

# Myriapoda (Chilopoda, Diplopoda) of Shumen City and Shumen Plateau (NE Bulgaria): Taxonomic Structure and Zoogeographical Analysis

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**Abstract:** Myriapod fauna of the town of Shumen and Shumen Plateau has not been yet a subject of long-term systemic research. This article presents new data obtained from the conducted two years long study (April 2007 – May 2009) of Diplopoda and Chilopoda of this region of Bulgaria. In eight work sites, covering urban, suburban and rural habitats by using Barber's traps, direct sampling and soil sampling a total of 7833 myriapods were collected. Class Diplopoda was established by a total of 21 species from four orders: Glomerida (2), Polydesmida (5), Chordeumatida (2) and Julida (12). Five species are new to the fauna of the area – *Polydesmus mediterraneus*, *Craspedosoma transsylvanicum*, *Nopoiulus kochii*, *Typhloiulus kotelensis* and *Megaphyllum lictor*. Class Chilopoda was established by a total of 37 species from the four orders known in the country – Scutigermorpha (1), Lithobiomorpha (19), Scolopendromorpha (5) and Geophilomorpha (11). Twenty-nine of them were registered for first time during this study. Twelve species identified in this study are new to the fauna of the area, while *Cryptops trisulcatus* and *Shendyla carniolensis* are also new to Bulgarian fauna. There are species of unknown taxonomic status as they belong to families or groups and orders of problematic species that need a thorough revision. At least one of those is new to science, which description will be published elsewhere. The 53 identified millipede species are divided into 9 zoogeographical categories of 3 zoogeographical complexes. There is no evidence of significant differences in the distribution of myriapod fauna throughout the zoogeographical categories in urban, suburban and natural habitats as well as throughout the individual sites.

**Key words:** faunistics, myriapods, Chilopoda, Diplopoda, Shumen, Shumen Plateau, Northeastern Bulgaria

## Introduction

Study of the biodiversity on a global scale has not only purely scientific but also practical significance. The results of such inventories of the biodiversity can be effectively used in the development of measures aimed at protecting specific habitats and the creation of management plans of protected areas. Despite that various international conventions (e.g. Convention in Biological Diversity), and the national legislation take into account the need to stimulate taxonomic and faunistic studies on a local, regional and global level, there is still a large number of organism groups

with mega-diversity that remain poorly studied, or are the subject of only marginal research.

One such poorly documented group among the terrestrial arthropods is Myriapoda which is the third most diverse group terrestrial arthropods after insects and chelicerates. From the Class Diplopoda in the world there are only about 10 000 described species, which represents only 10-15% of the actually existing species (KIME & GOLOVATCH 2000). The centipedes currently amount to approximately 3300 species (EDGECOMBE & GIRIBET 2007). A significant

part of the species diversity in the tropics and many other parts of the world remains unexplored.

The first documented reports of millipedes in Bulgaria were produced by GEORGI HRISTOVICH (1892) and STEFAN JURINICH (1904). Afterwards, Bulgarian myriapods have been studied by dozens, mostly international zoologists, among which the most significant contributors are Karl Verhoeff, Karl Strasser, Jadwiga Kaczmarek and Zahiu Matic. A full review of the studies of myriapod fauna in Bulgaria up to 2007 can be found in STOEV (2007).

So far there are some 242 species and subspecies of myriapods known in Bulgaria. Those belong to 31 families and 71 genera (STOEV 2007, 2008, STOEV *et al.* 2008). The knowledge of myriapods is relatively detailed in Sredna Gora Mts., Western Rhodopes and Strandzha-Sakar regions, while areas like Danubean Plain and Ludogorie remain very poorly studied.

The first records of millipedes living in the town of Shumen and Shumen Plateau have been established by JURINICH (1904) who had found three species – *Megaphyllum unilineatum* and *Ommatoiulus sabulosus*, and *Clinopodes flavidus* inhabiting the Kioshkovete park. Later Strasser (STRASSER 1969, 1973) reported four species – *Trachysphaera costata*, *Polydesmus denticulatus*, *Anamastigona bilselii* and *Apfelbeckiella trnowensis*. Stoev (STOEV 2004) reported *Polydesmus complanatus* found in Nahodka 13 and Mladezhka caves located in Shumen Plateau, thus the total number of known milliped species in the region amounts to 7 species of 4 orders – Glomerida, Polydesmida, Chordeumatida and Julida. After Jurinich, the centipedes of Shumen and Shumen Plateau were studied by Kaczmarek who reported a total of 8 new species for the region and described a new to science species *Lithobius zelezovae* (KACZMAREK 1969a, 1969b, 1970, 1972, 1973, 1975). Stoev (STOEV 2001) added two more – *Lithobius mutabilis* and *Lithobius nigripalpis*, found in caves on Shumen Plateau. In the catalog of Bulgarian centipedes Stoev (STOEV 2002) indicated a total of twelve centipede species located on Shumen Plateau – 6 lithobiomorphs, and 3 each, scolopendromorphs and geophilomorphs.

In 2008, BACHVAROVA & STOEV (2008) reported their results from two-month research of the town of Shumen and Shumen Plateau and complemented the list of millipedes in the region with nine new spe-

cies – *Glomeris hexasticha*, *Polydesmus renschi*, *Strongylosoma stigmatosum*, *Leptoiulus trilineatus*, *Cylindroiulus boleti*, *Megaphyllum bosniense*, *M. transsylvanicum*, *Pachyiulus hungaricus* and *P. varius* and four new centipede species – *Scutigera coleoptrata*, *Eupolybothrus transsylvanicus*, *Lithobius forficatus* and *L. muticus*. Another publication (BACHVAROVA *et al.* 2008) examines the diurnal activity of certain myriapod species in the area.

The aim of this study is to outline the taxonomic and zoogeographical characteristics of the two major classes in Myriapoda, namely Diplopoda and Chilopoda, in one of the least studied in terms of faunistic research regions of Bulgaria – the town of Shumen and Shumen Plateau. Until now, such an extensive and complex study of myriapod fauna in that area has not been conducted.

## Material and Methods

### Study area

The material was collected in the period April 2007 – May 2009 by using Barber traps set at 8 collecting sites, distinguished by their origin and composition of plant formations. Two of the sites are located in urbanised areas that are subject to considerable human pressure: **UI** – City park and **UII** – University of Shumen park. Site 3, **SU** – Park Kioshkovete, is located in a transitional zone between the urban area and Shumen Plateau. Collecting sites 4-8 are situated in rural habitats located in the natural park Shumen Plateau: **RI** – beech forest at Bukaka reserve, **RII** – mixed deciduous-coniferous forest, **RIII** – hornbeam forest, **RIV** – pine forest and **RV** – open meadow (Fig. 1).

