PECKIANA • Volume 4 (2005) • 131 – 142

ISSN 1618-1735

Myriapods from ant nests in Bulgaria (Chilopoda, Diplopoda)

PAVEL STOEV & ALBENA LAPEVA-GJONOVA

Abstract

This paper summarises preliminary results from the investigation of myriapods living in ant nests in Bulgaria. The material was collected applying a method for extracting a maximum number of arthropods from each nest. Altogether, 209 specimens belonging to 22 species were found in 24 nests of *Formica pratensis*, five nests of *F. rufa*, and one nest, each of *F. exsecta*, *Camponotus aethiops*, *Tetramorium caespitum* and *Myrmica* sp. The most frequent mound-dwelling myriapods were *Brachydesmus* sp., *Polyxenus lagurus*, *Megaphyllum* sp. and *Lithobius microps*. The study revealed that the third sampling layer/horizon of the nests was always poor in species while the first, second and fourth ones were invariably preferred by myriapods. The life cycle of some facultative myrmecophiles like *Brachydesmus* sp., *Megaphyllum* sp., *Lithobius forficatus*, *L. microps* and *L. burzenlandicus* takes place to a certain extent in the anthill. Additionally investigations on centipedes and millipedes associated with ants in both temperate and tropical latitudes are reviewed.

1. Introduction

Numerous arthropods are closely related with ants, a phenomenon referred to as myrmecophily (cf. Wasmann 1894, 1925, Wheeler 1910, Donisthorpe 1927, Kistner 1979, Hölldobler & Wilson 1990). Normally aggressive to alien organisms, ants appear to be friendly towards beneficent and some neutral species living in their nests. Some myrmecophiles are so highly specialised that they even acquire an ant-like appearance. Such specialisation, called Wasmann's mimicry (McIver & Stonedahl 1993), is found among spiders, staphylinid, scydmaenid and anthicid beetles, as well as some other invertebrates.

Myriapods have long been reported from ant nests too, though very few obligate myrmecophiles have hitherto been found. These are largely small exotic species from the millipede family Pyrgodesmidae, order Polydesmida (Chamberlin 1947, Schubart 1950, 1953, Rettenmeyer 1962, Akre & Rettenmeyer 1968). In contrast, facultative myrmecophiles among myriapods seem to be far more common both in tropical and temperate environments, with millipedes usually strongly outnumbering centipedes, symphylans and pauropods (Schubart 1950).

Several species from the order Polyxenida appear to be quite typical myrmecophiles all over the globe. Thus, Ishii & Yamaoka (1982) found *Eudigraphis takakuwai* (Miyosi, 1947) to be quite abundant in arboreal ant nests in maritime forests of Japan. Polyxenida are also very common in the nests of tropical ants. Condé (1971) reported four polyxenidan species from nests of *Camponotus rufipes* (Fabricius, 1775) in Brazil. *Probolomyrmex dammermani* Wheeler, 1928, a ponerine ant from Southeast Asia, is exclusively specialised in feeding on polyxenids (Ito 1998). Likewise, some ants in Brazil are specialised predators of certain Polyxenida and eggs of Spirobolida (Brandão et al. 1991, Diniz & Brandão 1993).

Silvestri (1911) reported two millipedes of the genus *Myrmecodesmus* Silvestri, 1910 from ant nests in Mexico. Loomis (1959) found colonies of four army ant species in Panama and Mexico populated by nine millipede species from the family Pyrgodesmidae. Schubart (1953) recorded a pyrgodesmid millipede on the march with Amazon ants in Brazil. Crosland (1994) discovered the pantropical millipede *Glyphiulus granulatus* (Gervais, 1847) (Cambalopsidae, Spirostreptida) in the nests of the ant *Harpegnathos venator* (Smith, 1858) in Southeast Asia.

As regards temperate regions, Wasmann (1894) found the North American endemic millipede *Scytonotus granulatus* (Say, 1821) (Polydesmidae) in *Rhoptromyrmex melleus* (Emery, 1897) anthills. A collection of millipedes taken from nests of *Formica obscuripes* Forel, 1886 in Washington State, USA contained 4 – 5 species from four families, including one introduced European species, *Polydesmus inconstans* Latzel, 1884 (Loomis 1972). Information concerning myriapods found in association with ants in Europe is also rather scant. For example, Donisthorpe (1927) reported *Blaniulus guttulatus* (Fabricius, 1798), *Proteroiulus fuscus* (Am Stein, 1857) and *Polyxenus lagurus* from ant nests in Great Britain. Palmén (1948, 1949) mentioned *Schendyla nemorensis*, *Lamyctes emarginatus* (Newport 1844), *Polyxenus lagurus*, *Polydesmus denticulatus* C. L. Koch, 1847 and *Proteroiulus fuscus* from ant nests in Fennoscandia. In the nests of *Formica polyctena* (Förster, 1850) in Poland, Wiśniewski (1968) found the centipedes *Lithobius forficatus*, *L. erythrocephalus*, *L. crassipes*, *Schendyla nemorensis*, and millipedes *Polyxenus lagurus*, *Polydesmus complanatus* and *Proteroiulus fuscus*. *Geoglomeris subterranea jurassica* Verhoeff, 1915 (Glomeridae, Glomerida) is known from *Lasius niger* (Linnaeus, 1758) nests in Switzerland, *Lophoproctus lucidus* (Chalande, 1888) (Lophoproctidae, Polyxenidae) in nests of several ant species in Italy (cf. Schubart 1950).

