ectoparasites of small mammals (except of *H. lubrica*) and of species bound to various wooden substrates (except of *Proctolaelaps scolyti*). Mite ectoparasites on small mammals (species of the genera *Eulaelaps*, *Haemogamasus*, *Hirstionyssus*, *Hyperlaelaps*, *Laelaps*) are usually absent or occur rarely in bird nests situated highly above ground, excepting the nests of birds of prey, in which the mammals are the main or substitution component of food. Owing to it they can be introduced into the nest and become a typical and specific component of the fest fauna (Philips & Dindal 1990; Philips 2000; Gwiazdowicz 2003). Their presence was also observed in nests of red-backed shrike (Krištofík et al. 2002), which are known to hunt and eat facultatively small mammals.

Composition of beetle fauna in the nests, roughly, is similar to fauna in nests of other bird species, in particular of those nesting in cavities or boxes (Jurík &

Šustek 1978; Šustek & Krištofík 2002). However, the striking difference from nests of other birds was absence of the nidicolous staphylinid *Haplogossa puncticollis* (Kirby, 1832), which together with histerids of the genus *Gnathoncus* belong to the dominant component of beetle fauna in nests of almost all birds except of penduline tit (Krištofík et al. 1993, 1995) and sand martin (Šustek & Jurík 1980; Krištofík et al. 1994), where it is replaced by more specialized *Haploglossa nidicola* (Fairmar, 1852). The reason of absence of this characteristic nidicol can be the generally higher requirements for humidity in staphylinids (Smetana 1958; Boháč & Matějíček 2003) unlike the more xerophilous histerids (Kryzhanovskij & Reikhardt 1976; Mazur 1981), especially of the subfamily Saprinae, to which the genus *Gnathoncus* belongs. The much larger number of species recorded in two nests studied by Roubal (1907) is obviously due to intentional regular introducing of plants and mosses into the nest cavities, with which characteristic representatives of soil surface fauna of deciduous forests (Boháč & Matejíček 2003; Šustek 1983) could be introduced in the nests. Among the 39 species recorded by him, only one is specifically nidicolous, while next five species frequently occur also, but not exclusively, in bird nests. On other hand, one beetle species recorded in the hoopoe nests by some authors cited by Hicks (1959) results from the fact that some of the works (e.g., Everts 1922; Reikhardt 1941 in Hicks 1959) are systematical monographs, where occurrence in hoopoe nests is give within ecological characteristics of individual beetle species.

When compared with nests of other birds, the beetle fauna in the hoopoe nests belongs to the poorest ones, as to number of species, as to number of individuals. This is especially a striking contrast with all cavity- or box-nesting birds (Jurík & Šustek 1978; Krištofík et al. 1996, 2003; Šustek & Krištofík 2002, 2003), which are usually inhabited by a very rich beetle fauna characterized by two dominant trophic groups of beetles – the carnivores and necrophags, whose representation in nests reaches tens or even hundreds of individuals per one nest.

A striking difference between beetle fauna in hoopoe nests and in many bird species having been studied systematically (Nordberg 1936; Jurík & Šustek 1978; Šustek & Hornychová 1983; Krištofík et al. 1993, 1995, 1996, 2001, 2002, 2003, 2005, 2007, 2009; Šustek & Krištofík 2003, 2006) was absence of fungivorous beetles eating the moulds growing on wet nests material or food rests and represented in nests of other birds predominantly by lathridiids and cryptophagids and to a lesser degree by mycetophagids and endomychids. Their absence in hoopoes probably results from several factors. The placement of nest boxes cottages perfectly protected them against rain. The temperature in closed cottages exposed the whole day over to sun also reduced humidity in the nests. In addition, the surrounding of the cottages was dry, as indicated by composition of carabids in vicinity of the nests. The substances released from mixture of sawdust and bark detritus covering bottom of the boxes might act as a repellent for the fungivores. Absence of a plant lining, what is characteristic for nests of hoopoes in natural cavities, prevents introduction of these beetles into the nests with already moldy construction material or their attraction in later developmental stages of the nests. Although presence of different species of the genus *Trox* is a characteristic feature of nests of many bird species (see above), in the case of the studied nest it is in accordance with the dry microclimate in the nests. The placement of the nests studied in the cottages isolated them from surrounding environment and inhibited penetration of nests by various arboricolous, planticolous and phytophagous species representing an occasional, but often considerable component of beetle fauna in nests of other birds. A particularly strong influence of fauna in the immediate vicinity of the nests was observed in birds building nests on trees and shrubs (Krištofík et al. 2002, 2009; Šustek & Krištofík 2003) or on reed and cattail (Krištofík et al. 2001, 2005, 2007). Also the much richer fauna in the hoopoe nests studied by Roubal (1907) was connected, to considerable degree, with their placement in an oak forest, unlike vineyards in our study.