The material has been collected through quantitative and qualitative methods. The quantitative methods include Barber's traps, 10 traps at each site, arranged in a straight line with 10 m in between. The catches were measured once a month during the period April 2007 – May 2009. The qualitative methods included underground traps (MSS), direct sampling and soil samples. Four soil samples were taken from each work site during the period June – July 2009 and September – October 2009. Each sample was of 0.75 m<sup>3</sup> in volume and was handled manually. Later those samples were extricated for 48 h using Tullgren-Berlese apparatus. Direct sampling was

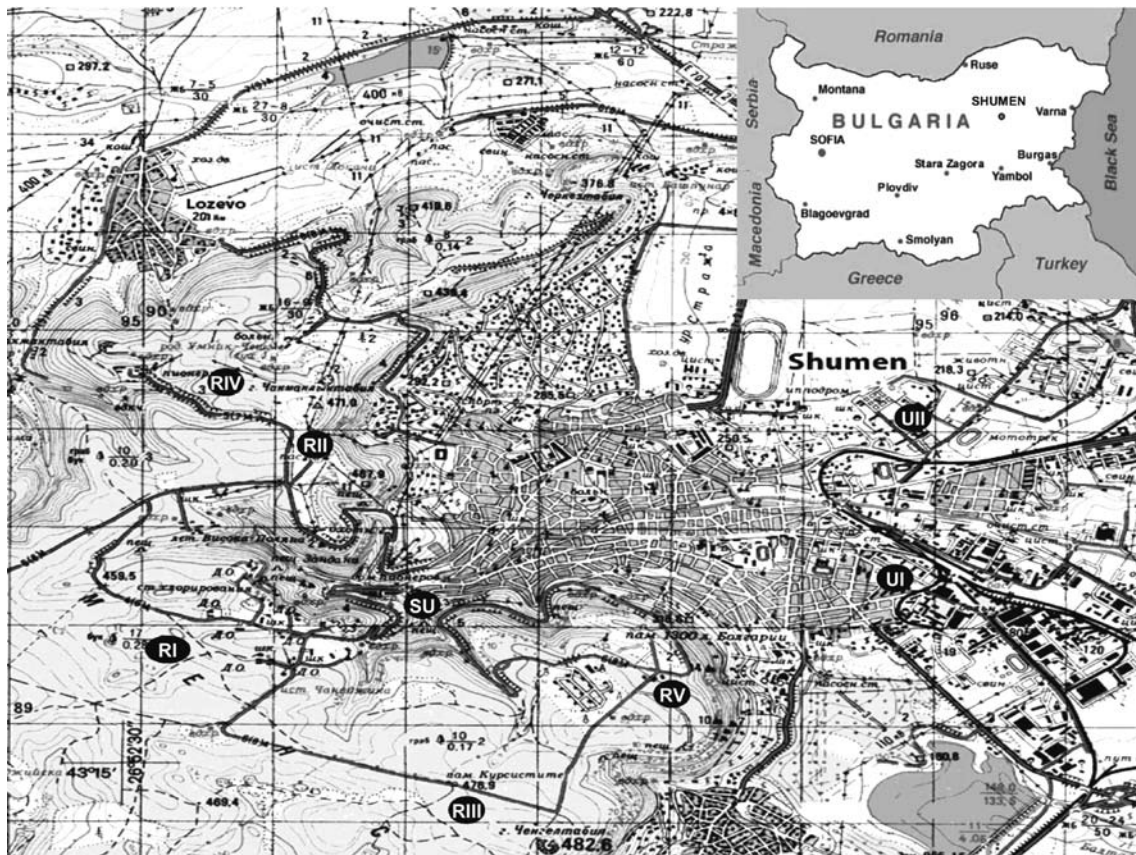


Fig. 1. Map of the research area and location of work sites.

used in all eight work sites and in other specific habitats and microhabitats such as in between buildings spaces, homes, garden paths, patios in the city center and others. The floristic similarity of the work sites was determined by Czekanowski-Dice-Sorensen's index and by using the computer program Past.

#### Characterization and floristic analysis of the ecosystems at the work sites

The Nature Park Shumen Plateau is located in the Southeastern suburbs of Moesian plane. The park falls within Moesian beech forest and Lower plane-hilly oak forest belts with an altitude from 0 to 800 m (ANDREEV 1992). In general the vegetation cover is characterised by predominance of xerophyllic and more or less thermophilic elements, such as *Carpinus orientalis*, *Quercus pubescens*, *Q. cerris*, *Q. frainetto*, *Syringa vulgaris*, *Paliurus spina-christi*. The mesophilic and mesothermic elements, such as *Carpinus betulus*, *Quercus robur*, *Tilia argentea*, *Tilia tomentosa*, *Ulmus campestris*, have more limited distribution. Pretty close to mesophilic ecosystems are those of Moesian beech *Fagus sylvatica moesiaca*, but they must be regarded as intermedi-

ate to xerophyllic ones. The coniferous forests cover about 16% of park's territory and are artificially introduced tree species. The chasmophytic communities within the protected area relate to the endemic for Balkan Peninsula association *Ramondion nathaliae*, that combines rock phytocenoses of limestone substrates. The average altitude is 350 m, with the highest point being 502 m and the lowest – 225 m.

#### Description of sites

**RI:** Thermophilic Moesian beech forest (TZONEV *et al.* 2006), with presence also of hornbeam *Carpinus betulus*, durmast *Quercus dalechampii*, oak *Quercus frainetto*, oak *Quercus cerris*, silver lime *Tilia tomentosa*, etc. Scrub floor does not form almost anywhere. The participation of several types of xerophyllic species from the neighboring oak and hornbeam forests, such as *Glechoma hederacea*, *Hedera helix*, *Lathyrus laxiflorus*, *Melissa officinalis*, *Mercurialis perennis*, *Milium effusum*, *Muscari botryoides*, *Polygonatum latifolium*, *Ruscus aculeatus*, *Tamus communis*, *Viola riviniana*, etc. Dominants for the grass synusie are *Rubus hirtus*, *Poa nemoralis*, *Brachypodium sylvaticum*, *Galium*

*odoratum*, *Festuca heterophylla*, *Lamiaeum galeobdolon*, *Sanicula europaea*, *Cyclamen coum* and *Carex sylvatica*. Geographical coordinates: 43°01'5N, 26°05'3E, pH of soil is 4.18.

**RII:** Located at the border of coniferous and deciduous hornbeam-Sessile oak forests. In a relatively equal amount are found the following tree species: *Fagus sylvatica*, *Carpinus betulus*, *Pinus nigra*, and *Pinus sylvestris*. The scrub floor resembles that of the coniferous forests and includes representatives of *Rosa* sp., *Crataegus mongoina*, *Paliurus spina-christi* and not as often of *Fraxinus ornus*. Grass synusie is composed primarily by xerophytic species such as *Hedera helix*, *Muscari botryoides*, *Glechoma hederacea*, *Viola riviniana*, etc. Geographical coordinates: 43°01'6N, 26°05'3E, pH of soil is 5.16.

**RIII:** Besides the dominant species *Carpinus betulus* and *Quercus petraea* in the composition of the tree floor there are also *Fagus sylvatica*, *Carpinus orientalis*, *Quercus frainetto*, *Quercus cerris* and *Populus tremula*. The scrub synusie is composed of *Crataegus monogyna* and *Coryllus avellana* and not as often of *Fraxinus ornus*. Except *Lamiaeum galeobdolon*, the other major dominants among the grasses are characteristic of thermophilic oak forests – *Poa nemoralis*, *Brachypodium sylvaticum*, *Festuca heterophylla* and *Melica uniflora*. Geographical coordinates: 43°01'4N, 26°05'4E, pH of soil is 5.02.

**RIV:** The worksite is located in a coniferous forest, composed mainly of a pure culture of *Pinus nigra*. The coniferous forests in Shumen Plateau occupy about 16% of its territory and are composed of artificially introduced tree species. The scrub floor is composed of *Rosa* sp., *Crataegus mongoina*, and not as often of *Prunus spinosa*. Grass synusie is lacking. Geographical coordinates: N 43°01'6N, 26°05'3E, pH of soil is 7.19.

**RV:** Depending on its phytocenologic outlook, the site can be divided in two parts. Its eastern half belongs to xerophytic grasslands, which on the territory of Shumen Plateau refer to phytocenose Festuco-Brometea. These phytocenoses have occurred at the place of forests that have been destroyed in the distant past. Now they compose a little part of the plant cover (0.6%). The western part of the site is occupied by low shrub phytocenoses of *Prunetum tenellae* association, which have a symbolic participation (0.08%) in the vegetation cover of Shumen

Plateau. These secondary communities are found on eroded landscapes along with *Syringa vulgaris*, *Paliurus spina-christi*, blackthorn *Prunus spinosa*, *Carpinus orientalis* and xerophytic grasslands. Geographical coordinates: 43°01'5N, 26°05'5E, pH of soil is 7.76.

