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Association of pseudoscorpions with different types of bird nests

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Abstract: The hypothesis of associating pseudoscorpions with bird nest types was tested on the basis of an analysis of 480 specimens. Eleven pseudoscorpion species were found in 171 nests of 28 different bird species collected in Slovakia, Austria and the Czech Republic. The frequent appearance of *Cheiridium museorum*, *Dactylochelifer latreillii*, *Chernes hahnii*, *Dendrochernes cyrneus* and *Allochernes wideri* was confirmed. High proportion and association of *Pselaphochernes scorpioides* in hoopoe hollow nests with decomposed substrate, *D. cyrneus* in the Eurasian tree sparrow nest boxes and *A. wideri* in the nests of the tawny owls, the European scops owls and the European roller was proved. In contrast, *C. hahnii* and *D. latreillii* were related to the nest fauna of blackbirds and song thrushes, *C. museorum* to the nests of white wagtails situated on the ground and on buildings and *C. cancroides* to the nests in synanthropic habitats. Until present, the occurrence of 22 pseudoscorpion species has been confirmed in the bird nests of Central Europe based on the obtained results and published resources. According to the association to bird nests these pseudoscorpions were classified as (1) nidixenous species – *Chthonius fuscimanus*, *C. tetrachelatus*, *Mundochthonius styriacus*, *Neobisium carcinoides*, *N. crassifemoratum*, *N. inaequale*, *N. sylvaticum*, *Chernes cimicoides*, *C. similis*, *C. vicinus*, *Allochernes powelli*, *Lamprochernes chyzeri*, *L. nodosus* and *Larca lata*; and (2) nidiphilous species – *C. museorum*, *C. cancroides*, *A. wideri*, *D. cyrneus*, *D. latreillii*, *C. hahnii*, *D. panzeri* and *P. scorpioides*.

Key words: pseudoscorpions; nests of bird; relation; ecology; Central Europe

Introduction

Bird nests form a temporary habitat, in which pseudoscorpions can establish themselves and breed (Jones 1975). Pseudoscorpions, in spite of being typical predators, represent a less examined group, although they are certainly a significant part of the bird nest fauna. The rudimentary data concerning the presence of pseudoscorpions in bird nests originated at the beginning of the 20th century. Kew (1901) mentioned pseudoscorpions in the sparrow nests and Butterfield (1908) in the nests of starlings, Nordberg (1936) and Kaisila (1949) found pseudoscorpion species in the nests of Passeriformes, Columbiformes and Piciformes. In the papers dealing with faunistic data in Europe, information about the association of pseudoscorpions to this type of habitat or their ecological requirements were insufficient. The occurrence of pseudoscorpions in the bird nests in Europe was partially mentioned in the papers of Beier (1948, 1963), Nosek & Lichard (1962), Rafalski (1967), Jost (1982) and Jędryczkowski (1985). Beier (1971) described the species *Mundochthonius styriacus* Beier, 1971 present in the hollow nests of the great tit. Pseudoscorpions were discussed in several studies dealing with the nest fauna of bird species in Central Europe, mainly from Slovakia. Krumpál & Cyprich (1988), examining 162 bird nests, found 915 pseudoscorpion individuals belonging to 16 species. They pointed at a regular phenomenon of pseudoscorpions seeking for nests as a food source, a refuge and a breeding location. Cyprich et al. (1992) considered pseudoscorpions in the domestic rock pigeon nests as accidental. Krištofík et al. (1993) recorded an affinity of *Dactylochelifer latreillii* (Leach, 1817) to differently situated nests. Rare occurrence of low numbers of *Lamprochernes* sp. in the sand martin nests, *Lamprochernes nodosus* (Schrank, 1803) and *Cheiridium museorum* (Leach, 1817) in the penduline tit nests, *L. nodosus* and *Chernes hahnii* (C.L. Koch, 1839) in the bee-eater nests, *Chelifer cancroides* (L., 1758), *Dinocheirus panzeri* (C.L. Koch, 1837) and *Chernes cimicoides* (F., 1793) in the tengmalm's owl nests, *Neobisium inaequale* Chamberlin, 1930 in the marsh warblers nests was noticed (Krištofík et al. 1994, 1995, 1996, 2003, 2005). Based on small quantities of collected individuals the authors assumed that pseudoscorpions occurred accidentally in the nests mentioned above, without any specific relationship to the nest environment or the hosts. Cyprich et al. (2000) found nymphal stages of *C. cancroides* in the Timor zebra finch nests. Krumpál et al. (2000–2001) characterized pseudoscorpions in the Eurasian tree sparrow's nest-boxes as typical inhabitants of this type of micro-

habitat. Krištofík et al. (2002) found a higher number of *Neobisium sylvaticum* (C.L. Koch, 1835) and *D. latreillii* in the nests of the red-backed shrike and the lesser grey shrike. *Pselaphochernes scorpioides* (Hermann, 1804) was observed in the lesser-spotted eagle nests (Krištofík et al. 2009). The pseudoscorpion fauna and its relation to bird species are also reported in Legg (2002), Christophoryová (2010a) and Christophoryová & Krumpálová (2010). Recently, Turienzo et al. (2010) elaborated global checklist of pseudoscorpions found in bird nests and they recorded 14 families with 85 species from this biotope worldwide.