The flea *C. gallinae* is distributed in the Palaearctic region and was introduced to North America, New Zealand and Australia (Beaucournu & Launay 1990). In Europe it is the most abundant flea parasitizing on birds. It was recorded in more than 80 bird species (Nordberg 1936; Ash 1952; Jurík 1974; Cyprich et al. 1999). It occurs first of all in the passeriform birds and is particularly abundant in the cavity nesting birds. *C. gallinae* has a high abundance in nests of the species of genus *Parus*, especially in great tits (Jurík 1974; Eeva et al. 1994; Heeb et al. 1996; Tripet & Richner 1997), blue tits (Jurík 1974; Tripet & Richner 1999), in nests of house sparrows (Jurík 1974; Cyprich & Krumpál 1996), collared flycatchers (Jurík 1974) and pied flycatchers (Eeva et al. 1994).

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References

Ambros M., Krištofík J. & Šustek Z. 1992. The mites (Acari, Mesostigmata) in the birds' nests in Slovakia. Biologia **47 (5):** 369–381.

Ash J. 1952. Siphonaptera bred from birds' nests. Entomol. Month. Mag. **88:** 217–222.

Beaucournu J.-C. & Launay H. 1990. Les puces (Siphonaptera) de France et du Bassin méditerranéen occidental. Fédération

Française des Sociétés de Sciences Naturalles, Paris, 548 pp. ISBN: 2–903052–10–7

Boháč J. & Matějíček J. 2003. Katalog brouků Prahy, Svazek IV, Vol. 4. Drabčíkovití – Staphylinidae. Praha, 256 pp. ISBN: 8023920278

Borisova V.I. 1972. Itogi izucheniya ekologii gnezdovo-norovykh parazitov ptits. TASSR I. Parazitologiya **6 (5):** 457–464.

Borisova V.I. 1977. Gamazovye kleshchi gnezd ptits Volzhsko-Kamskogo Zapovednika. Parazitologiya **11 (2):** 141–146.

Cyprich D. & Krumpál M. 1996. Fleas (Siphonaptera) in nests of the house sparrow (*Passer domesticus*) and tree sparrow (*P. montanus*). Biologia **51:** 153–161.

Cyprich D., Krumpál M. & Rolníková T. 1999. Výskyt a rozšírenie *Ceratophyllus gallinae* (Schrank, 1803) (Siphonaptera) na Slovensku. Folia Faunistica Slovaca **4:** 79–88.

Eeva T., Lehikoinen E. & Nurmi J. 1994. Effects of ectoparasites on breeding success of great *tits* (*Parus major*) and pied flycatchers (*Ficedula hvpoleuca*) in an air pollution gradient. Can. J. Zool. **72:** 624–635. DOI: 10.1139/z94–085

Gaud J. 1981. Acariens Sarcoptiformes plumicoles des oiseaux Coraciiformes d'Afrique 5. Parasites des Phoeniculidae et des Upupidae. Rev. Zool. Afric. **95:** 390–402.

Gwiazdowicz D.J. 2003. Mites (Acari, Mesostigmata) appearing in Poland, in the birds's nests of Passeriformes, Falconiformes and Strigiformes orders, pp. 562–572. In: Miler A.T. (ed.), Kształtowanie i ochrona środowiska leśnego, Wydawnictwo Akademii Rolniczej, Poznań, 720 pp. ISBN: 8371603312, 9788371603310

Hajela K.P. & SaxenaV.K. 1982. A note on the predation of ticks by birds. Kanpur Univ. Res. J. (Sci.) **1:** 229–230.

