

**Pseudoscorpions (Arachnida: Pseudoscorpiones)
in the nests of *Formica* ants in Slovakia**

**Šťúriky (Arachnida: Pseudoscorpiones)
v hniezdach mravcov rodu *Formica* na Slovensku**

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Abstract. The study presents new data on the occurrence of pseudoscorpions in anthills of *Formica gagates* Latreille, 1798 and *Formica rufa* Linnaeus, 1761 in Slovakia. Pseudoscorpions were collected from 10 sampling sites and 11 ant nests (two nests of *F. gagates* and nine nests of *F. rufa*). Altogether, 1041 pseudoscorpions belonging to six species and three families were collected. Five species were obtained from anthills of *F. rufa*, in contrary to the nest of *F. gagates*, where only one species, *Allochernes solarii* (Simon, 1898), was present. The family Chernetidae was ranked first with four species, followed by families Atemnidae and Chthoniidae, each with one species. The most abundant species from the examined material was *Allochernes wideri* (C. L. Koch, 1843). On the other hand, only a single specimen of *Atemnus polius* (Simon, 1878) was recorded. This species is recorded from ant nests for the first time worldwide. *Chernes vicinus* (Beier, 1932), from the nests of *F. rufa*, is recorded for the first time for Slovakia.

INTRODUCTION

Many pseudoscorpion species colonise nests of social insects, mainly termites, ants and bees (Beier 1948, Turk 1951, Weygoldt 1969). Beier (1948) categorized the pseudoscorpion species inhabiting nests of social insects into three categories. The first category includes species occurring exclusively in nests, for example, species from the genus *Pilanus* Beier, 1930 in termitaries, *Dasychernes* Chamberlin, 1929 and *Ellingsenius* Chamberlin, 1932 in beehives, *Hesperochernes* Chamberlin, 1924 in wasp nests and *Myrmochernes* Tullgren, 1907 in ant nests (Beier 1948). The second category includes species occurring regularly in nests of social insects, but not fixed to this habitat type. Many chernetid species belong to this category, for example *Pselaphochernes scorpioides* (Hermann, 1804), *Chernes cimicoides* (Fabricius, 1793), *Allochernes wideri* (C. L. Koch, 1843) and others, which were collected from ant nests, bumble bee nests and beehives (Beier 1948, Ressler 1974, Droglá & Lippold 2004). *Chelifer cancroides* (Linnaeus, 1758) is very often found in beehives (Weygoldt 1969, Šťáhlavský 2011, Šťáhlavský & Chytil 2013). The last category includes species occurring in nests randomly and occasionally. Neobisiid and chthoniid species can easily enter ant nests because of their way of life in the soil, leaf litter and moss (Beier 1948). They are found mostly in low abundance in nests (Beier 1948, Jászayová et al. 2015, Christophoryová et al. 2017a).

The relationship between pseudoscorpions and ants, in general, it seems to be synoekete; that means that pseudoscorpions live in the ant nests without receiving any attention from their hosts (Turk 1951, Jones 1978). Pseudoscorpions, which are found regularly near or in ant nests with all developmental stages, can be considered as myrmecophilous (Cushing 1997, Henderickx 2011). They can be found at the periphery of the ant nests, near entrances, within chambers at the periphery or deeper in the nests (Fowles 1994, Cushing 1997). Ant nests provide favourable temperature and the presence of small arthropods living there, such as mites, springtails or beetle larvae that serve as a food for pseudoscorpions (Weygoldt 1969). Pseudoscorpions normally do not harm their ant hosts. However, some of them can use their hosts as prey (Turk 1953, Vachon 1954).

In Central Europe, some faunistic data about pseudoscorpions from ant nests were published from Germany (Drogla & Lippold 2004), Austria (Ressler & Beier 1958, Kofler 1972, Ressler 1974), Poland (Rafalski 1967) and from the Czech Republic (Štáhlavský 2001).

The first data about pseudoscorpions in ant nests in Slovakia were documented by Jászayová et al. (2015). Four species were collected from anthills of *Formica polyctena* Förster, 1850. *Pselaphoernes scorpioides* was the most abundant and *Allochernes peregrinus* Lohmander, 1939 was recorded for the first time in ant nests worldwide (Jászayová et al. 2015). Later, Christophoryová et al. (2017a) found six species from nests of *Formica rufibarbis* Fabricius, 1793 and *Formica rufa* Linnaeus, 1761, of which *A. wideri* was the most abundant.