**SU:** The site is located in semi-natural formation, strongly influenced by human activity. There are no dominant species, although horse chestnut *Aesculus hippocastanum*, is quite common. Well represented are also: *Tilia tomentosa*, *Acer campestre*, *Acer pseudoplatanum* and *Juglans regia*. Scrub floor is very scanty and represented by ornamental species such as *Hedera helix*. In the grass synusie there are representatives of *Parietaria officinalis*, *Dactylis glomerata*, *Geum urbanum*, *Geranium* sp., *Ballota nigra*, *Vinca minor*, *Chaerophyllum temulentum*, etc. Geographical coordinates: N 43°01'5, E 26°05'4, pH of soil is 7.41.

**UI:** Wet meadows in highly urbanised spaces – small parks, public squares and around the streets. There are no clearly dominant species. Phytocenosis is represented by horse chestnut *Aesculus hippocastanum*, *Amorpha fruticosa*, *Platanus orientalis*, *Prunus mahaleb*, *Tilia tomentosa*, *Acer campestre*, *Cereis silignastrum*, *Bellis perennis*, *Lolium perenne*, *Taraxacum officinale*, *Parietaria officinalis*, *Geum urbanum*, etc. Geographical coordinates: 43°01'6N, 26°05'6E, pH of soil is 7.59.

**UII:** The site is located near University of Shumen, which is urbanised territory containing sport facilities (football playground and two tennis courts), three parking lots, a number of buildings, alleys and lawns. The total surface area amounts to 180 ha. In terms of habitats it can be divided into two parts. The northeast part is composed of mixed plantations of park type, where the most numerous species are *Pinus nigra*, *Tilia tomentosa*, *Acacia robinia*, *Aesculus hippocastanum* and *Cereis silignastrum*. The scrub floor is relatively scanty and grass synusie is formed by *Hedera helix*, *Clematis vitalba*, *Salvia nemorosa*, *Galium* sp., *Poa pratensis*, *Capsella bursa-pastoris*, *Taraxacum officinale*, *Malva silvestris*, *Silene vulgaris*, etc. The southwestern part of the site encompasses meadows with individual trees and shrubs. Geographical coordinates: 43°01'6 N, 26°05'6E, pH of soil is 7.37.

**Table 1.** An annotated list of Myriapoda (Dipllopoda, Chilopoda) of Shumen City and Shumen Plateau. Abbreviations: BG – Bulgarian species, BK – Holobankan species, CEU – Central European species, CPBK – Carpathian-Balkan species, EEU – East European species, EME – Eastern Mediterranean species, EMT – European-Mediterranean-Turanian species, ESI – Euro-Siberian species, EU – European species, EUAN – European-Anatolian species, LE – Local endemic, MED – Holomediterranean species, SPE – Endemic species of Stara Planina Mountain.

N	Species	Zoographic category	Location	Source	Notes
	<b>Class DIPLOPODA</b>				
	<b>Order Glomerida</b>				
	<b>Family Glomeridae</b>				
1.	<i>Glomeris hexasticha</i> Brandt, 1833	CEU	Shumen Plateau: RII, RIV; Shumen Plateau: RI, RII, RIV	BACHVAROVA & STOEV, 2008; Current study	
	<b>Family Doderiidae</b>				
2.	<i>Trachysphaera costata</i> (Waga, 1857)	CEU	Dipsiskuyu Cave; Shumen Plateau: Zandana Cave*	STRASSER, 1969; STRASSER, 1973; Current study	* material collected by: P. Beron - 09/28/1996 B. Petrov, T. Ivanova -.06/ 22/2000 T. Ivanova - on 12/30/2001
	<b>Order Polydesmida</b>				
	<b>Family Polydesmidae</b>				
3.	<i>Polydesmus complanatus</i> (Linnaeus, 1761)	CEU	Shumen Plateau: Mladezhka and Nahodka 13 caves; Shumen, Shumen Plateau: UII, SU, RI, RII; Shumen: UII; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIV	STOEV, 2004; Bachvarova & Stoev, 2008; BACHVAROVA <i>et al.</i> , 2008; Current study	
4.	<i>Polydesmus denticulatus</i> C.L. Koch, 1847	EU	Cave 1 at Shumen; Shumen Plateau: Zandana Cave; Shumen, Shumen Plateau: UI, SU; Shumen: UII; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIV	STRASSER, 1973; STOEV, 2004 a; BACHVAROVA & STOEV, 2008; BACHVAROVA <i>et al.</i> , 2008; Current study	
5.	<i>Polydesmus renschi</i> Schubart, 1934	CPBK	Shumen, Shumen Plateau: SU; Shumen, Shumen Plateau: SU, RIII	BACHVAROVA & STOEV, 2008; Current study	

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
6.	<i>Polydesmus mediterraneus</i> Daday, 1899 <b>Family Paradoxosomatidae</b>	MED	Shumen: UII	Current study	New to the fauna of the region
7.	<i>Strongylosoma stigmatosum</i> (Eichwald, 1830) <b>Order Chordeumatida</b> <b>Family Anthroleucosomatidae</b>	EEU	Shumen, Shumen Plateau: SU; Shumen, Shumen Plateau: SU	BACHVAROVA & STOEY, 2008; Current study	
8.	<i>Anamastigona biselii</i> (Verhoeff, 1940) <b>Family Craspedosomatidae</b>	BK	Shumen * Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIV	STRASSER, 1973; Current study	*reported as <i>Prodicus biselii</i>
9.	<i>Craspedosoma transsylvanicum</i> Verhoeff, 1897 <b>Order Julida</b> <b>Family Blaniulidae</b>	EEU	Shumen, Shumen Plateau: SU	Current study	New to the fauna of the region
10.	<i>Nopoiulus kochii</i> (Gervais, 1847) <b>Family Julidae</b>	EUAN	Shumen, Shumen Plateau: UI, UII, SU	Current study	New to the fauna of the region
11.	<i>Leptoiulus trilineatus</i> (C.L. Koch, 1847)	EEU	Shumen Plateau: RI; Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RIV, RV	BACHVAROVA & STOEY, 2008; Current study	
12.	<i>Typhloiulus kotelensis</i> Jawlowski, 1938	SPE	Shumen, Shumen Plateau: SU	Current study	New to the fauna of the region
13.	<i>Cylindroiulus boleti</i> (C.L. Koch, 1847)	EEU	Shumen, Shumen Plateau: RI, RIII, RIV; Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RIV, RV	BACHVAROVA & STOEY, 2008; Current study	
14.	<i>Megaphyllium bosniense</i> (Verhoeff, 1897)	BK	Shumen Plateau: RII; Shumen, Shumen Plateau: SU, RI, RII, RII, RIV, RV	BACHVAROVA & STOEY, 2008; Current study	
15.	<i>Megaphyllium lictor</i> (Attems, 1904)	BK	Shumen, Shumen Plateau: SU, RIV, RV	Current study	New to the fauna of the region
16.	<i>Megaphyllium transsylvanicum</i> (Verhoeff, 1897)	EEU	Shumen, Shumen Plateau: UI, SU, RIV; Shumen: UII, RI; Shumen, Shumen Plateau: UI, UII, SU, RII, RIV, RV	BACHVAROVA & STOEY, 2008 BACHVAROVA <i>et al.</i> , 2008; Current study	