The disproportion in opinions about the relation of pseudoscorpions to the bird nests as a type of environment has encouraged us to deal with this phenomenon. The specific objectives of the study were: (1) to evaluate pseudoscorpion presence in different types of nests and (2) to characterize and categorize pseudoscorpion species according to their relationship to the type of the host nest.

Material and methods

171 nests of 28 bird species (Tables 1, 2) were collected in 1989–2004 and in 2007–2009 in Slovakia, Austria and in the Czech Republic (leg. P. Berka, M. Filípek, J. Jamriška, V. Jánošková, J. Krištofík, Z. Országhová, J. Plachý, P. Puchala, K. Sobeková, M. Šuplatová, M. Takácsová, M. Tiefenbach). Majority of nests were collected immediately after the fledging of chicks and packed into plastic bags, 18 of them were collected about 20 days after the fledging (one nest of the black redstart, two nests of the collared flycatcher and the tawny owl each, 13 nests of the Eurasian tree sparrow). 15 nests of the Eurasian tree sparrow were collected during the winter or early in the spring. The boxes with the European roller were filled with sawdust and pieces of tree bark to the depth of about one third of the box; the hoopoe hollow nests were picked up thoroughly together with the decomposed substrate of the hollows. The collected bird nests were divided into seven categories according to the built type and certain location in the environment (Table 1). The category A (except of nests situated in tree hollows) includes long-tailed tit and winter wren closed nests with nesting chamber accessed only by a small entrance, and being usually placed on tree trunks or on dense shrubs. The pseudoscorpion specimens were extracted from the nests using Tullgren's funnels. The specimens were preserved in 96% ethyl alcohol and were studied as permanent slide mounts. The material is deposited at the Comenius University in Bratislava, Slovakia. The determination of specimens follows Beier (1963) and Mahnert (2004). Nomenclature for pseudoscorpion species follows Harvey (2009), for bird species Heinzel et al. (1995) and ecological terminology follows Allaby (2006). Obtained data about pseudoscorpion species representation in bird nests categories (specimen's number of pseudoscorpion species in concrete bird nests category) were normalized. Data were evaluated using PAST (Hammer et al. 2001) based on a single linkage cluster analysis using the Bray-Curtis similarity index and detrended correspondence analysis (DCA). Bird nests of categories D and G were not included into the analysis because of the insufficient number of collected nests (Table 1). Box and whisker plot diagrams were created using the Statgraphics Plus for Windows 3.0, only species occurring in at least 13 bird nests were included into the diagram (Table 2).