The most recent known pseudoscorpion record from ant nests in Slovakia was mentioned by Červená et al. (2018). Adults and nymphs of *Allochernes solarii* (Simon, 1898) were found in the nests of *Formica gagates* Latreille, 1798 in the locality Vajnorská Hora Mt., and simultaneously this species was presented as new for the Slovakian pseudoscorpion fauna (Červená et al. 2018).

The aim of the present study is to provide new data on pseudoscorpions associated with nests of *Formica* Linnaeus, 1758 species in Slovakia.

MATERIAL AND METHODS

Pseudoscorpions were collected from ant nests at 10 sampling sites in Slovakia over two years (2017, 2018) (Table 1, Fig. 1). Altogether, 11 anthills of *Formica gagates* (two nests) and *Formica rufa* (nine nests) were examined (Table 1). Samples from nests were collected during the winter and early spring months when the activity of ants is the least. Nests of *F. rufa* were mostly big anthills situated above the ground level and consisted of detritus or decaying wood (Fig. 2). Both nests of *F. gagates* were situated under stones below ground level, and the distance from each other was at most four metres. Samples of the nests were taken from the centre and sometimes from the surface of the nests and then heat extracted in Tullgren funnels. After rolling away the stones above the nests of *F. gagates*, some pseudoscorpions were observed crawling and were collected individually using forceps. Collected specimens were studied as temporary slide mounts, prepared by immersing the specimens in lactic acid for clearing and using Leica DM1000 microscope. After study, the specimens were rinsed in water and returned to 75% ethanol. The majority of pseudoscorpions were identified using the key in Christophoryová et al. (2011b) and *Allochernes solarii* was identified using the keys in Beier (1932, 1963). Nomenclature for all taxa follows Harvey (2013) and Zaragoza (2017). The list of collected taxa is given below, with locality code (see Table 1), collecting method, date, number of developmental stages (female: ♀, male: ♂, tritonymph: Tn, deutonymph: Dn, protonymph: Pn) and collector name. The material is deposited in the zoological collections of Comenius University in Bratislava, Slovakia.

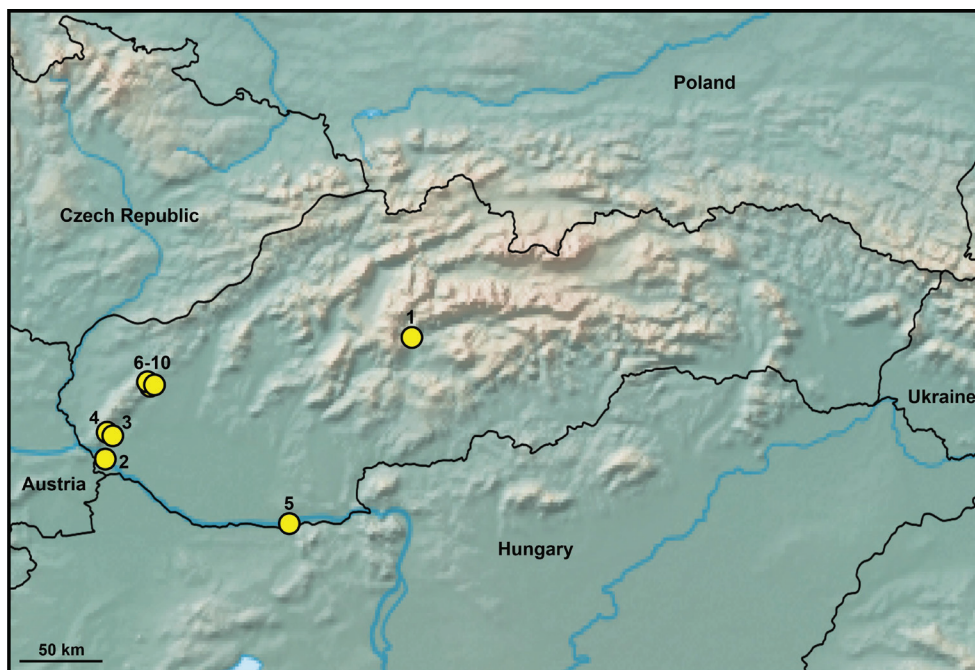


Fig. 1. Location of the sampling sites in Slovakia. For locality codes see Table 1.

Obr. 1. Rozmiestnenie študovaných plôch na Slovensku. Pre kódy lokalít viď Tabuľku 1.