Heeb P., Werner I., Richner H. & Kolliker M. 1996. Horizontal transmission and reproductive rates of hen fleas in great tits. J. Anim. Ecol. **65:** 474–484. DOI: 10.2307/5782

Hicks E.A. 1959. Check-list and bibliography on the occurrence of insects in bird's nests. The Iowa State College Press, Ames Iowa USA, 681 pp.

Hudec K. & Šťastný K. (eds) 2005. Fauna ČR, Sv. 29/2: Ptáci-Aves. Díl II/2 (2. přepr. a dopl. vydání). Academia, Praha, 581–1203 pp. ISBN: 80–200–1114–5.

Jurík M. 1974. Bionomics of fleas in birds' nests in the territory of Czechoslovakia. Acta Sci. Nat. Brno **8 (10):** 1–54.

Jurík M. & Šustek, Z. 1978. The Coleoptera in the nests of *Passer domesticus* in Czechoslovakia. Věst. Čsl. Spol. Zool. **42**: 255–272.

Krištofík J., Mašán P. & Šustek Z. 1996. Ectoparasites of bee-eater (*Merops apiaster*) and arthropods in its nests. Biologia **51:** 557–570.

Krištofík J., Mašán P. & Šustek Z. 2001. Mites (Acari), beetles (Coleoptera) and fleas (Siphonaptera) in the nests of great reed warbler (*Acrocephalus arundinaceus*) and reed warbler (*A. scirpaceus*). Biologia **56:** 525–536.

Krištofík J., Mašán P. & Šustek Z. 2005. Arthropods in the nests of marsh warbler (*Acrocephalus palustris*). Biologia **60:** 171–177.

Krištofík J., Mašán P. & Šustek Z. 2007. Arthropods (Pseudoscorpionidea, Acarina, Coleoptera, Siphonaptera) in nests of the bearded tit (*Panurus biarmicus*). Biologia **62:** 749–755. DOI: 10.2478/s11756-007-0142-0

Krištofík J., Mašán P., Šustek Z. & Gajdoš P. 1993. Arthropods in the nests of penduline tit (*Remiz pendulinus*). Biologia **48:** 493–505.

Krištofík J., Mašán P., Šustek Z. & Karaska D. 2009. Arthropods in nests of lesser spotted eagle (*Aquila pomarina*). Biologia **64:** 974–980. DOI: 10.2478/s11756-009-0148-x

Krištofík J., Mašán P., Šustek Z. & Kloubec B. 2003. Arthropods (Pseudoscorpionidea, Acari, Coleoptera, Siphonaptera) in the nests of the tengmalm's owl, *Aegolius funereus*. Biologia **58:** 231–240.

Krištofík J., Šustek Z. & Gajdoš P. 1994. Arthropods in nests of the Sand Martin (*Riparia riparia* Linnaeus, 1758) in South Slovakia. Biologia **49:** 683–690.

Krištofík J., Šustek Z. & Gajdoš P. 1995. Arthropods in the penduline tit *(Remiz pendulinus*) nests: occurrence and abundance in different breeding phases. Biologia **50:** 487–493.

Krištofík J., Šustek Z. & Mašán P. 2002. Arthropods (Pseudoscorpionida, Acari, Coleoptera, Siphonaptera) in the nests of red-backed shrike (*Lanius collurio*) and lesser grey shrike (*Lanius minor*). Biologia **57:** 603–613.

Kryzhanovskij O.L. & Rejhkardt A.N. 1976. Zhuki nadsemeĭstva Histeroidea (semeĭstva Sphaeritidae, Histeridae, Synteliidae). Fauna SSSR. Zhestkokrylye. Tom. 5, vyp. 4. Nauka, Leningrad, 435 pp. Novaja serija No 111.