List of collecting sites

Austria: Feuersbrunn (48°26′ N, 15°47′ E) *Passer montanus* L., 1758 (1 nest = 1 n); bei Straden, Zweistromland (46°47′ N, 15°53′ E) *Coracias garrulus* L., 1758 (1 n.); Illmitz (47°45′ N, 16°45′ E) *Upupa epops* L., 1758 (3 n.); Karbach (46°48′ N, 15°53′ E) *C. garrulus* (2 n.); Laasen Nord (46°46′ N, 15°56′ E) *C. garrulus* (1 n.); Tieschen (46°46′ N, 15°56′ E) *C. garrulus* (2 n.). Czech Republic: Břeclav (48°45′ N, 16°52′ E) *Ficedula albicollis* Temminck, 1815 (2 n.); Pavlov (48°51′ N, 16°38′ E) *Sylvia atricapilla* (L., 1758) (1 n.), *Turdus merula* L., 1758 (1 n.), *Turdus philomelos* C.L. Brehm, 1831 (1 n.). Slovakia: Bátorove Kosihy (47°51′ N, 18°20′ E) *Merops apiaster* L., 1758 (1 n.); Bodíky (47°55′ N, 17°26′ E) *Carduelis chloris* (L., 1758) (1 n.), *Fringilla coelebs* (L., 1758) (2 n.), *S. atricapilla* (2 n.), *T. merula* (1 n.), *T. philomelos* (5 n.); Bratislava, Lištiny (48°10′ N, 17°03′ E) *Parus major* L., 1758 (1 n.), *P. montanus* (1 n.), *T. merula* (2 n.); Bratislava, Železná studnička (48°11′ N, 17°04′ E) *Erithacus rubecula* (L., 1758) (1 n.), *Troglodytes troglodytes* (L., 1758) (2 n.); Čičov (47°46′ N, 17°43′ E) *Muscicapa striata* (Pallas, 1764) (1 n.); Dobrohošť (47°59′ N, 17°20′ E) *C. chloris* (1 n.), *T. merula* (1 n.), *T. philomelos* (1 n.); Dolný Štál (47°58′ N, 17°43′ E) *Luscinia megarhynchos* (C.L. Brehm, 1831) (2 n.); Gabčíkovo (47°52′ N, 17°32′ E) *Delichon urbica* (L., 1758) (1 n.), *Motacilla alba* L., 1758 (3 n.), *T. merula* (2 n.), *T. philomelos* (1 n.); Hriňová, Javorinka (48°37′ N, 19°28′ E) *M. alba* (1 n.); Hriňová, Pivnička (48°35′ N, 19°28′ E) *Turdus pilaris* L., 1758 (1 n.); Jahodná (48°02′ N, 17°43′ E) *Aegithalos caudatus* (L., 1758) (1 n.), *T. merula* (1 n.), *T. philomelos* (3 n.); Jakubov, ponds (48°24′ N, 16°58′ E) *A. caudatus* (1 n.), *C. chloris* (1 n.); Jarovce (48°02′ N, 17°07′ E) *T. philomelos* (1 n.); Kamenica nad Hronom (47°49′ N, 18°44′ E) *Phoenicurus ochruros* (S.G. Gmelin, 1774) (1 n.), *U. epops* (1 n.); Komárno, NPR Apáli (47°48′ N, 18°03′ E) *A. caudatus* (1 n.), *T. philomelos* (1 n.); Koromľa (48°43′ N, 22°17′ E) *Otus scops* (L., 1758) (1 n.); Kováčová (48°37′ N, 19°05′ E) *Certhia familiaris* L., 1758 (1 n.), *Phylloscopus sibilatrix* (Bechstein, 1793) (1 n.); Lehnice (48°04′ N, 17°28′ E) *S. atricapilla* (1 n.), *T. merula* (2 n.); Malé Leváre (48°31′ N, 16°55′ E) *F. coelebs* (1 n.), *T. troglodytes* (4 n.), *T. merula* (2 n.), *T. philomelos* (1 n.); Medveďov (47°47′ N, 17°40′ E) *S. atricapilla* (1 n.); Mikušovce (49°03′ N, 18°12′ E) *Ph. ochruros* (1 n.); *Strix aluco* L., 1758 (1 n.); Ohrady (47°58′ N, 17°42′ E) *U. epops* (1 n.); Rusovce (48°04′ N, 17°09′ E) *Oriolus oriolus* (L., 1758) (1 n.); Sobotište (48°44′ N, 17°24′ E) *S. aluco* (1 n.); Stankovany, Podšíp (49°09′ N, 19°09′ E) *M. alba* (5 n.), *Sitta europaea* (L., 1758) (1 n.); Svätý Jur, Šúr Nature Reserve (48°13′ N, 17°12′ E) *P. montanus*: (78 n.); Šuľany (47°56′ N, 17°25′ E) *S. atricapilla* (1 n.); Tuchyňa (49°02′ N, 18°12′ E) *S. aluco* (1 n.); Veľké Blahovo, ponds (48°03′ N, 17°35′ E) *Ixobrychus minutus* (L., 1766) (1 n.); Vysoká pri Morave (48°20′ N, 16°53′ E) *T. merula* (1 n.); *T. philomelos* (2 n.); Vysoká pri Morave, Horný les (48°20′ N, 16°52′ E) *Accipiter gentilis* (L., 1758) (1 n.). For more details see Christophoryová (2010b).

Results

Pseudoscorpion species range in bird nests

A total of 480 pseudoscorpion specimens were studied. Most of the individuals (72%) were found in the hollow nests and nest boxes, 15% of them in the open nests in

Table 1. Abundance of pseudoscorpion developmental stages in bird nests.

Nest category	Number of positive nests	Host/Taxon	*N. carcinoides*	*L. lata*	*C. museorum*	*C. cancroides*	*D. latreillii*	*C. hahnii*	*D. cyrneus*	*A. wideri*	*L. chyzeri*	*L. nodosus*	*P. scorpioides*	Sum
A	3	*A. caudatus*					1p 1d	1m						3
	1	*C. familiaris*			1f 1p									2
	1	*M. striata*			2m 1f									3
	1	*O. scops*								3m 7f 6t				16
	1	*P. major*						1f						1
	2	*P. montanus*								3f				3
	1	*S. europaea*											1f	1
	1	*S. aluco*		2m 2t						1f 3t				8
	6	*T. troglodytes*	1m					2m 2f 3d 1t						9
	5	*U. epops*						1f		1m 3f 11p 2d 2t			31m 21f 2d 16t	90
B	6	*C. garrulus*					2m	2f		2m 9f 1t		1f		17
	2	*F. albicollis*				2m				1m 9f				12
	78	*P. montanus*			1p	5t	4m 3f 1p 6d 4t	3m 5f 1d 7t	8m 24f 18p 13d 11t	4m 18f 8d	1m	1f		146
	2	*S. aluco*				3t				9m 6f 15t				33
C	1	*E. rubecula*	1f											1
	2	*L. megarhynchos*					3m 1d 1t							5
	3	*M. alba*			12m 9f 5t									26
	1	*Ph. sibilatrix*	1d 1t											2
D	1	*I. minutus*					1m							1
E	1	*A. gentilis*						1f 1t						2
	3	*C. chloris*					2f	2d						4
	3	*F. coelebs*					1f 1t	1m 1f						4
	1	*O. oriolus*					1t							1
	6	*S. atricapilla*					1f 2m 5t 2d							10
	12	*T. merula*					2m 4f 10p 3d 1t	2m 3f 1d 1t						27
	16	*T. philomelos*					3m 4f 1p 7d 8t	1f 1d						25
	1	*T. pilaris*						1f						1
F	2	*Ph. ochruros*				1t	1p							2
	6	*M. alba*			11m 6f 1p 4t									22
	1	*D. urbica*			2t									2
G	1	*M. apiaster*								1d				1
Total	171		4	4	56	11	87	45	74	125	1	2	71	480

Explanations: A – nests in hollows, B – nests in boxes, C – open nests situated on the ground, D – open nests in reeds, E – open nests in trees and shrubs, F – nests in synanthropic habitats, G – nests in burrows. Table caption: m – male, f – female, p – protonymph, d – deutonymph, t – tritonymph.