Table 1. List of the sampling sites in Slovakia with ant hosts. Abbreviations: AH – number of anthills, NR – Nature Reserve, PL – Protected Landscape.

Tabuľka 1. Zoznam študovaných plôch na Slovensku s hostiteľskými mravcami. Skratky: MR – počet mravenísk, NR – Prírodná Rezervácia, PL – Chránený Areál.

Code	Locality	N	E	a.s.l. (m)	Enviroment	Host	AH
Kód	Lokalita	S	V	m n.m.	Prostredie	Hostiteľ	MR
1	Banská Bystrica	48°44'41"	19°08'35"	365	city park	<i>F. rufa</i>	1
2	Podunajské Biskupice	48°06'17"	17°09'29"	134	bushes	<i>F. rufa</i>	1
3	Šúr NR	48°13'46"	17°12'53"	130	oak-hornbeam forest	<i>F. rufa</i>	1
4	Vajnorská Hora Mt.	48°13'54"	17°10'36"	280	oak-hornbeam forest	<i>F. gagates</i>	2
5	Virt	47°45'02"	18°20'43"	120	robinia forest	<i>F. rufa</i>	1
6	Všivavec PL	48°28'50"	17°26'28"	251	oak-hornbeam forest	<i>F. rufa</i>	1
7	Všivavec PL	48°28'54"	17°26'36"	224	oak-hornbeam forest	<i>F. rufa</i>	1
8	Všivavec PL	48°28'57"	17°26'60"	218	oak-hornbeam forest	<i>F. rufa</i>	1
9	Všivavec PL	48°28'57"	17°26'36"	219	oak-hornbeam forest	<i>F. rufa</i>	1
10	Všivavec PL	48°28'58"	17°26'39"	220	oak-hornbeam forest	<i>F. rufa</i>	1

RESULTS

Altogether, 1041 specimens belonging to six species and three families were examined. Five species were obtained from samples from *F. rufa* anthills, in contrast to the nests of *F. gagates*, where only one species, *A. solarii*, was obtained (Table 2). Chernetidae was ranked first with four species, Atemnidae and Chthoniidae were represented by one species each. *Allochernes wideri* was the most abundant species in the material examined (Table 2). On the other hand, only a single specimen of *A. politus* was recorded (Table 2). Moreover, this is the first record of *A. politus* found in anthills worldwide. *Chernes vicinus* (Beier, 1932), from the nests of *F. rufa*, is recorded for the first time for Slovakia.

Faunistics data of recorded taxa:

Chthoniidae Daday, 1889

Ephippiochthonius tetrachelatus (Preyssler, 1970)

5: extraction, nest centre, 19.i.2018, 1 ♂, A. Purkart, D. Selnekovič lgt.;

6: extraction, nest centre, 2.iii.2017, 2 ♀♀, 2 Tn, P. Fend'a lgt.;

10: extraction, nest centre, 2.iii.2017, 1 Tn, P. Fend'a lgt.

Atemnidae Kishida, 1929

Atemnus politus (Simon, 1878)

5: extraction, nest centre, 19.i.2018, 1 ♂, A. Purkart, D. Selnekovič lgt.

Chernetidae Menge, 1855

Allochernes solarii (Simon, 1898)

4: individual sampling, nest centre and surface, 11.iv.2018, 1 ♀, 1 ♂, A. Purkart lgt.; individual sampling and extraction, nest centre and surface, 3.v.2018, 1 ♂, M. Červená, K. Krajčovičová, A. Purkart lgt.; extraction, nest centre and surface, 26.vi.2018, 1 ♂, J. Christophoryová, M. Červená, A. Purkart lgt.

Allochernes wideri (C. L. Koch, 1843)

3: extraction, nest centre, 25.iii.2018, 5 ♀♀, 4 ♂♂, 16 Tn, 16 Dn, 7 Pn, A. Purkart lgt.;

6: extraction, nest centre, 2.iii.2017, 1 ♀, 1 Tn, P. Fend'a lgt.;

7: extraction, nest centre under the decaying trunk, 2.iii.2017, 110 ♀♀, 62 ♂♂, 54 Tn, 58 Dn, 11 Pn, P. Fend'a lgt.;

8: extraction, nest centre, 2.iii.2017, 33 ♀♀, 19 ♂♂, 10 Tn, 13 Dn, 2 Pn, M. Holecová lgt.;

9: extraction, nest centre, 2.iii.2017, 56 ♀♀, 21 ♂♂, 44 Tn, 66 Dn, 73 Pn, P. Fend'a lgt.; extraction, nest surface, 2.iii.2017, 51 ♀♀, 4 ♂♂, 6 Tn, 3 Dn, 61 Pn, P. Fend'a lgt.