More data can be found in the publications of Verhoeff (1928), Holmquist (1928), Manfredi (1949), Schubart (1950), Auerbach (1951), Barber & Keay (1988) and Jeekel (2000). Recently, brief overviews of the myriapods associated with ant nests are also available, e.g. Lewis (1981) for centipedes and Hopkin & Read (1992) for millipedes. No myriapods have ever been reported from anthills in Bulgaria.

Generally, the diversity of myrmecophiles, however modest, tends to be higher in millipedes compared to centipedes. This corresponds with tropical faunas, where millipedes not only dominate symbiotic ant complexes among the myriapods but also involve a few obligate myrmecophiles, especially among Pyrgodesmidae. In temperate regions, the myriapod-ant association seems much weaker, as at least in Europe no obligate myrmecophiles have hitherto been documented.

There are two general classifications of the relationships between ants and their associated fauna. The pioneer work on this subject was published by Wasmann (1894). He distinguished the following five categories: synoecious, synechtricans, symphiles, trophobionts, and parasites. Kistner (1979) introduced a different classification recognising only two groups, i.e. species integrated in the social life of the ants and those that are not. Very often there is no clear boundary between these categories. According to Wasmann (1894) and Donisthorpe (1927), although often found in ant nests, most of the myriapods cannot be considered as true myrmecophiles (= integrated species, according to Kistner 1979).

We prefer to use here the term »facultative myrmecophily« (= hemimyrmecophily) for those myriapods that maintain healthy populations in the anthills, yet are also found in other habitats in nature. This term seems to better characterise the myriapod symbionts of ant nests commonly, but uncritically, referred to as »myrmecophiles« in the myriapodological literature (e.g. Manfredi 1949, Condé 1971, Kania 1995). In contrast, obligate myrmecophiles are only those species that are not found beyond the ant nest or, in case of Amazon ants, columns on the march.

The present paper is part of a long-term project aimed at an inventory of the fauna associated with anthills, mainly of the genus *Formica*, in Bulgaria, in particular *F. pratensis* Retzius, 1783 (Ilieff & Lapeva 1997, Lapeva & Simov 2000, Simov 2002, Lapeva-Gjonova & Chehlarov 2003, Lapeva-Gjonova 2004). As information about the myrmecophily (in broad sense) of myriapods in Europe is quite limited, the paper provides some considerations on their biology and possible relationships with ants.