Table 2. Number of bird nests positive on pseudoscorpion species.

Taxon/Host	*A. gentilis*	*A. caudatus*	*C. chloris*	*C. familiaris*	*C. garrulus*	*D. urbica*	*E. rubecula*	*F. albicollis*	*F. coelebs*	*I. minutus*	*L. megarhynchos*	*M. apiaster*	*M. alba*	*M. striata*	*O. oriolus*	*O. scops*	*P. major*	*P. montanus*	*Ph. ochruros*	*Ph. sibilatrix*	*S. europaea*	*S. aluco*	*S. atricapilla*	*T. troglodytes*	*T. merula*	*T. philomelos*	*T. pilaris*	*U. epops*	Total
N. carcinoides							1													1				1					3
L. lata																						1							1
C. museorum				1		1							9	1				1											13
C. cancroides								1										1	1			1							4
D. latreillii		2	2		1				1	1	2				1			17	1				6		6	14			54
C. hahnii	1	1	1		2				2								1	12						5	6	2	1	1	35
D. cyrneus																		50											50
A. wideri					4			1				1				1		10				2						4	23
L. chyzeri																		1											1
L. nodosus					1													1											2
P. scorpioides																					1							2	3

the trees and shrubs, the lowest number was collected in the open nests on the ground, inside buildings, in the reeds and burrows (Table 1). The highest number of species belonged to the family of Chernetidae (six species, 318 specimens), a lower number to Cheliferidae (two species, 98 specimens) and the families of Neobisiidae (four specimens), Larcidae (four specimens) and Cheiridiidae (56 specimens) were represented by one species. *Dactylochelifer latreillii* and *Dendrochernes cyrneus* were found frequently in bird nests (50 or more positive nests), the lowest frequency was recorded in *Larca lata* and species of the genus *Lamprochernes* (in 1 or 2 nests) (Table 2).

Neobisium carcinoides (Hermann, 1804) occurred accidentally and in a low abundance (0.8%) in the hollow or in the nests situated on the ground (1.3 ind./positive nest). Its nymphal stages were found in July, the adults in June.

Larca lata (Hansen, 1884) occurred in a low abundance in the tree hollow (tawny owl nest) in May.

Cheiridium museorum was an abundant and a constant species (Fig. 1), recorded in the hollow nests and nest boxes, in the nests on the ground and the nests in the synanthropic habitats. More than 85% specimens of this species were found in the white wagtail nests (4.3 ind./positive nest) and protonymphs (June–July), tritonymphs and adults (June–September) were recorded.

Chelifer cancroides was found predominantly in the hollow nests; tritonymphs were found in July, later from September to October, the adults in March.

Dactylochelifer latreillii was an abundant species in the nests (18.1%, Fig. 1) and frequently occurred in the nests of all types, except for the nests in the burrows (1.6 ind./positive nest). Its females were found with brood-sac in June–August; adults (May–August), tritonymphs (May–August), deutonymphs (February–August) and protonymphs (March–August) were recorded.

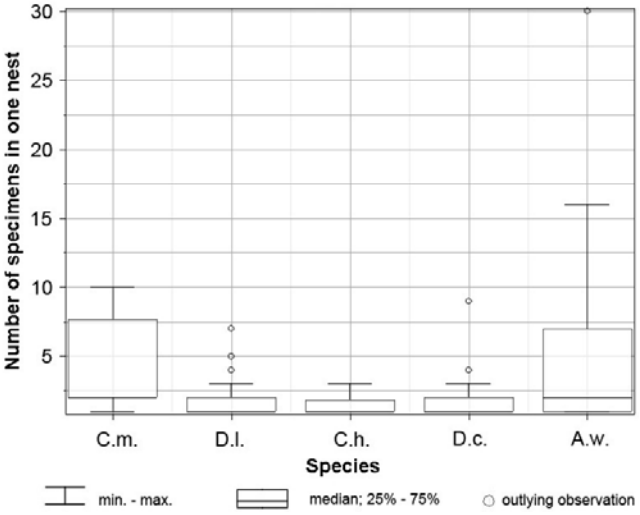

Fig. 1. Abundance of pseudoscorpions in bird nests (Box and whisker plots). C.m. – *Cheiridium museorum*, D.l. – *Dactylochelifer latreillii*, C.h. – *Chernes hahnii*, D.c. – *Dendrochernes cyrneus*, A.w. – *Allochernes wideri*.

Chernes hahnii, an abundant species (Fig. 1), was found in all types of the nests, except for the nests in synanthropic habitats and burrows. Adults and tritonymphs of *C. hahnii* (May–August; two in November), four females with brood-sac (May–June) and deutonymphs (May–September) were found.