Chernes vicinus (Beier, 1932)

2: extraction, nest centre, 24.i.2017, 8 ♀♀, 3 ♂♂, 11 Tn, 1 Dn, 4 Pn, P. Fend'a lgt.;

6: extraction, nest centre, 2.iii.2017, 2 ♀♀, 2 ♂♂, 2 Tn, 2 Dn, 1 Pn, P. Fend'a lgt.;

8: extraction, nest centre, 2.iii.2017, 17 ♀♀, 5 ♂♂, 23 Tn, 5 Dn, 1 Pn, M. Holecová lgt.;

9: extraction, nest centre, 2.iii.2017, 1 ♀, P. Fend'a lgt.;

10: extraction, nest centre, 2.iii.2017, 24 ♀♀, 26 ♂♂, 26 Tn, 16 Dn, 7 Pn, P. Fend'a lgt.



Fig. 2. Anthill of *Formica rufa* Linnaeus, 1761 in locality Všivavec. Photograph: P. Fend'a.
Obr. 2. Mravenisko *Formica rufa* Linnaeus, 1761 na lokalite Všivavec. Fotografia: P. Fend'a.

***Pselaphochernes scorpioides* (Hermann, 1804)**

- 1: extraction, nest centre, 12.ii.2017, 1 ♀, M. Holecová lgt.;
5: extraction, nest centre, 19.i.2018, 4 ♀♀, 4 ♂♂, A. Purkart, D. Selnekovič lgt.;
6: extraction, nest centre, 2.iii.2017, 6 ♀♀, 4 ♂♂, 2 Tn, P. Fend'a lgt.;
7: extraction, nest centre under the decaying trunk, 2.iii.2017, 1 ♀, P. Fend'a lgt.;
9: extraction, nest centre, 2.iii.2017, 9 ♀♀, 2 ♂♂, 3 Tn, P. Fend'a lgt.

Table 2. Abundance of all developmental stages of pseudoscorpions found in ant nests in Slovakia. Abbreviations: TN – tritonymph, DN – deutonymph, PN – protonymph, Σ – total number of specimens.

Tabuľka 2. Početnosť jednotlivých vývinových štádií šťúrikov nájdených v hniezdach mravcov na Slovensku. Skratky: TN – tritonymfa, DN – deutonymfa, PN – protonymfa, Σ – celkový počet jedincov.

Species/Developmental stages	Female	Male	TN	DN	PN	Σ
Druhy/Vývinové štádiá	Samica	Samec	TN	DN	PN	Σ
<i>Ephippiochthonius tetrachelatus</i> (Preysler, 1970)	2	1	3			6
<i>Atemnus politus</i> (Simon, 1878)		1				1
<i>Allochneres solarii</i> (Simon, 1898)	1	3				4
<i>Allochneres wideri</i> (C. L. Koch, 1843)	256	110	131	156	154	807
<i>Chernes vicinus</i> (Beier, 1932)	52	36	62	24	13	187
<i>Pselaphochernes scorpioides</i> (Hermann, 1804)	21	10	5			36

DISCUSSION

The most dominant and regular pseudoscorpion visitors in anthills are certain species of the family Chernetidae (Beier 1948), as was shown by previous studies of ant nests in Slovakia (Jászayová et al. 2015, Christophoryová et al. 2017a), as well as by the present study. During the current research, six pseudoscorpion species were found in ant nests, four of them belonging to Chernetidae.