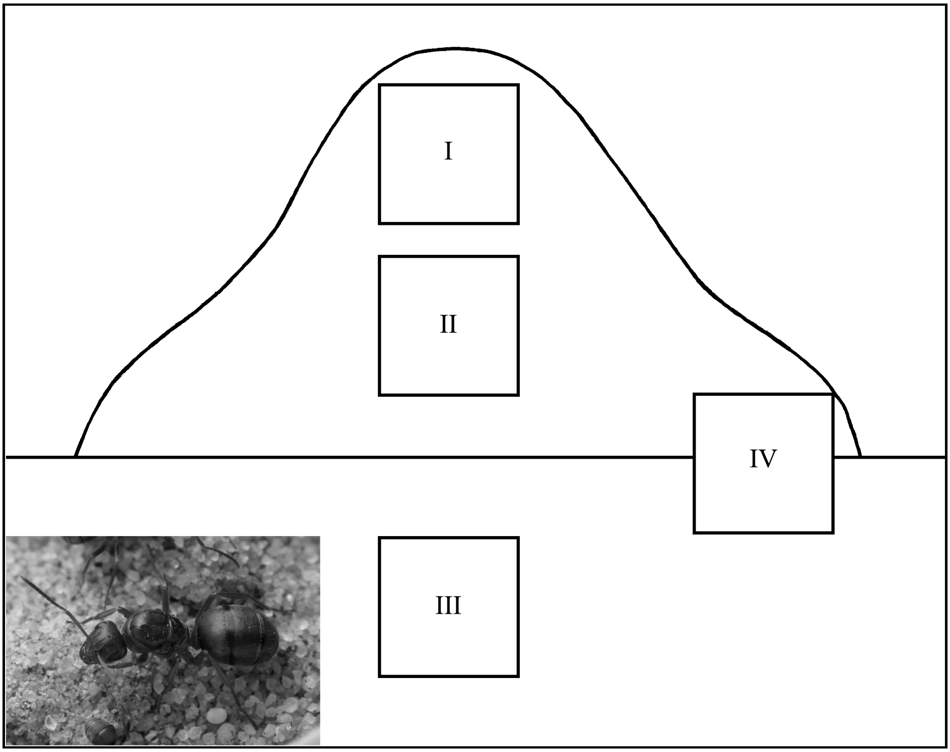

Fig. 1 Schematic presentation of the sampling sites in the nest of *Formica pratensis*.

2. Materials and methods

This paper treats a large collection of myriapods gathered mostly by the second author between 1994 and 2003. A substantial part of material comes from near the village of Bistritsa, Vitosha Mts (950 – 1050 m a.s.l.), few samples originate from other parts of southwestern Bulgaria. A method for extracting the maximum number of arthropods from the nests of *F. pratensis* was used (Ilieff & Lapeva 1997, Simov 2002). Four samples, each comprising 500 cm^3 of organic nest material, were taken from different layers/horizons (marked with the Roman numerals I, II, III, IV) of anthills selected to be subequal in size (height 60 –70 cm, diameter 80 – 100 cm) (Fig. 1). The first samples (I) came from the top of the nest and consisted mostly of dry foliage components. The second and fourth samples (II and IV) covered the centre and a periphery of the nest, respectively. The third samples (III) was taken from below the soil surface, i.e. it was the deepest. All material was extracted with Tullgren funnels (metal funnel with an overall height of 80 cm and diameter 35 cm; gauze openings: 2 x 2 mm; lamp holder with a 45 W electric bulb) for a period of 48 hours. Prior to that, all ants were hand-removed from the samples. The material of extracted myriapods was preserved in 70 % ethanol and is kept at the National Museum of Natural History, Sofia.

3. Results and discussion

Altogether, 24 nests of *Formica pratensis*, five nests of *F. rufa* Linnaeus, 1758 and one nest, each of *F. exsecta* Nylander, 1846, *Camponotus aethiops* (Latreille, 1798), *Tetramorium caespitum* (Linnaeus, 1758) and *Myrmica* sp. were investigated for myriapods. We have examined 209 specimens belonging to 22 species, of which 15 were centipedes and 7 millipedes (Tab. 1). Only 14 of them could be identified to species level. The other five myriapods, represented only by juveniles or females, were affiliated to known species, though these identifications have yet to be confirmed using adults and/or males. Two species from the millipede genera *Brachydesmus* Heller, 1858 and *Megaphyllum* Verhoeff, 1894 could not be reliably identified due to the absence of adult males in the samples. However, it is highly probable that these are *B. superus* Latzel, 1884 and *M. bosniense* (Verhoeff, 1897), both widely distributed in the studied region. In addition, some unidentified symphylans were found in nests of *F. pratensis*.

Out of 24 studied nests of *F. pratensis*, 15 contained 19 identifiable myriapods. Seven species were found in the nests of *F. rufa*. A sample from an anthill of *F. exsecta* contained two specimens of *Polyxenus lagurus*, while another one taken from a soil nest of *Myrmica* sp. yielded mature specimens of *Cylindroiulus boleti*. Several polyxenidans belonging to the genus *Lophoproctus* Pocock, 1894[1] were found in the nests of *Tetramorium caespitum* and *Camponotus aethiops* only (Tab. 2). This find is of particular interest, being the first record of the genus in Bulgaria.

As expected for temperate latitudes, no obligate myrmecophiles were found among the studied material. The species found in our samples could be categorised as either facultative myrmecophiles, or occasional nest visitors. *Lithobius forficatus*, *L. crassipes*, *L. burzenlandicus*, *L. microps*, *Polyxenus lagurus*, *Megaphyllum* sp., and *Brachydesmus* sp. most likely belong to the former category, while *Eupolybothrus tridentinus*, *Lithobius erythrocephalus* and *Schendyla nemorensis*, which were found only in the fourth peripheral layer (samples IV), probably penetrated accidentally.

---

[1] Most likely it is a new species belonging to the *Lophoproctus lucidus* group (M. Nguyen-Duy Jacquemin, pers. comm.).

Tab. 1 Chilopoda and Diplopoda collected from ant nests in Bulgaria.