Dendrochernes cyrneus (L. Koch, 1873) was an abundant (15.4%) and frequent species, it prevailed in the Eurasian tree sparrow nest boxes (Fig. 1). We confirmed the presence of its females with brood-sac (May–July), all the nymphal stages – the protonymphs (July and September), the deutonymphs (May–August), the tritonymphs (May–July) and the adults (May and August).

Allochernes wideri (C.L. Koch, 1843), the most abundant (26%, 5.2 ind./positive nest) and frequent

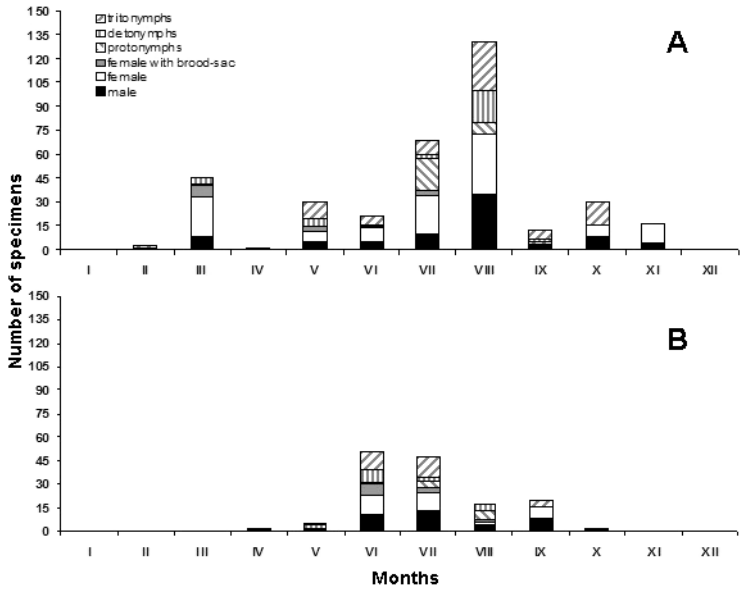

Fig. 2. Developmental stages of pseudoscorpions in: A – hollow nests and nest boxes (344 specimens), B – open nests (135 specimens).

bird-nest pseudoscorpion prevailed in the burrows and hollow nests and in the boxes (Fig. 1). All nymphal stages and females of this species with brood-sac occurred regularly in March and July. We collected its protonymphs (July–August), deutonymphs (August) and tritonymphs (May, August and October). Adults were found in March, later from July to August and from October to November. The adults of *L. chyzeri* (Tömösváry, 1882) and *L. nodosus* were found in the nest boxes sporadically.

Pselaphochernes scorpioides was an abundant species (14.8%, maximum of 69 ind./positive nest) and it prevailed in the hoopoe hollow nests; the adults were obtained in June–August, the tritonymphs and the deutonymphs in August (Table 1).

More than two third of pseudoscorpion specimens were found in the nest boxes and hollow nests (Table 1, A, B categories). The species *A. wideri*, *C. hahnii*, *P. scorpioides* and *D. cyrneus* were the most abundant, represented by all or majority of developmental stages. The females, males and tritonymphs were found in the boxes collected during the winter and spring before the nesting. The first females with brood-sacs appeared and reached a peak in March and then their numbers declined. Protonymphs reached the maximum in July, deutonymphs in August. Maximal occurrence of all developmental stages in the boxes and hollows was recorded in July and August (Table 1, Fig. 2A).

The pseudoscorpions *D. latreillii*, *C. museorum* and *C. hahnii* predominated in open nests (Table 1, C–G categories). Species collected in open nests reached maximum in June and July, when all developmental stages were present. Occurrence of nymphal stages depended very closely on bird nesting. The first females with brood-sacs were found in June, three month later than in boxes. Protonymphs reached the maximum in August, majority of them owing to *D. latreillii* in the nests of blackbirds, deutonymphs occurred in June in the nests of song thrushes (Table 1, Fig. 2B). In September, the adults and tritonymphs of *C. museorum* prevailed in the nests of wagtails. Since pseudoscorpions left the open types of nests from November to March, none specimens were found in this period.

Most of the positive nests were inhabited by one pseudoscorpion species. Altogether twelve bird nests (7%) were found with more than one species inhabiting (seven Eurasian tree sparrow nest boxes, one European roller nest box, two hoopoes hollows, one tawny owl hollow nest). Species *A. wideri* was found three times with *D. cyrneus* (in Eurasian tree sparrow nests) as well as with *C. hahnii* (in Eurasian tree sparrow, hoopoe and European roller nests). *Allochernes wideri* was found in one case with *L. lata* (in tawly owl nest) and *P. scorpioides* (in European roller nest). In one sparrow nest we found *D. latreillii* with *C. hahnii* and in second one *C. cancroides* with *D. cyrneus*. Combinations of three pseudoscorpions species were the following: *D. latreillii* – *C. hahnii* – *A. wideri* (in European roller nest) and *C. hahnii* – *D. cyrneus* – *A. wideri* (in Eurasian tree sparrow nest). Generally, in the coexistence of more species in one bird nest, adults prevailed. Nymphal stages were confirmed only in a few cases.