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
17.	<i>Megaphyllum unilineatum</i> (C.L. Koch, 1838)	EEU	Shumen: Kyoshkovete forest; Shumen: UII; Shumen Plateau: UI, UII, SU, RIV	JURINICH, 1904; BACHVAROVA & STOEY, 2008; Current study	
18.	<i>Pachyiulus hungaricus</i> (Karsch, 1881)	CPBK	Shumen, Shumen Plateau: SU; Shumen, Shumen Plateau: UI, SU, RI	BACHVAROVA & STOEY, 2008; Current study	
19.	<i>Pachyiulus varius</i> (Fabricius, 1781)	MED	Shumen, Shumen Plateau: SU; Shumen, Shumen Plateau: SU, RI	BACHVAROVA & STOEY, 2008; Current study	
20.	<i>Apfelbeckiella trnovensis trnovensis</i> (Verhoeff, 1928)	BG	The labyrinth cave near Shumen; Shumen Plateau: Zandana Cave; Shumen: UI; Shumen, Shumen Plateau: UI, UII, SU, RI	STRASSER, 1969 STOEY, 2004; BACHVAROVA & STOEY, 2008; Current study	
21.	<i>Ommatoiulus sabulosus</i> (Linnaeus, 1758)		Shumen: above the Kyoshkovete region	JURINICH, 1904	Not registered in the study
	<b>Class CHILOPODA</b>				
	<b>Order Scutigromorpha</b>				
	<b>Family Scutigeridae</b>				
1.	<i>Scutigera coleoptrata</i> (Linnaeus, 1758)	MED	Shumen: UII (in the University building); Shumen: UI	BACHVAROVA & STOEY, 2008; Current study	
	<b>Order Lithobiomorpha</b>				
	<b>Family Lithobiidae</b>				
1.	<i>Eupolybothrus (Mesobothrus) transsylvanicus</i> (Latzel, 1882)	CPBK	Shumen, Shumen Plateau: SU; Shumen, Shumen Plateau: SU, RIV	BACHVAROVA & STOEY, 2008; Current study	Reported by Kaczmarek (1973) from Patleyna near Shumen as <i>Polybothrus ochraceus</i>
2.	<i>Lithobius (Lithobius) erythrocephalus</i> C.L. Koch, 1847	EU	Shumen, Shumen Plateau: SU	Current study	New to the fauna of the region
3.	<i>Lithobius (Lithobius) forficatus</i> (Linnaeus, 1758)	EU	Shumen, Shumen Plateau: UI, SU; Shumen: UII; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIV, RV	BACHVAROVA & STOEY, 2008; BACHVAROVA <i>et al.</i> , 2008; Current study	

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
4.	<i>Lithobius (Lithobius) lucifugus</i> L. Koch, 1862	CEU	Shumen: UII; Shumen, Shumen Plateau: UI, UII, SU, RII, RIII	BACHVAROVA <i>et al.</i> , 2008; Current study	
5.	<i>Lithobius (Lithobius) mutabilis</i> L. Koch, 1862	CEU	Shumen Plateau: Nahodka 13 cave; Shumen Plateau: RI; Shumen, Shumen Plateau: SU, RI, RII	STOEY, 2001; BACHVAROVA & STOEY, 2008; Current study	
6.	<i>Lithobius (Lithobius) muticus</i> C.L. Koch, 1847	CEU	Shumen, Shumen Plateau: UI, UII, SU, RV; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIII, RIV, RV	BACHVAROVA & STOEY, 2008; Current study	
7.	<i>Lithobius (Lithobius) nigripalpis</i> L. Koch, 1867	EME	Shumen Plateau: Nahodka 13 cave; Shumen, Shumen Plateau: UI, UII, RI, RII, RIII, RIV, RV; Shumen, Shumen Plateau: UII, RI; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIII, RIV, RV	STOEY, 2001; BACHVAROVA & STOEY, 2008; BACHVAROVA <i>et al.</i> , 2008; Current study	Morphologically the species belongs to a group of species with many unresolved taxonomic problems, which is in need of an overall revision. Possibly a new to science species
8.	<i>Lithobius</i> aff. <i>melanops</i> Newport, 1845		Shumen: UI, UII	Current study	
9.	<i>Lithobius (Lithobius)</i> aff. <i>oglednicus</i> Ribarov, 1987		Shumen, Shumen Plateau: SU, RI, RII, RIII, RV	Current study	A species that to a large extent matches the description of <i>Lithobius oglednicus</i> . However, since <i>L. oglednicus</i> has been poorly described, a revision of the type material is needed. New species to the fauna of the region
10.	<i>Lithobius (Lithobius) parietum</i> Verhoeff, 1899	CPBK	Shumen Plateau: RV	Current study	New species to the fauna of the region

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
11.	<i>Lithobius (Lithobius) schuleri</i> Verhoeff, 1925	CEU	Shumen Plateau: RII, RIV	Current study	New species to the fauna of the region
12.	<i>Lithobius (Monotarsobius) aeryginosus</i> L. Koch, 1862		Shumen: Kyoshkovete	KACZMAREK, 1975	Not registered in the study
13.	<i>Lithobius (Monotarsobius) crassipes</i> L. Koch, 1862	ESI	Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIII, RIV	Current study	New species to the fauna of the region
14.	<i>Lithobius (Sigibius) beroni</i> Negrea, 1965	BK	Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RIV	Current study	New species to the fauna of the region
15.	<i>Lithobius (Sigibius) aff. micropodus</i> (Matic, 1980)		Shumen, Shumen Plateau: UI, UII	Current study	Kaczmarek (1975) reported <i>L. microps</i> from Shumen, a record which according to the current understanding should be assigned to a species from the group of <i>L. micropodus</i> . Since the group includes a large number of ambiguous taxa (including <i>L. zelezovae</i> ) and needs a thorough revision, we prefer to record the species as <i>L. aff. micropodus</i> .
16.	<i>Lithobius (Sigibius) microps</i> Meinert, 1868	EU	Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RV	Current study	New species for the fauna of the region
17.	<i>Lithobius (Sigibius) zelezovae</i> Kaczmarek, 1975		Shumen	KACZMAREK, 1975	Not registered in the study. See the note in <i>L. aff. micropodus</i> .
-	<i>Harpolithobius radui</i> Matic, 1955		Shumen	Current study	Not registered in the study but it is most likely inaccurately identified new species of the group of <i>H. radui</i>
18.	<i>Harpolithobius</i> sp. n. 1 ( <i>radui</i> group)	LE	Shumen, Shumen Plateau: SU, RI	Current study	Possibly a new to science species
19.	<i>Harpolithobius</i> sp. n. 2	LE	Shumen, Shumen Plateau: SU, RI	Current study	Possibly a new to science species

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
	<b>Order Scolopendromorpha</b>				
	<b>Family Scolopendridae</b>				
22.	<i>Scolopendra cingulata</i> Latreille, 1829	MED	Shumen Plateau: RV	Current study	New species for the fauna of the region
	<b>Family Cryptopidae</b>				
23.	<i>Cryptops anomalans</i> Newport, 1844	EU	Shumen Shumen, Shumen Plateau: RI, RII, RIII; Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RIV, RV	KACZMAREK, 1969A; BACHVAROVA & STOEY, 2008; Current study	
24.	<i>Cryptops croaticus</i> Verhoeff, 1931		Shumen	KACZMAREK, 1969a;	Not registered in the study
25.	<i>Cryptops parisi</i> Brolemann, 1920	CEU	Shumen; Shumen Plateau: Nahodka 13 cave; Shumen, Shumen Plateau: UI, SU, RI	KACZMAREK, 1969A; STOEY, 2001; Current study	
26.	<i>Cryptops trisulcatus</i> Brölemann, 1902	MED	Shumen, Shumen Plateau: SU	Current study	New species for the Bulgarian fauna
	<b>Order Geophilomorpha</b>				
	<b>Family Schendylidae</b>				
27.	<i>Shendyla carniolensis</i> Verhoeff, 1902	CEU	Shumen, Shumen Plateau: RI, RIV	Current study	New species for the Bulgarian fauna
28.	<i>Shendyla</i> aff. <i>delicatula</i> Kaczmarek, 1969		Shumen, Shumen Plateau: UII	Current study	The whole genus <i>Shendyla</i> needs to be revised. Since the group includes a large number of unclear taxa and is in need of a thorough revision, I prefer to treat the species as <i>Shendyla</i> aff. <i>delicatula</i>
29.	<i>Shendyla</i> aff. <i>montana balcanica</i> (Kaczmarek, 1969)		Shumen, Shumen Plateau: RIII, RIV	Current study	See previous note.
30.	<i>Shendyla</i> aff. <i>walachica</i> Verhoeff, 1900		Shumen, Shumen Plateau: RI, RIII	Current study	See note on <i>Shendyla</i> aff. <i>delicatula</i> .