	Species	***F. pratensis***	***F. rufa***	***F. exsecta***	***C. aethiops***	***T. caespitum***	***Myrmica* sp.**
	Chilopoda						
	Lithobiomorpha						
1.	*Eupolybothrus tridentinus* (Fanzago, 1874)	+					
2.	*Lithobius* (s. str.) *erythrocephalus* C. L. Koch, 1847	+					
3.	*Lithobius* (s. str.) *forficatus* (Linnaeus, 1758)	+	+				
4.	*Lithobius* (*Monotarsobius*) *crassipes* L. Koch, 1862	+					
5.	*Lithobius* (*Sigibius*) *burzenlandicus* Verhoeff, 1931	+	+				
6.	*Lithobius* (*Sigibius*) *microps* Meinert, 1868	+					
	Geophilomorpha						
7.	*Schendyla montana montana* Attems, 1895	+					
8.	*Schendyla* aff. *montana balcanica* (Kaczmarek, 1969)	+					
9.	*Schendyla nemorensis* (C. L. Koch, 1836)	+					
10.	*Schendyla* aff. *varnensis* (Kaczmarek, 1969)	+					
11.	*Henia illyrica* (Meinert, 1870)	+	+				
12.	*Clinopodes flavidus* C. L. Koch, 1847 (s.l.)		+				
13.	*Geophilus* aff. *rhodopensis* Kaczmarek, 1970	+					
14.	*Geophilus proximus* C. L. Koch, 1847	+					
15.	*Geophilus* aff. *linearis* C. L. Koch, 1835		+				
	Diplopoda						
	Polyxenida						
16.	*Polyxenus lagurus* (Linnaeus, 1758)	+	+	+			
17.	*Lophoproctus* sp.				+	+	
	Polydesmida						
18.	*Polydesmus* aff. *complanatus* (Linnaeus, 1761)	+					
19.	*Brachydesmus* sp.	+	+				
	Julida						
20.	*Cylindroiulus horvathi* (Verhoeff, 1897)	+					
21.	*Cylindroiulus boleti* (C. L. Koch, 1847)	+?					+
22.	*Megaphyllum* sp.	+					

Tab. 2 Myriapods from other localities and ant nests in Bulgaria. Abbreviations: M – male; F – female; subad. – subadult; juv. – juvenile; p.l. – pair of legs (numbered).

Species	Specimens	Locality	Host (nest)
Lithobius (s. str.) *erythrocephalus*	1 ad. F	Vitosha Mts., above v. Bistritsa, 1000 m, 03.03.1995, A. Lapeva-Gjonova leg.	*Formica pratensis*
Lithobius (s. str.) *forficatus*	1 subad.	Osogovo Mts., Osogovo Hut, 1600 m, 22.09.2002, A. Lapeva-Gjonova leg.	*Formica rufa*
Lithobius (*Sigibius*) *burzenlandicus*	1 ad. F	Pirin Mts., Bansko, 1050 m, 01.09.2001, N. Simov leg.	*Formica rufa*
Henia illyrica	1 juv.	Belasitsa Mts., above Belasitsa Hut, 1000 m, 01.05.2001, N. Simov leg.	*Formica rufa*
Clinopodes flavidus (s. l.)	1 juv., 63 p.l.	Belasitsa Mts., above Belasitsa Hut, 1000 m, 01.05.2001, N. Simov leg.	*Formica rufa*
Geophilus aff. *linearis*	1 juv., 59 p.l.	Belasitsa Mts., above Belasitsa Hut, 1000 m, 01.05.2001, N. Simov leg.	*Formica rufa*
Polyxenus lagurus	2 ex.	Rila Mts., below Kamenna mandra Peak, *ca*. 2100 m, 24.07.1998, I. Gjonov leg.	*Formica exsecta*
Polyxenus lagurus	20 ex.	Rila Mt., Panichishte, racing-track, *ca*. 1400 m, 27.07.1998, A. Lapeva-Gjonova leg.	*Formica rufa*
Polyxenus lagurus	2 ex.	Vitosha Mts., v. Zheleznitsa, 1250 m, 17.08.1998, A. Lapeva-Gjonova leg.	*Formica pratensis* – II layer
Polyxenus lagurus	3 ex.	Lozenska planina Mts., 900 m, 03.02.2002, R. Bekchiev leg.	*Formica rufa*
Lophoproctus sp.	4 ad., 7 subad.	South Pirin Mts., v. Kalimantsi, 01.03.2003, A. Lapeva-Gjonova leg.	*Tetramorium caespitum*
Lophoproctus sp.	1 ad.	South Pirin Mts., v. Kalimantsi, 01.03.2003, A. Lapeva-Gjonova leg.	*Camponotus aethiops*
Brachydesmus sp.	1 ad. F	Belasitsa Mts., above Belasitsa Hut, 1000 m, 01.05.2001, N. Simov leg.	*Formica rufa*
Cylindroiulus boleti	1 M, 1 F, 1 subad.	Vitosha Mts., v. Simeonovo, 20.06.1997, A. Lapeva-Gjonova leg.	*Myrmica* sp.