Similarity of the pseudoscorpion fauna in the bird nests categories

The pseudoscorpion assemblages in the bird nests categories were evaluated according to the single linkage cluster analysis using the Bray-Curtis similarity index (Fig. 3) (coph. correlation coefficient = 0.7577). High degree of species resemblance was found between plentifully represented species *D. cyrneus*, *A. wideri* in nest boxes and hollow nests and *P. scorpioides* found numerously in hollow nests. Subsequently species *D. latreillii* and *C. hahnii* were linked with preference to hollow and open nests built on the shrubs and trees and *C. cancroides* represented in lower number in hol-

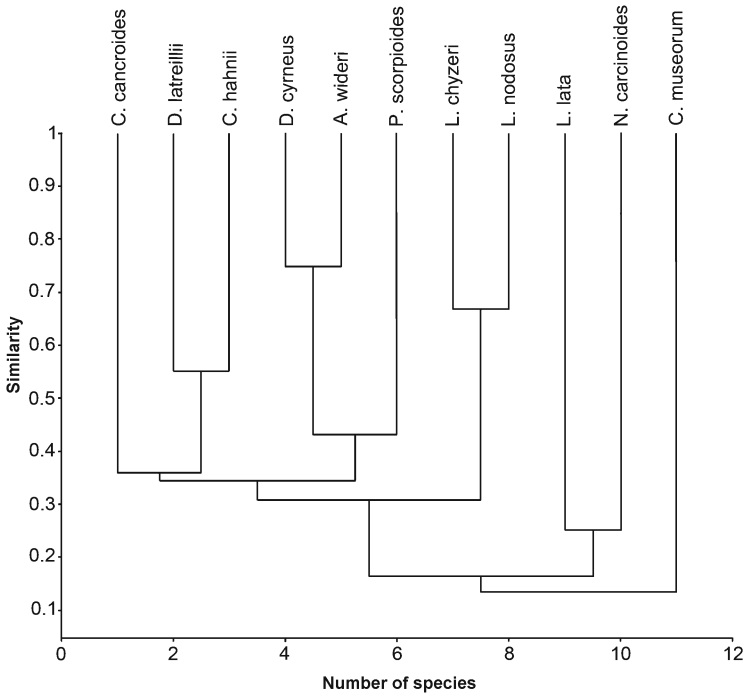

Fig. 3. Cluster analysis (Bray-Curtis index) of the pseudoscorpion species in bird nests categories.

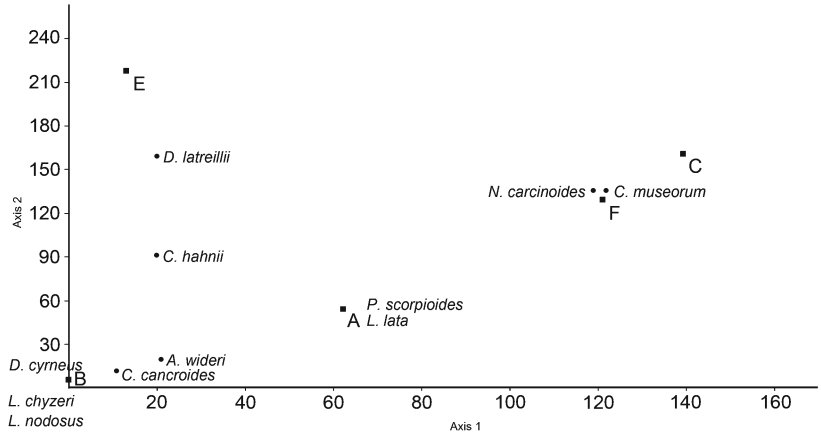

Fig. 4. Detrended correspondence analysis of pseudoscorpions in bird nests categories. A – nests in hollows, B – nests in boxes, C – open nests situated on the ground, E – open nests in trees and shrubs, F – nests in synanthropic habitats.

low nests on the trees. The lower similarity to the previously mentioned species was recorded in *Lamprochernes* species accidentally occurred in Eurasian tree sparrow box nests. Highest dissimilarity was among the species *L. lata*, *N. carcinoides* and *C. cancroides* presented in low number in hollow nests. *Cheiridium museorum* found in the nests in synanthropic habitats and on the ground, besides the hollow nest, was dissimilar to other pseudoscorpions (Fig. 3).

Classification of pseudoscorpions finding in the bird nests

The classification based on the associations of the pseudoscorpion species to the bird nests habitats showed that *C. hahnii*, *A. wideri*, *D. cyrneus*, *D. latreillii*, *P. scorpioides* and *C. museorum* occurred in a high proportion in the nests. DCA analysis (Fig. 4) confirmed a great proportion and association of *P. scorpioides* in hollow nests (mainly of the hoopoe), *D. cyrneus* in the Eurasian tree sparrow nest boxes and *A. wideri* in hollow nests and nest boxes (mainly of the tawny owl, European scops owl and the European roller). In contrast, *C. hahnii* and *D. latreillii* influenced the nest fauna of open and hollow nest situated on the shrubs and trees (mainly of Eurasian tree sparrow and the blackbirds and the song thrushes) and *C. museorum* the nests situated on the ground or on buildings (of the white wagtails) (Table 1, Fig. 4). Other pseudoscorpion species appeared in nests randomly or without a distinct preference to particular category (*Lamprochernes* species in nest boxes, *L. lata* in tawny owl hollow nest and *N. carcinoides* in nests situated in hollow nest and nests situated on the ground).