Table 1. Continued.

N	Species	Zoographic category	Location	Source	Notes
	<b>Family Geophilidae</b>				
31.	<i>Geophilus flavus</i> (De Geer, 1778)	ESI	Shumen Plateau: RIV	Current study	New species for the fauna of the region
32.	<i>Clinopodes flavidus</i> C.L. Koch, 1847	EMT	Shumen: above Kyoshkovete; Shumen; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIII, RIV, RV	JURINICH, 1904; KACZMAREK, 1970; Current study	
33.	<i>Stenotaenia linearis</i> (C.L. Koch, 1835)	EU	Shumen, Shumen Plateau: UI, UII, RIV	Current study	New species for the fauna of the region
	<b>Family Dignathodontidae</b>				
34.	<i>Henia illyrica</i> (Meinert, 1870)	EEU	Shumen; Shumen, Shumen Plateau: UI; Shumen, Shumen Plateau: UI, UII, SU, RI, RII, RIII, RIV, RV	KACZMAREK, 1970; BACHVAROVA & STOEY, 2008; Current study	
	<b>Family Linotaeniidae</b>				
35.	<i>Strigamia crassipes</i> (C.L. Koch, 1835)	EU	Shumen* Shumen, Shumen Plateau: UII, SU, RI, RII, RIII, RIV, RV	KACZMAREK, 1969a; Current study	*reported as <i>Linotaenia crassipes</i>
36.	<i>Strigamia engadina</i> (Verhoeff, 1935)	CEU	Shumen Plateau: RI	Current study	New species for the fauna of the region
37.	<i>Strigamia transsylvanica</i> (Verhoeff, 1928)	CPBK	Shumen, Shumen Plateau: SU, RI	Current study	New species for the fauna of the region

## Results and Discussion

### Species composition

As a result of the study were collected a total of 7833 specimens – 5077 millipedes and 2756 centipedes. Of these, 4669 specimens were collected by Barber's traps, 1756 through direct sampling, 269 through underground traps and 1139 through soil samples (Table 1).

Currently, millipedes are known from a total of 21 species of four orders: Glomerida (2), Polydesmida (5), Chordeumatida (2) and Julida (12). All orders were represented by two families. The largest relative share belongs to the family Julidae (11 species), followed by Polydesmidae (4), while the remaining families are represented by only one species each. In the conducted study there is only one unverified species – *Ommatoiulus sabulosus*, reported by JURINICH (1904) from the place Kioshkovete. Five species are new to the fauna of the area – *Polydesmus mediterraneus*, *Craspedosoma transsylvanicum*, *Nopoiulus kochii*, *Typhloiulus kotelensis* and *Megaphyllum lictor*.

A total of 37 species of centipedes were established, 29 of which were also registered in the current study. The highest relative proportion of species belongs to the Lithobiidae family (19 species). The Geophilomorpha order is represented by four families that include a total of 11 species. Scolopendromorpha

is represented by 2 families and 5 species, while Scutigermorpha only by the synantropic species – *Scutigera coleoptrata*. Four previously reported species remain unconfirmed in this study: *Lithobius aeruginosus*, *Lithobius zelezovae*, *Harpolithobius radui* and *Cryptops croaticus*. Almost half of all species found in the current study are new to the fauna of the region (12 species), and *Cryptops trisulcatus* and *Shendyla carniolensis* are also new to Bulgarian fauna. Eight species are of unclear taxonomic status as they belong to families or groups of problematic species that need an overall revision. At least one of them is new to science and its description will be published elsewhere (Table 1).

### Comments on the new for the country species

#### *Cryptops trisulcatus*

This species is hitherto known from Canary Islands, Algeria, Tunisia, Maltese Archipelago, Portugal, Spain (incl. Balearic Islands), South of France (incl. Corsica), Italy (incl. Sicily, Sardinia), Romania, Insular Greece (Ionian, Dodecanese islands and Crete), SE Turkey (AKKARI *et al.* 2008). In neighbouring Romania the species is comparatively rare, being known only from caves in the southern part of the country (MATIĆ 1972, see also NEGREA 2006).

#### *Shendyla carniolensis*

This species has hitherto known from Ukraine, Austria, Poland, Italy, Romania, Slovenia, France, Monaco and Spain (MINELLI *et al.* 2006). This repre-

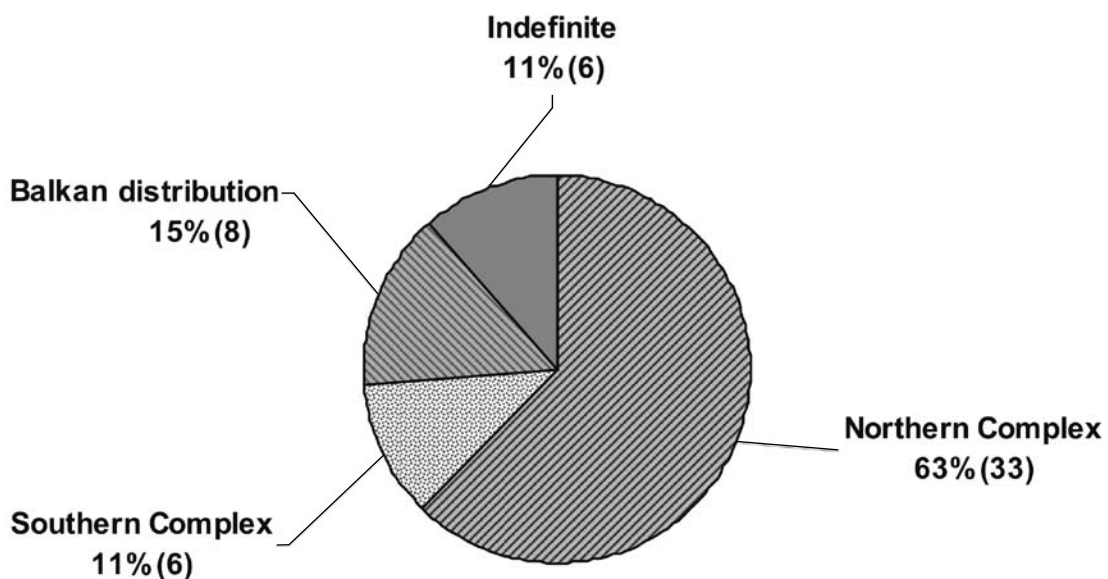


Fig. 2. Zoogeographical structure of Myriapoda (Diplopoda, Chilopoda) of the town of Shumen and Shumen Plateau.

sents its first formal record in Bulgaria. In Romania the species is known (also under its synonym *S. zonalis*) from several localities in Dobrogea lying approximately 150-170 km North of Shumen (MATIC 1972).