Lambrechts M.M., Adriaensen F., Ardia D.R., Artemyev A.V., Atiénzar F., Bańbura J., Barba E., Bouvier J.-C., Camprodon J., Cooper C.B., Dawson R.D., Eens M., Eeva T., Faivre B., Garamszegi L.Z., Goodenough A.E., Gosler A.G., Grégoire A., Griffith S.C., Gustafsson L., Johnson L.S., Kania W., Keišs O., Llambias P.E., Mainwaring M.C., Mänd R., Massa B., Mazgajski T.D., Møller A.P., Moreno J., Naef-Daenzer B., Nilsson J.-Å., Norte A.C., Orell M., Otter K.A., Park Ch.R., Perrins Ch.M., Pinowski J., Porkert J., Potti J., Remes V., Richner H., Rytkönen S., Shiao M.-T., Silverin B., Slagsvold T., Smith H.G., Sorace A., Stenning M.J., Stewart I., Thompson Ch.F., Török J., Tryjanowski P., van Noordwijk A.J., Winkler D.W. & Ziane N. 2010. The design of artificial nestboxes for the study of secondary hole-nesting birds: a review of methodological inconsistencies and potential biases. Acta Ornithol. **45:** 1–26. DOI: 10.3161/000164510X516047

Margolis L., Esch G.W., Holmes J.C., Kurts A.M. & Schad G.A. 1982. The use of ecological terms in parasitology (Report of an ad hoc commitee of the American Society of Parasitologists). J. Parasitol. **68:** 131–133.

Martín-Vivaldi M., Ruiz-Rodríguez M., Soler J. J Peralta-Sánchez J. M., Méndez M., Valdivia E., Antonio Manuel Martín-Platero A.M. & Martínez-Bueno M. 2009. Seasonal, sexual and developmental differences in hoopoe *Upupa epops* preen gland morphology and secretions: evidence for a role of bacteria. J. Avian Biol. **40:** 191–205. DOI: 10.1111/j.1600–048X.2009.04393.x

Mazur S. 1981. Histeridae, gnilikowate (Insecta, Coleoptera). Fauna Polski – Fauna Poloniae. Tom 9. Państwowe Wydawnictwo Naukowe, Warszawa, 204 pp. ISBN: 8301017538, 9788301017538

Møller A.P. 1997. Parasitism and evolution of host life history, pp. 105–127. In: Clayton D.H. & Moore J. (eds), Host-Parasite Evolution: General Principles and Avian Models. Oxford University Press, Oxford, 486 pp. ISBN: 0198548923, 9780198548928

Møller A.P., Allander K. & Dufva R. 1990. Fitness effects of parasites on passerine birds: a review, pp. 269–280. In: Blondel J., Gosler A., Lebreton J.D & McCleery R.H. (eds), Population Biology of Passerine Birds: An Integrated Approach, Springer-Verlag, Berlin, Heidelberg, New York, 496 pp. ISBN: 3540517596, 9783540517597

Mrciak M. & Sixl W. 1979. Faunistic-ecological investigation on mites living in the nests of tree cavities in Austria, pp. 611–614. In: Piffl E. (ed.), Proceedings of the 4th International Congress of Acarology (1974), Akadémiai Kiadó, Budapest, 751 pp. ISBN: 9630516950, 9789630516952

Nagar S.K., Raizada R.N. & Saxena V.K. 1977. Observation on the prevalence of babesiasis and the composition and ecology of ixodid ticks in Delhi, India. Indian J. Anim. Sci. **47:** 654–663.

Nordberg S. 1936. Biologisch-ökologische Untersuchungen über die Vogelnidicolen. Acta Zool. Fenn. **21:** 1–168.

Piryanik G.I. & Akimov I.A. 1964. Gamazovye kleshchi ptits i ikh gnezd v Ukrainskoĭ SSR. Zool. Zh. **43:** 671–679.

Philips J.R. 2000. A review and checklist of the parasitic mites (Acarina) of the Falconiformes and Strigiformes. J. Raptor Res. **34:** 210–231.

Philips J.R. & Dindal D.L. 1990. Invertebrate populations in the nests of a screech owl (*Otus asio*) and an American kestrel (*Falco sparverius*) in Central New York. Entomol. News **101:** 170–192.