We found 11 species, seven of which were ni-

diphilous (Table 1). Until present, the occurrence of 22 pseudoscorpion species has been confirmed in the bird nests of Central Europe based on the obtained results (Table 1) and published resources (Ressl 1963; Beier 1971; Krumpál & Cyprich 1988; Fenďa et al. 1998; Krumpál et al. 2000–2001; Krištofík et al. 2002, 2005; Turienzo et al. 2010). We classified above mentioned pseudoscorpions into two main categories:

A. Nidixenous species – they occur accidentally in the bird nests, the nymphal stages are present only sporadically – *Chthonius fuscimanus* Simon, 1900; *C. tetrachelatus* (Preyssler, 1790); *Mundochthonius styriacus*; *Neobisium carcinoides*; *N. crassifemoratum* (Beier, 1928); *N. inaequale*; *N. sylvaticum*; *Chernes cimicoides*; *C. similis* (Beier, 1932); *Chernes vicinus* (Beier, 1932); *Allochernes powelli* (Kew, 1916); *L. chyzeri*, *L. nodosus* and *L. lata*;

B. Nidiphilous species – they occur regularly in the bird nests, presented with nymphal stages and females with brood-sacs and seem to prefer the nests in certain habitats: (i) nests in synanthropic habitats: *C. museorum*, *C. cancroides*; (ii) hollow nests: *A. wideri*; (iii) hollow nests in the flooded forest and alder forest: *D. cyrneus*; (iv) open and hollow nests in the trees and shrubs: *D. latreillii*, *C. hahnii, D. panzeri*; and (v) nests with decomposed substrate:*P. scorpioides*.

Association of nidiphilous species to certain type of bird nests observed is an important contribution on the ecology and biology of pseudoscorpions. Our classification does not include the category of nidicolous pseudoscorpion species that live exclusively in nests, because we have not found these species in Central Europe yet.

Discussion

Some pseudoscorpions occurred in the nests accidentally, others regularly. Beier (1948), Cyprich et al. (1992) and Krištofík et al. (1994, 1995, 1996, 2003, 2005) considered the occurrence of pseudoscorpions in the nests as random, without any specific relation to the nest habitat. However, these results were based on small numbers of collected individuals. In contrast, Ressl & Beier (1958) mentioned the nesters and nest types which pseudoscorpions search for. Krumpál & Cyprich (1988) tried to define ecological preferences of pseudoscorpion species in relation to open nests or nest boxes. Finally we classify 8 species of pseudoscorpions as nidiphilous and 14 as nidixenous species.

We classify the species *C. museorum* and *C. cancroides* as nidiphilous preferring mainly nests in synanthropic habitats. Krumpál & Cyprich (1988) also mentioned that nests represent their favoured habitat and considered *C. cancroides* and *C. museorum* as nidicols in nests. The occurrence of *C. museorum* has been frequently noticed in nests of the barn swallow (Rafalski 1967, Krumpál & Cyprich 1988, Drogla & Lippold 2004, Christophoryová 2010a), the house sparrow (George 1961), the Eurasian tree sparrow (Kew 1901, Jones 1975, Krumpál et al. 2000–2001), the house martin (Jones 1975) and in nests of Passeriformes and Columbiformes (Nordberg 1936, Legg 2002). It was found probably coincidentally in the nests of the Eurasian penduline tit (Krištofík et al. 1995).

Chelifer cancroides is a cosmopolitan species which prevailed in the open and hollow nests, mainly in the synanthropic conditions (Nordberg 1936; Rothschild & Clay 1952; Woodroffe 1953; Ressl & Beier 1958; Rafalski 1967; Jones 1975; Cyprich et al. 1992, 2000; Ducháč 1994; Krumpál et al. 2000–2001; Christophoryová 2010a; Turienzo et al. 2010). Nosek & Lichard (1962) found six specimens of the species in a Eurasian blackbird nest placed in the shrubs. The low numbers of the obtained specimens seems to be a result of a few nests in synanthropic habitats analysed in this study but the published resources proved that it occurred regularly in these nest category.

Allochernes wideri was found regularly in the hollow nests and belongs to the nidiphilous species; it lives in the tree hollows and prefers dry substrate (Ranius & Wilander 2000; Šťáhlavský 2001; Christophoryová 2010a). The presence of the species was recorded in the hollow nests (Ressl 1963; Christophoryová 2010a) and to a lower extent in the open nests (Ressl & Beier 1958; Christophoryová 2010a). We confirmed its presence in the nests of the tawny owl, European scops owl and European roller. This species occurred in tree hollows and leaf litter as well (Beier 1963; Christophoryová 2010a).

Dendrochernes cyrneus occurred regularly with all the nymphal stages in the Eurasian tree sparrow nest boxes (50 nests). All records from Slovakia come from the nests situated in the alder forest in the Šúr Nature Reserve. This finding corresponds to the previous knowledge (Krumpál & Cyprich 1987; Krumpál et al. 2000–2001) as well as the fact that the species has a restricted distribution and is associated with the flooded forest (Beier 1963; Ducháč 1993a). Except of the findings in bird nests, a few specimens were collected using Malaise traps (Christophoryová & Krumpál 2010). This species occurred mainly under the tree bark and in the rotten wood of old trees or it is in phoretic association with the longhorn beetles (Beier 1963; Ducháč 1993b).