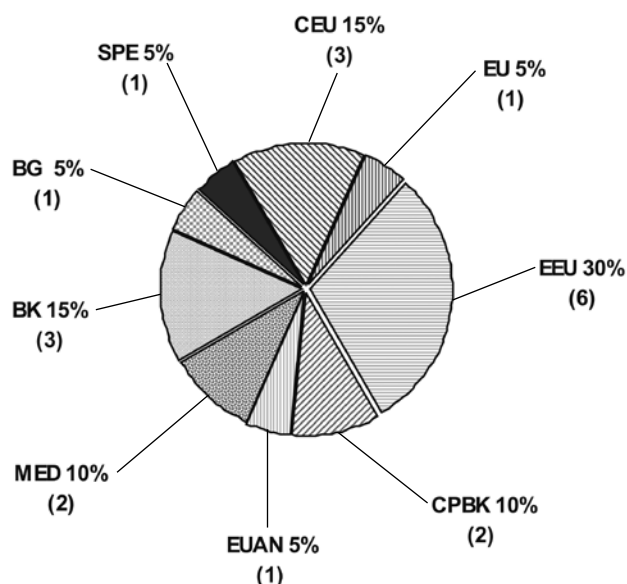
### Zoogeographical analysis

Out of the 53 established species of myriapods in the town of Shumen and Shumen Plateau, 63% (33 species) belong to the Northern Complex, 11% (6 species) to the Southern Complex, 15% (8 species) are characterised by Balkan distribution and 11% (6 species) due to their ambiguous taxonomic status are excluded from the analysis of zoogeographical structure (Fig. 2).

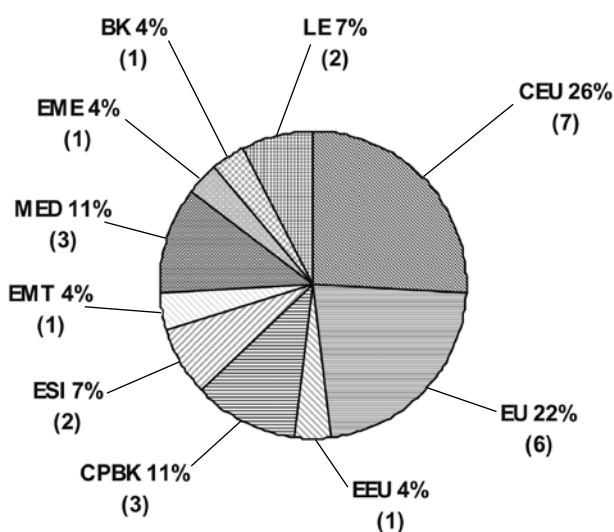
As a whole, in both classes the share of species of wide distribution in Europe significantly predominates over that of Mediterranean species and those of Balkan distribution. Among Diplopoda (Fig. 3) with the highest percentage (by number of species) in the Northern Complex are the species of Eastern European distribution (30%), followed by Central European species (15%), while among Chilopoda (Fig. 4) predominant are Central European species (26%) and European ones (22%).

In both classes the Southern complex is represented by a minimum number of species. In Diplopoda it includes only two species of Holomediterranean distribution (10%), while in the case of Chilopoda there are three Holomediterranean species (11%). In addition one Eastern Mediterranean species has been registered (4%). Certain differences could be observed regarding the ratio of species with Balkan distribution. In the case of Diplopoda this complex includes a small number of species – 3 Balkan species (15%), one Bulgarian endemic (*Apfelbeckiella trnowensis*) and one regional endemic, *Typhloiulus kotelensis*, restricted to Stara Planina Mts. and neighbouring areas. As for Chilopoda species of Balkan distribution there are only three species – the Balkan species *Lithobius beroni* and two very likely new to science species, *Harpolithobius* sp. n. 1 (*radui* group) and *Harpolithobius* sp. n. 2.

The distribution of myriapod fauna by zoogeographical categories in urban, suburban and natural habitats does not differ significantly. The suburban site Kioshkovete is species-richest, where there are representatives of all 13 zoogeographical categories



**Fig. 3.** Zoogeographical structure of Diplopoda in zoogeographical categories. Abbreviations: BG – Bulgarian species, BK – Holobalkan species, CEU – Central European species, CPBK – Carpathian-Balkan species, EEU – East European species, EU – European species, EUAN – European-Anatolian species, MED – Holomediterranean species, SPE – Endemic species of Stara Planina Mountain.



**Fig. 4.** Zoogeographical structure of Chilopoda in zoogeographical categories. Abbreviations: BK – Holobalkan species, CEU – Central European species, CPBK – Carpathian-Balkan species, EEU – East European species, EME – Eastern Mediterranean species, EMT – European-Mediterranean-Turanian species, ESI – Euro-Siberian species, EU – European species, LE – Local endemic, MED – Holomediterranean species.

established in the research area. Specific for the city area are Eastern European species *Strongylosoma stigmatosum* and *Craspedosoma transsylvanicum*, European species *Lithobius erythrocephalus*, Holomediterranean species *Pachyiulus varius* and *Cryptops trisulcatus* and Carpathian-Balkan species *Eupolybothrus transsylvanicus* (with the exception of one male specimen found in traps in pine forest (RIV) of Shumen Plateau). In the city area were found the endemic for Stara Planina mountain species *Typhloiulus kotelensis*, as well as two local endemics – *Harpolithobius* sp. n. 1 (*radui* group) and *Harpolithobius* sp. n. 2. The largest representation in Kioshkov park have the species from the Northern Complex – 7 Eastern European (EEU), 6 European (EU), 5 Central European (CEU) and 4 Carpathian-Balkan species (CPBK), which along with 4 Holobalkan species constitute 72% of the species composition of the work site (Fig. 5).

Species with the same zoogeographical categories constitute the core of myriapod fauna and natural habitats of Shumen Plateau. Predominant are again the species from the Northern Complex – 10 Central European, 6 European, 5 Eastern European and 5 Carpathian-Balkan species, which along with 4 Holobalkan species constitute 77% of species composition of suburban area. In the only working stations on the plateau are registered Central European species *Glomeris hexasticha*, *Lithobius schuleri*, *Strigamia engadina* and *Shendyla carniolensis*. Carpathian-Balkan species *Lithobius parietum* and Holomediterranean species *Scolopendra cingulata* are found only in traps in Open meadow collecting site (RV). Euro-Siberian species *Geophilus flavus* has only been detected in soil samples from pine forest (RIV).

Three zoogeographical categories of the Northern complex form the core of myriapod fauna in urban sites UI and UII. Those consist of 6 European, 5 Eastern European and 4 Central European species, which represent 60% of the total number of species in the area. European species *Stenotaenia linearis* and Holomediterranean species *Scutigera coleoptrata* were established only in urban sites. European-Anatolian species *Nopoiulus kochii* and Bulgarian endemic *Apfelbeckiella trnowensis* have been registered only in urban and suburban areas (except for one female *A. trnowensis* found in the soil samples from Bukaka reserve), and Holomediterranean spe-

cies *Polydesmus mediterraneus* has been found only in Shumen University Park.

In all sampled sites the millipedes have been represented mainly by Eastern European species which in the suburban site and the natural habitats of Shumen Plateau are complemented by Central European and Balkan species. The natural habitats of Shumen Plateau exhibit the lowest diversity since only five zoogeographical categories have been registered on that territory. Those include 3 Central European species, 3 Eastern European, 1 European species, 3 Balkan and 2 Carpathian-Balkan. Species representatives of the other zoogeographical categories registered in the study area were not found (Fig. 6).