From a taxonomic point of view, it is worth mentioning the discovery of the centipede *Schendyla montana montana* in Bulgaria. This find raises a question about the status of *S. montana balcanica*, so far known only from the type locality in the Central Stara planina Mts (Stoev 2002). Material morphologically similar to *balcanica* specimens was found in two samples from the Vitosha Mts, but the shape of the metatarsi on the last pair of legs, as well as some other differences, perhaps imply another member of the family Schendylidae. The same holds true for *Schendyla* aff. *varnensis*, whose status also warrants more precise study in the future.

The Geophilidae are also well represented in the samples. Four species were distinguished, but only *Clinopodes flavidus* (s.l.) and *Geophilus proximus*[2] could be identified with confidence. The occurrence of the latter outside ant nests, also in the Vitosha Mts, was recently established (Stoev ined.). Another poorly-known species is *Geophilus* cf. *rhodopensis* discovered only once in our material. Five specimens with leg pairs varying from 59 (1), 61 (2) to 63 (2), were examined. The species was already reported from the same region (Stoev 2002), but its resemblance to *G. abbreviatus* Verhoeff, 1925 raises serious doubts of its validity. From the abundant material of millipedes, only three species, *Polyxenus lagurus*, *Cylindroiulus boleti* and *C. horvathi*, were represented by males and reliably identifiable. A further four species, including perhaps *Polydesmus complanatus*, *Brachydesmus superus* and *Megaphyllum bosniense*, were represented by females or juveniles only.

We suspect that the mounds of the genus *Formica* are places where some facultative myrmecophiles like *Brachydesmus* sp., *Megaphyllum* sp., *Lithobius forficatus*, *L. microps* and *L. burzenlandicus* lay their eggs and where the juveniles develop into mature stadia. High number of newly-hatched and immature specimens were observed, but very few fully-grown, adult specimens. Our observations partly correspond with those of Ishii & Yamaoka (1982) based on the symbiotic millipedes *Eudigraphis takakuwai*, the life cycle of which is completed in the arboreal ant nests. Donisthorpe (1927) also supported the idea that ant nests are used for reproduction by millipedes. He explained the huge number of *Blaniulus guttulatus* in the nests as being due to the quality of earth they get there for making nests.

A rough estimate shows that the main proportion of the myriapods found in the nests belong to smaller and moderate-sized specimens, while larger ones are quite rare. It makes sense to presume that ants do not tolerate the occurrence of larger species, which – as in the case of millipedes, harmless to them and their progeny – are still undesirable bulldozers, which can disturb their nest systems. The largest myriapods in our samples were two adult males of *Lithobius forficatus*, a single adult female of *Eupolybothrus tridentinus* and two female *Cylindroiulus* aff. *boleti*.

The most frequently found myriapod was *Brachydesmus* sp. with 51 specimens from four mounds. *Polyxenus lagurus* and *Megaphyllum* sp. are the next frequent species, represented by 27 specimens, each from four and three nests respectively. Sixteen specimens of *Lithobius microps* were found in five nests altogether. *Eupolybothrus tridentinus*, *Lithobius erythrocephalus*, *Schendyla montana montana*, *Clinopodes flavidus*, *Geophilus* aff. *linearis* and *Polydesmus* aff. *complanatus*, were encountered in association with ants only once, with one specimen each.

[2] For the problems with the identity and the use of the names *G. proximus* and *G. insculptus/alpinus* see Jeekel (1999) and Spelda (1999, 2005).

Tab. 3 Myriapods from nests of *Formica pratensis* collected in different layers near the village of Bistritsa, Vitosha Mts. Abbreviations: M – male; F – female; ad. – adult; subad. – subadult; juv. – juvenile.