Dactylochelifer latreillii and *C. hahnii* belong to the category of nidiphilous species that regularly occurred in a high abundance in the open and hollow nests in trees and shrubs. These two species were found in the open nests of the European blackbirds and Eurasian thrushes, only. Krištofík et al. (1993) and Krumpál & Cyprich (1988) noticed *D. latreillii* with a high affinity to the differently situated nests. It was found in different nests and mostly occurred individually (Ressl & Beier 1958; Krumpál & Cyprich 1988; Krištofík et al. 1993, 2002; Krumpál et al. 2000–2001; Christophoryová 2010a; Turienzo et al. 2010). Ressl (1963) characterized this species as an occasional guest in the bird nests but we found it frequently in more than 50 nests. Only a few data are known about the occurrence of *C. hahnii* in the bird nests (Turienzo et al. 2010). The species regularly occurred in the nests placed in the trees, either in the open or in hollow nests. Krumpál

& Cyprich (1988) found it in the open nests and nest boxes. *Chernes hahnii* was recorded in the European bee-eater nests (Krištofík et al. 1996), the Eurasian tree sparrows nest boxes (Krumpál et al. 2000–2001) and in the open nests of the song thrush (Christophoryová 2010a). Records of *D. latreillii* and *C. hahnii* in these nest types correspond with the ecological requirements of the species. Both were found under the bark of trees and in tree hollows (Šťáhlavský 2001; Drogla & Lippold 2004; Christophoryová 2010a).

Dinocheirus panzeri lives in tree hollows, under the bark of trees and in bird nests (Beier 1963; Drogla & Lippold 2004). Beier (1948) and Jost (1982) considered this species as regularly occurring in nests. It was found in nests of the common starling (Butterfield 1908), Eurasian jackdaw, great tit, pigeon, swift and owl (Jones 1975), in the Eurasian tree sparrow nests (Krumpál et al. 2000–2001) and in the lesser grey shrike nests (Krištofík et al. 2002). The species was numerously recorded in the debris of old pigeon loft (Legg 2002).

Pselaphochernes scorpioides was characterized as nidiphilous species that preferred nests with decomposed substrate and was collected in the hollow nests of the hoopoe and wood nuthatch. These nests provide suitable living conditions; because this species prefers various humid materials, manure dumps, decaying wood or compost heaps (Beier 1963; Drogla & Lippold 2004). Jones (1975) found this species in the jackdaw nests, Drogla & Lippold (2004) in Eurasian tree sparrow nests. Legg (2002) supposed its association with the ant nests of *Formica rufa*.

The species *C. fuscimanus*, *C. tetrachelatus*, *M. styriacus*, *N. carcinoides*, *N. crassifemoratum*, *N. inaequale*, *N. sylvaticum*, *C. cimicoides*, *C. similis*, *C. vicinus*, *A. powelli*, *L. chyzeri*, *L. nodosus* and *L. lata* were classified as nidixenous species with accidental occurrence in the bird nests. *Neobisium carcinoides* is a eurytopic, mainly epigeic species; low numbers of individuals were present in the bird nests. Krumpál & Cyprich (1988) found this species in the open nests on the ground, Fenďa et al. (1998) in the wagtail, winter wren and white-throated dipper nests. Species of the genus *Lamprochernes* were collected in the nests occasionally. Our results correspond with several studies wherein these species were individually detected in the nests of the Eurasian penduline-tit, the European bee-eater, the Eurasian tree sparrow and the domestic rock pigeon (Krumpál & Cyprich 1988; Krištofík et al. 1995, 1996; Christophoryová 2010a).

Larca lata is suggested to be a scarce and extinct European species (Judson & Legg 1996; Ranius & Wilander 2000). It is restricted to dry shadowy and humid habitats with rich content of detritus or excrements of birds and rodents (Beier 1963). The species was found for the first time in a nest (tawny owl) that was taken immediately after fledging of the chicks. Most records of *L. lata* come from the hollows of old trees; it is often considered to be a stenotopic species living exclusively in the hollows of the oldest oak-trees (Rafalski 1953, 1967; Ducháč 1993a, b) and in the old abandoned bird nests (Ressl 1963; Ranius & Wilander 2000).

Bird nests offer pseudoscorpions the source of food, shelter and suitable conditions for reproduction (Krumpál & Cyprich 1988; Turienzo et al. 2010). Birds provide the temperature and nourishment necessary for the development of mites, springtails and larval stages of insects, which can serve as food for the pseudoscorpions (Jones 1975). Some invertebrate species can survive in the bird nests as long as for one year, but the majority of them live there during the breeding season only, than pseudoscorpions will tend to move away to more favourable neighbouring habitats (Jones 1975; Krumpál & Cyprich 1988). This result was confirmed also in our research but only 15 nests of the Eurasian tree sparrow were collected during the winter or early in the spring. Finding of a considerable relation of the nidiphilous pseudoscorpions to certain type of the bird nests is the most important contribution to the knowledge of their ecology and biology.

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