Three chernetid species, *Allochernes wideri*, *Chernes vicinus* and *Pselaphochernes scorpioides*, were represented in *Formica rufa* anthills by large numbers of individuals, including all nymphal stages. The presence of nymphal stages indicates that these species can be considered as myrmecophilous. As confirmed by the current study, ant nests represent habitat with stable temperature, protection and food source for pseudoscorpions, mainly during the winter months (Beier 1948, Turk 1951). In Slovakia, *A. wideri* and *P. scorpioides* were collected from nests of three *Formica* species during previous research (Jászayová et al. 2015, Christophoryová et al. 2017a). Until now, only a single specimen of *C. vicinus* was known from a *Formica rufibarbis* nest (Christophoryová et al. 2017a). In Europe, the presence of *A. wideri*, *C. vicinus* and *P. scorpioides* in ant nests has already been documented from several countries (Beier 1948, Ressler & Beier 1958, Kofler 1972, Ressler 1974, Fowles 1994, Štáhlavský 2001, Droglá & Lippold 2004). Although these species are regularly found in ant nests, they are not fixed to this habitat type (Beier 1948). They have been found in Slovakia in other habitat types, such as under tree bark, in tree hollows, compost heaps, dead wood or in association with birds and mammals (Christophoryová et al. 2011a, 2017b, Krajčovičová & Christophoryová 2014, Kaňuchová et al. 2015).

The presence of *Allochernes solarii* in *Formica gagates* anthills in Slovakia was recorded only recently by Červená et al. (2018). During the present study, specimens were collected from the same anthills at the same locality as in the original work (Červená et al. 2018). During the research, no specimens were found outside of the ant nests, in the surrounding soil or leaf litter. Gardini (2004) recorded this species in the nests of *Formica* sp. and *Lasius* sp. in Italy, and assumed that the species could be considered as myrmecophilous, which is supported by the present findings.

From the family Atemnidae, a single *Atemnus politus* specimen was collected from an anthill of *F. rufa* during the present study. The occurrence of this thermophilous species is restricted to a few localities in the southern part of Slovakia, where it lives in compost heaps, tree hollows, soil and leaf litter and bird nests (Štáhlavský et al. 2012, Christophoryová et al. 2014, Červená et al. 2020). It cannot be said with certainty, whether the presence of *A. politus* in anthill is accidental, or more regular.

According to Beier (1948), chthoniid species occur in ant nests mostly accidentally and they get into the nests because of their way of life. In the present study, six specimens of *Ephippiochthonius tetrachelatus* were collected from three *F. rufa* nests, including adults and tritonymphs. Despite the presence of tritonymphs, the occurrence of species in anthills can be considered as occasional. In contrary to others species, the abundance of *E. tetrachelatus* in the individual nests was low; in two of three nests only one specimen was obtained. This species has previously been found in *F. rufa* anthills in Slovakia and in Austria (Ressler 1974, Christophoryová et al. 2017a).

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SÚHRN

Predložená práca prináša nové údaje o výskyte štúrikov v hniezdach mravcov rodu *Formica* Linnaeus, 1758 na Slovensku. Materiál štúrikov bol zbieraný počas dvoch rokov (2017, 2018) na 10 vzorkovacích miestach. Celkovo bolo skúmaných 11 mravenísk, z ktorých deväť patrilo druhu *Formica rufa* Linnaeus, 1761 a dve patrili druhu *Formica gagates* Latreille, 1798. Vzorky z mravenísk boli zbierané v zimných a v skorých jarných mesiacoch, kedy je aktivita mravcov najnižšia. Vzorky boli odoberané z centrálnej časti hniezda, ale v niektorých prípadoch aj z povrchovej vrstvy mraveniska. Celkovo bolo extrahovaných 1041 jedincov patriacich do šiestich druhov a troch čeľadí. Z mravenísk druhu *F. rufa* bolo identifikovaných päť druhov a z mraveniska *F. gagates* bol identifikovaný len jeden druh, a to *Allochernes solarii* (Simon, 1898). Najviac druhov a jedincov bolo zaznamenaných z čeľade Chernetidae (štyri druhy), naopak čeľade Atemnidae a Chthoniidae boli zastúpené len jedným druhom. Najviac jedincov zo študovaného materiálu štúrikov patrilo druhu *Allochernes wideri* (C. L. Koch, 1843), ktorý bol zastúpený 807 jedincami. Naopak, *Atemnus politus* (Simon, 1878) bol zastúpený len jedným jedincom. Zároveň je tento druh z mraveniska zaznamenaný celosvetovo po prvýkrát. Druhým najpočetnejším štúrikom bol *Chernes vicinus* (Beier, 1932) zastúpený 187 jedincami a z hniezd *F. rufa* bol na Slovensku zaznamenaný po prvýkrát. Z čeľade Chthoniidae bol identifikovaný len jeden druh, *Epihippochthonius tetrachelatus* (Preyssl, 1970). Bol zastúpený len šiestimi jedincami a v mraveniskách sa vyskytuje len náhodne.