Species	**Date**	**I**	**II**	**III**	**IV**
Eupolybothrus tridentinus	06.05.1994	–	–	–	1 ad. ♀
Lithobius (s. str.) *forficatus*	16.10.1994	–	1 subad. ♀, 1 juv.	–	1 juv.
Lithobius (s. str.) *forficatus*	30.01.1995	2 ad. ♂♂	1 juv.	–	–
Lithobius (s. str.) *forficatus*	15.10.1995	2 subad. ♂♂	1 juv.	1 juv.	–
Lithobius (*Monotarsobius*) *crassipes*	30.01.1995	–	1 ad. ♂	1 subad. ♂	–
Lithobius (*Monotarsobius*) *crassipes*	15.08.1995	–	1 ad. ♀	–	2 juv.
Lithobius (*Monotarsobius*) *crassipes*	15.10.1995	–	–	1 juv.	–
Lithobius (*Sigibius*) *microps*	06.05.1994	–	–	–	1 ad. ♂, 2 juv.
Lithobius (*Sigibius*) *microps*	11.05.1994	–	2 ad. ♂♂	–	1 ad. ♂, 1 subad. ♂, 1 juv.
Lithobius (*Sigibius*) *microps*	16.10.1994	–	–	–	3 ad. ♂♂, 1 ♀
Lithobius (*Sigibius*) *microps*	31.05.1995	1 ad. ♀	1 juv.	–	–
Lithobius (*Sigibius*) *microps*	11.04.1998	1 ♀	1 juv.	–	–
Lithobius (*Sigibius*) *burzenlandicus*	06.05.1994	–	–	–	3 ad. ♂♂, 1 subad. ♀
Lithobius (*Sigibius*) *burzenlandicus*	16.10.1994	–	1 ad. ♂	–	–
Lithobius (*Sigibius*) *burzenlandicus*	15.10.1995	–	2 ad. ♂♂, 1 ad. ♀, 1 juv.	–	–
Schendyla montana montana	16.04.1995	1 ad. ♀	–	–	–
Schendyla nemorensis	16.10.1994	–	1 ex.	–	–
Schendyla nemorensis	30.01.1995	–	–	–	1 ♂
Schendyla sp. 1 aff. *varnensis*	16.10.1994	–	–	–	1 ex.

Schendyla sp. 2 aff. *montana balcanica*	30.01.1995	–	1 ad., 1 subad.	–	–
Schendyla sp. 2 aff. *montana balcanica*	03.03.1995	1 ex.	–	–	–
Henia illyrica	27.06.1998	–	1 subad. ♂, 2 subad. ♀♀	–	–
Geophilus aff. *rhodopensis*	09.04.1998	–	–	–	5 ex.
Geophilus proximus	11.05.1994	–	–	–	1 ex.
Geophilus proximus	16.10.1994	–	–	–	1 ex.
Polydesmus aff. *complanatus*	15.10.1995	1 subad. ♀	–	–	–
Brachydesmus sp.	15.10.1995	24 ♀♀ and juv.	6 ♀♀, 11 juv.	–	–
Brachydesmus sp.	14.11.1997	–	–	2 ♀♀, 4 juv.	–
Brachydesmus sp.	09.04.1998	–	–	–	1 ♀, 2 juv.
Polydesmidae gen. sp.	06.05.1994	–	–	–	1 juv.
Polydesmidae gen. sp.	15.10.1995	–	–	6 juv.	–
Polydesmidae gen. sp.	09.04.1998	–	1 juv.	–	–
Cylindroiulus horvathi	15.10.1995	–	–	–	2 ♂♂
Cylindroiulus aff. *boleti*	06.05.1994	–	–	–	1 ad. ♀
Cylindroiulus aff. *boleti*	11.05.1994	–	2 ad. ♀♀	–	2 juv.
Cylindroiulus aff. *boleti*	07.09.1994	–	–	–	1 juv.
Cylindroiulus aff. *boleti*	15.10.1995	1 ♀	–	–	–
Megaphyllum sp.	07.09.1994	1 subad. ♀	–	1 ♀, 1 juv.	4 ad. ♀♀, 1 juv.
Megaphyllum sp.	15.10.1995	9 ♀♀, 5 juv.	1 ♀, 1 juv.	–	1 ♀, 1 juv.
Megaphyllum sp.	11.04.1998	–	–	–	1 juv.
Julidae gen. sp.	15.08.1995	–	–	5 juv.	–

The myriapods are not spread in the ant nests equally. Our observations showed that the third (deepest) layer was always poor in species (Tab. 3) while the first, second and fourth ones were preferred by both chilopods and diplopods. A possible explanation of this phenomenon is that ants use the inner parts of the nest as a nursery, where they lay their eggs. They do not allow myriapods to go so deep, and also undertake regular procedures to prevent fungi and bacteria growing in this part of the nest, which correspondingly limits the source of food for millipedes. At the same time, the decreased number of possible victims does not stimulate predators like centipedes to penetrate so deeply in search of food, where they are also more actively pursued by the ants. Conversely, millipedes and other saprophages are desirable in the other layers, where they filter waste products and prevent the ants from possible diseases (Kania 1995).

In conclusion, the anthills are a preferred habitat for many myriapods across the world. So far no obligate myrmecophiles have been found in temperate regions, while several millipedes perform symbiotic relationships with tropical ants. As an initial investigation of this kind in Bulgaria, the current paper outlines only some peculiarities of species distribution and biology, and should be considered as a preliminary study.