The urban and suburban sites are identical in regard to zoogeographical categories registered there. The only exception is the endemic for Stara Planina Mts. species *Typhloiulus kotelensis*, which is found in the suburban area of Kioshkovete, but is absent from urban sites. However, there is difference in the proportion of species of different zoogeographical categories. While the core of urban sites is represented only by 4 species of Eastern European distribution – *Leptoiulus trilineatus*, *Cylindroiulus boleti*, *Megaphyllum transsylvanicum* and *Megaphyllum unilineatum*, in the suburban area those species are complemented by Balkan and Carpathian-Balkan species and their distribution there resembles that of the natural habitats (Fig. 5). Unlike the natural habitats, two Holomediterranean species have been registered in urban and suburban sites – *Polydesmus mediterraneus* in Shumen University Park and *Pachyiulus varius* in Kioshkovete, as well as Bulgarian species *Apfelbeckiella trnowensis*.

The centipedes in the researched areas exhibit much greater diversity in their zoogeographical structure than millipedes do.

The group is represented mainly by European and Eastern European species, while in suburban area and natural habitats of Shumen Plateau they are complemented by Carpathian-Balkan species (Fig. 7). All other zoogeographical categories are found in relatively equal quantities with the exception of European-Anatolian and Bulgarian species that have not been registered in the area of study. Common to the researched area are Central European species *Lithobius muticus* and Eastern European species *Henia illyrica* since they were registered in all

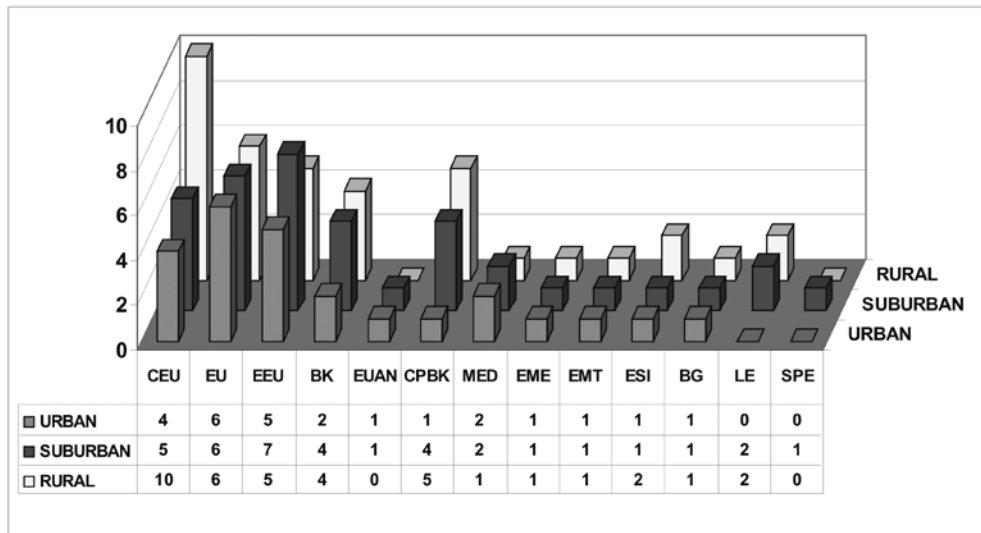


Fig. 5. Distribution of myriapod fauna in urban, suburban and rural areas by zoogeographical categories.

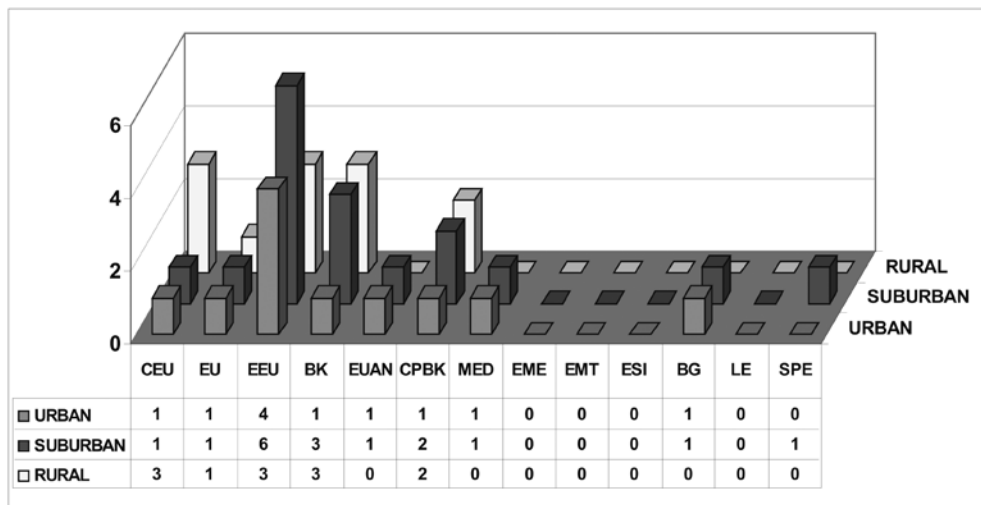


Fig. 6. Distribution of millipedes by zoogeographical categories in the researched areas.

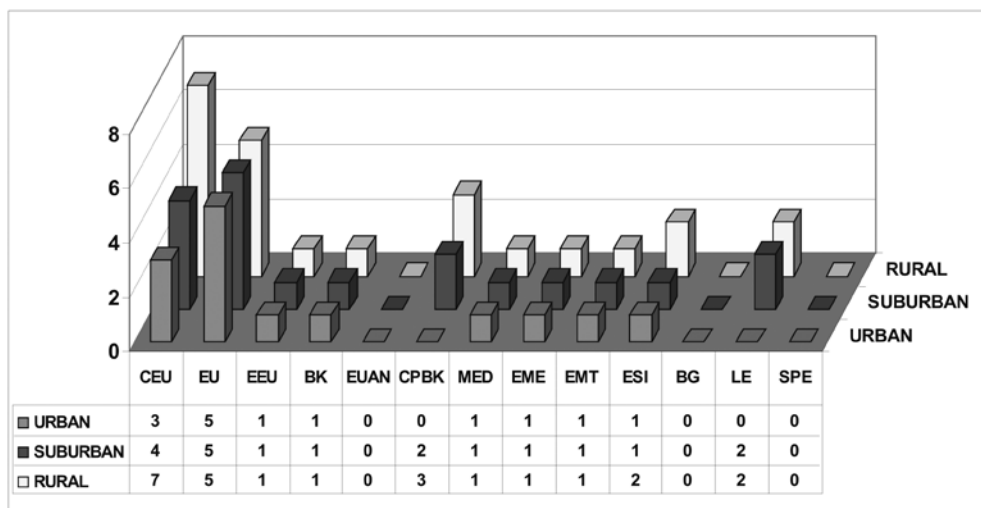


Fig. 7. Distribution of centipedes by zoogeographical categories in the researched areas.