Rosický B. 1957. Fauna ČSR svazek 10. Blechy – Aphaniptera. Nakladatelsví ČSAV Praha, 439 pp.

Roubal J. 1907. O broucích ve hnízdech ssavců a ptáků. Acta Soc. Entomol. Bohemoslov. **4:** 124–134.

Schaufuss C. 1908. "Rundschau". (Besprechung der Arbeit von Roubal). Entomol. Wbl. **25 (8):** 30.
Shumilo R.P. & Lunkashu M.I. 1971. Gamazovye kleshchi dikikh sukhoputnykh ptits Dnestrovsko-prutskogo Mezhdurechya. Parazity zhivotnykh i rasteniĭ: Sbornik nauchnikh trudov **5:** 64–71.
Smetana A. 1958. Drabčíkovití – Staphylinidae I. Staphylininae. Fauna ČSR 12. Nakladatelství ČSAV, Praha, 437 pp.
Sohn B.O. & Noh Y.T. 1994. Feather mites of Kramerellidae and Pterolichidae in Korea (Acari, Pterolichoidea). Korean J. Parasitol. **32:** 75–83. PMID: 8025036
Šustek Z. 1983. The comparison of the Carabidae and Staphylinidae in the selected geobiocoenoses of Pavlovské kopce hills during the years 1971–1981. Biológia **38 (2)**: 105–115.
Šustek Z. 2004. Characteristics of humidity requirements and relations to vegetation cover of selected Centra-European Carabids (Col., Carabidae), pp. 210–214. In: Polehla P. (ed.), Hodnocení stavu a vývoje lesních geobiocenóz. Geobiocenologické spisy, Svazek 9, Lesnická a dřevařská fakulta MZLU v Brně, Ústav lesnické botaniky, dendrologie a typologie, Brno, 249 pp. ISBN: 80–7157–787–1
Šustek Z. & Hornychová D. 1983. The beetles (Coleoptera) in the nests of *Delichon urbica* in Slovakia. Zborník Slov. Nár. Múzea. Prír. Vedy **29:** 119–133.
Šustek Z. & Jurík M. 1980. The Coleoptera from the nests of *Riparia riparia* in Czechoslovakia. Věst. Čsl. Spol. Zool. **44:** 286–292.
Šustek Z. & Krištofík J. 2002. Beetles (Coleoptera) in deserted nest of *Phoenicurus ochruros*, *Parus caeruleus*, *Parus major*, *Sitta europea* and *Sturnus vulgaris*. Entomofauna Carpathica **14:** 64–69.
Šustek Z. & Krištofík J. 2003. Beetles (Coleoptera) in nests of house and tree sparrows (*Passer domesticus* and *P. montanus*). Biologia **58:** 953–965.
Šustek Z. & Krištofík J. 2009. Beetles (Insecta: Coleoptera) in nests of five species of passeriforms birds (*Carduelis chloris, Troglodytes troglodytes, Turdus merula, Turdus philomelos, Turdus pilaris*) in Central Europe. Oltenia, Studii şi comunicări. Ştiinţele Naturii **25:** 97–104.
Tesař Z. 1957. Brouci listorozí, Lamellicornia. Díl II. Scarabaeidae – vrubounovití, Laparosticti. Fauna ČSR 11. Nakladatelství ČSAV, Praha, 326 pp.
Tripet F. & Richner H. 1997. The coevolutionary potential of a generalist parasite, the hen flea *Ceratophyllus gallinae*. Parasitology **115:** 419–427. DOI: 10.1017/S0031182097001467
Tripet F. & Richner H. 1999. Dynamics of hen flea *Ceratophyllus gallinae* subpopulations in Blue Tit nests. J. Insect Behav. **12:** 159–174. DOI: 10.1023/A:1020958615191
Wesolowski T. & Stanska M. 2001. High ectoparasite loads in hole-nesting birds – A nestbox bias? J. Avian Biol. **32:** 281–285. DOI:10.1111/j.0908–8857.2001.320313.x
Zeman P. & Jurík M. 1981. A contribution to the knowledge of fauna and ecology of gamasoid mites in cavity nests of birds in Czechoslovakia. Folia Parasitol. **28:** 265–271.

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