4. Acknowledgments

We are especially grateful to Dr Sergei Golovatch (Moscow) and the anonymous referees for their valuable comments on the manuscript. A.L.G. is especially grateful to the late Dr Ilko Vassilev (Sofia) for his overall support and advice in the course of the preparation of her Ph.D. thesis. Special thanks are also due to Dr Jason Dunlop (Berlin) who improved the English and helped to obtain some obscure literature. Prof. H. Enghoff (Copenhagen) and Dr M. Nguyen-Duy Jacquemin (Paris) confirmed the identity of some problematic species. Part of the work was undertaken with financial support from the Sofia University. We thank also N. Simov, I. Gjonov and R. Bekchiev for providing us their myriapod collection for study.

5. References

Akre, R. & C. Rettenmeyer (1968): Trail-following by guests of army ants (Hymenoptera: Formicidae: Ecitonini). – J. Kans. Entomol. Soc. **41** (2): 165 – 174

Auerbach, S. I. (1951): The centipedes of the Chicago area with special reference to their ecology. – Ecol. Monogr. **21**: 97 – 124

Barber, A. D. & A. N. Keay (1988): Provisional atlas of the centipedes of the British Isles. – Biological Records Centre, Institute of Terrestrial Ecology, Lavenham Press, 127 pp.

Brandão, C. R. F., J. L. M. Diniz & E. M. Tomotake (1991): *Thaumatomyrmex* strips millipedes for prey: a novel predatory behaviour in ants, and the first case of sympatry in the genus (Hymenoptera: Formicidae). – Insectes Soc. **38**: 335 – 344

Chamberlin, R. V. (1947): A new myrmecophilous milliped from Mexico. – Pan-Pac. Entomol. **23** (3): 101 – 102

Condé, B. (1971): Diplopodes Pénicillates des nids brésiliens de *Camponotus rufipes*. – Rev. Écol. Biol. Sol **8** (4): 631 – 634

Crosland, M. W. J. (1994) Millipede myrmecophile, *Glyphiulus granulatus*, found with the primitive ant *Harpegnathos venator*. – J. Entomol. Sci. **29** (1): 141 – 142

Diniz, J. L. M. & C. R. F. Brandão (1993): Biology and myriapod egg predation by the Neotropical myrmicine ant *Stegomyrmex vizottoi* (Hymenoptera: Formicidae). – Insectes Soc. **40**: 301 – 311

Donisthorpe, H. St. J. K. (1927): The guests of British ants, their habits and life histories. – George Routledge & Sons, London, xxiii + 244 pp.

Hölldobler, B. & E. O. Wilson (1990): The Ants. – Harvard University Press, Cambridge, Mass., 732 pp.

Holmquist, A. M. (1928): Notes on the life history and habits of the mound-building ant *Formica ulkei* Emery. – Ecology **9**: 70 – 87

Hopkin, S. P. & H. J. Read (1992): The biology of millipedes. – Oxford University Press, Oxford, New York, Tokyo, 233 pp.

Ilieff, I. & A. Lapeva (1997): Rove beetles (Coleoptera, Staphylinidae) from nests of the meadow ant *Formica pratensis* Retz. (Hymenoptera, Formicidae). – Acta zool. Bulg. **49**: 102 – 104

Ishii, K. & H. Yamaoka (1982): The species and number of symbiotic penicillate millipede in arboreal ant nests. – Can. Entomol. **114**: 767 – 768

Ito, F. (1998): Colony composition and specialized predation on millipedes in the enigmatic ponerine ant genus *Probolomyrmex* (Hymenoptera, Formicidae). – Insectes Soc. **45**: 79 – 83

Jeekel, C. A. W. (1999): On the status of the names *Geophilus proximus* C. L. Koch, 1847, *Geophilus insculptus* Attems, 1895, and *Geophilus oligopus* (Attems, 1895). – Myriapod Memoranda **1**: 71 – 79

– (2000): Some miscellaneous records of Chilopoda and Diplopoda from the Netherlands. – Myriapod Memoranda **2**: 55 – 61

Kania, G. (1995): Współżaleznośći między mrówkami (Formicidae) a dwuparcami (Diplopoda) jako jedna z form myrmekofilii. – Przegl. Zool. **39** (1-2): 151 – 153

Kistner, D. H. (1979): Social and evolutionary significance of social insect symbionts. – In: Hermann, H. R. (ed.): Social Insects, Volume 1. – Academic Press, New York, 339 – 413

Lapeva, A. & N. Simov (2000): *Xylocoris formicetorum* (Boheman, 1844) (Heteroptera: Anthocoridae), a new member of the myrmecophilous fauna of the Balkan Peninsula. – Hist. Nat. Bulg. **12**: 29 – 31

Lapeva-Gjonova, A. (2004): Pselaphinae (Coleoptera: Staphylinidae) from Ant Nests (Hymenoptera: Formicidae) in Southwestern Bulgaria. – Acta zool. Bulg. **56** (1): 69 – 73

– & E. Chehlarov (2003): Contribution to the knowledge of the myrmecophilous Histeridae (Insecta: Coleoptera) in Bulgaria. – Acta zool. Bulg. **55** (1): 11 – 14

Lewis, J. G. E. (1981): The biology of centipedes. – University Press, Cambridge, 428 pp.