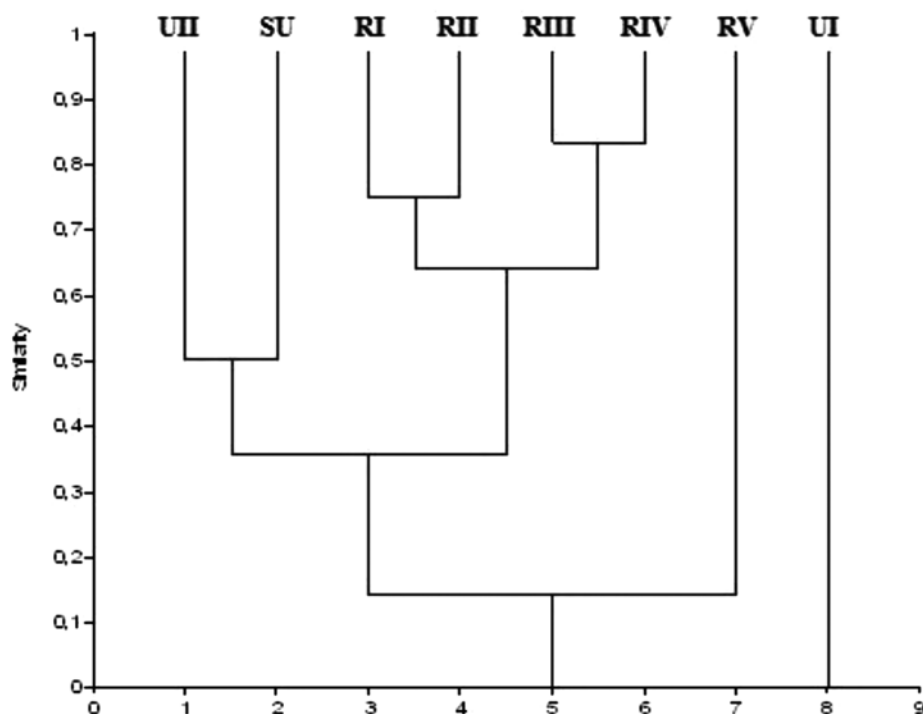
work sites. Two very likely new to science species of *Harpolithobius* were registered in Kioshkovete park and Bukaka reserve. Species of the Southern complex are present in all work sites: Holomediterranean species *Scutigera coleoptrata* – in urban sites, *Cryptops trisulcatus* – in suburban area, *Scolopendra cingulata* in Open meadow (RIV) and Eastern Mediterranean species *Lithobius nigripalpis* along with European-Mediterranean-Turanian *Clinopodes flavidus* both found throughout all of the researched areas. Unlike millipedes, centipedes are represented by two Euro-Siberian species. These are *Lithobius crassipes*, registered in all work sites except for Open meadow (RV) and *Geophilus flavus*, found exclusively in pine forest (RIV) of Shumen Plateau.

Fig. 8 presents a cladogram that reflects the floristic similarity between all work sites in the area of study. It is noteworthy that two of the work sites are very different from the others by their floristic component and are separated as individual categories. These are the most highly urbanised area – City Park (UI), which is located in the central part of the city and is in no way similar to any of the other sites. The other such work site is Open meadow (RV), which has a very low degree of similarity (about 15%) with the other sites. The forest habitats of Shumen Plateau

are isolated in a separate area with two groups of similarity – between Bukaka reserve (RI) and the mixed deciduous-coniferous forest (RII) and between the hornbeam forest (RIII) and the pine forest (RIV). These two groups form a common group of forests with a degree of similarity of 63%.

The other urban site – Shumen University park (UII) exhibits a degree of 50% similarity to the suburban area of Kioshkovete. These two sites exhibit 35% similarity to the forest habitats of Shumen Plateau. Regardless of this differentiation of the work sites on the basis of species composition of the plant formations there are no significant differences in the distribution of myriapod fauna by zoogeographical categories (Fig. 9). It should only be noted that in the forest habitats of Shumen Plateau there are no European-Anatolian and Holomediterranean species registered. All other zoogeographical categories occur with relatively equal frequency and proportion in all work sites.

**Acknowledgements:** Special thanks to Dr. Pavel Stoev and Dr. Nikolai Tsankov, National Museum of Natural History, Bulgarian Academy of Science (BAS) for their invaluable assistance in the identification of the material and numerous advices during preparation of this article. I am grateful to Ms Radina Efremova (American University in Bulgaria) for help-



**Fig. 8.** Floristic similarity of work sites.

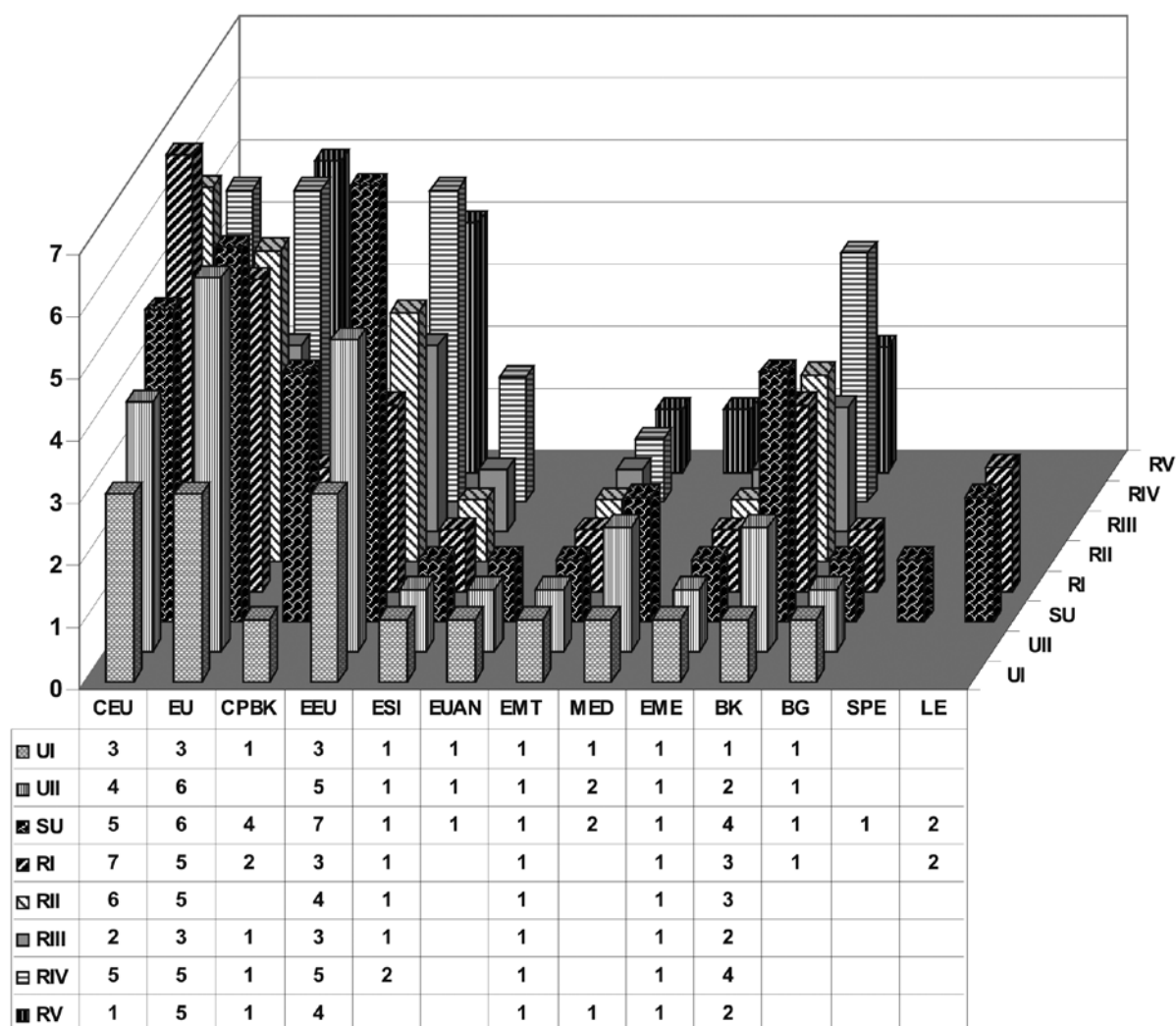


Fig. 9. Distribution of myriapod fauna in the work sites by zoogeographical categories.

ing with the translation of the text, as well as to Ms Natalia Georgieva and Mr Dejan Zahariev (Shumen University) for the selfless help with the collecting of material. The study was

conducted with the financial support of research projects N GD-07-1008/2007, RD 05-240/2009 and RD 05-310/2010, funded by the Shumen University.

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Received: 06.06.2011  
Accepted: 07.10.2011