Loomis, H. F. (1959): New myrmecophilous millipeds from Barro Colorado Island, Canal Zone, and Mexico. – J. Kans. Entomol. Soc. **32** (1): 1 – 7

– (1972): Millipedes associated with ants in Washington State. – Fla. Entomol. **35** (4): 145 – 151

Manfredi, P. (1949): Miriapodi mirmecofili. – Natura, Milano **40** (3-4): 82 – 83

McIver, J. D. & G. Stonedahl (1993): Myrmecomorphy: Morphological and behavioral mimicry of ants. – Annu. Rev. Entomol. **38**: 351 – 379

Palmén, E. (1948): The Chilopoda of eastern Fennoscandia. – Ann. Zool. Soc. Zool.-Bot. Fenn. »Vanamo« **13** (4): 1 – 45

– (1949): The Diplopoda of eastern Fennoscandia. – Ann. Zool. Soc. Zool.-Bot. Fenn. »Vanamo« **13** (6): 1 – 54

Rettenmeyer, C. W. (1962): The behavior of millipeds found with neotropical army ants. – J. Kans. Entomol. Soc. **35** (4): 377 – 384

Schubart, O. (1950): Ameisen und Diplopoden in ihren gegenseitigen Beziehungen. – Rev. Entomol. (Rio de Janeiro) **21** (3): 615 – 622

– (1953): Um Diplopoda (*Calymmodesmus sodalis* n. sp.), companheiro de formigas em migracão (Proterospermophora, Stylodesmidae). – An. Acad. Bras. Ciênc. **24**: 437 – 442

Silvestri, F. (1911): Contributo alla conoscenza dei mirmecofili del Messico. – Boll. Lab. Zool. gen. agr. Portici **5**: 172 – 195

Simov, N. (2002): Distribution of *Xilocoris* [sic!] *formicetorum* (Boheman, 1844), (Heteroptera: Anthocoridae) in Bulgaria. – Acta zool. Bulg. **54** (2): 55 – 58

Spelda, J. (1999): Verbreitungsmuster und Taxonomie der Chilopoda und Diplopoda Südwestdeutschlands. Diskriminanzanalytische Verfahren zur Trennung von Arten und Unterarten am Beispiel der Gattung *Rhymogona*, 1896 (Diplopoda: Chordeumatida: Craspedosomatidae). – Ph.D. Thesis, University of Ulm. Part 1, 217 pp. Part 2, 324 pp.

– (2005): Improvements in the knowledge of the myriapod fauna of southern Germany between 1988 and 2005 (Myriapoda: Chilopoda, Diplopoda, Pauropoda, Symphyla). – Peckiana **4**: 101 – 129

Stoev, P. (2002): A catalogue and key to the centipedes (Chilopoda) of Bulgaria. – Pensoft, Sofia-Moscow, 103 pp.

Verhoeff, K. W. (1928): Klasse Diplopoda. – In: Dr. H. G. Bronns Klassen und Ordnungen des Tierreichs. Band 5. Abteilung 2. Teil I. – Akademische Verlagsgesellschaft m.b.H., Leipzig, xi + 1071 pp., Taf. I – XI

Wasmann, E. (1894): Kritisches Verzeichnis der myrmecophilen und termitophilen Arthropoden. – Felix Dames, Berlin, xi + 231 pp.

– (1925): Die Ameisenmimikry. Ein exakter Beitrag zum Mimikryproblem und zur Theorie der Anpassung. – Abhandlungen zur theoretischen Biologie, 19. – Verlag von Gebrüder Borntraeger, Berlin, 164 pp.

Wheeler, W. M. (1910): Ants: their structure, development and behavior. – Columbia University Press, New York, xxv + 663 pp.

Wiśniewski, J. (1968): Isopoda, Chilopoda i Diplopoda występujące w mrowiskach *Formica polyctena* Först. w nadleśnictwie doświadczalnym ziełonka. – Prace Kom. Nauk Roln. i Kom. Nauk Leśn. PTPN **25**: 355 – 359

Authors' addresses:

Dr Pavel Stoev
National Museum of Natural History
1, Tsar Osvoboditel Blvd.
1000 Sofia, Bulgaria
e-mail: stoev@nmnh.bas.bg

Dr Albena Lapeva-Gjonova
Sofia University
Department of Biology
8, Dragan Tsankov Blvd.
1164 Sofia, Bulgaria
e-mail: gjonova@abv.bg