

Екол.Зашт.Живот.Сред.	Том 2	Број 1	стр. 47-57	Скопје 1994
Ekol.Zašt.Život.Sred.	Vol.	No.	p.p.	Skopje

Примено во редакција:
21. април 1994

ISSN 0354-2491
UDC 595,142.39:591.553(497.17)
оригинален научен труд

COMMUNITIES OF THE EARTHWORMS (*OLIGOCHAETA: LUMBRICIDAE*) IN THE SOIL OF VARIOUS PLANT ASSOCIATIONS OF THE SKOPJE VALLEY, MACEDONIA

J.A.ŠAPKAREV

Institute of Biology, Faculty of Natural Sciences, p.o. box 162, Skopje, Macedonia

ABSTRACT

Šapkarev.J. (1994). Communities of the earthworms (*Oligochaeta: Lumbricidae*) in the soil of various plant associations of the Skopje valley, Macedonia. Ekol.Zašt.Život.Sred., Vol.2, No.1. Skopje.

In this artical species composition, density of populations and vertical distribution of the lumbricid fauna in the soils from six various plant associations of Skopje'a valley are given. Comparison of the eartworm communities in the various types of soils is made. Finally,some of more important environmental factors of the explored soils are presented.

Key words: earthworms, community, soil, environmental factors, species composition, population density, vertical distribution.

БОБЕД

Шапкарев, Ј. (1994). Заедници од дождовни црви (*Oligochaeta: Lumbricidae*) во почвата од различни растителни заедници во Скопската Котлина. Екол.Зашт.Жив.Сред., Том 2, Бр. 1. Скопје.

Во трудот се прикажани видовиот состав, густината на папулациите и вертикалната дистрибуција на лумбрицидната фауна во почвите од шест различни растителни асоцијации во Скопската Котлина. Исто така извршено е споредување на заедниците од дождовните црви во различните типови почви. Презентирани се и некои од поважните животни фактори од истражуваните почви.

Клучни зборови: дождовни црви, заедница, почва, животни фактори, состав на видови, густина на популација, вертикална дистрибуција

INTRODUCTION

Earthworms, being an important group of soil inhabiting invertebrates, play a significant role in the soils. For earthworms to survive, a number of ecological conditions must be fulfilled. Many environmental factors can affect earthworm population densities and the species complex. Undoubtedly, the obvious and most important are soil moisture, soil temperature, and soil acidity, each of which can act as a complete limiting factor at extremes (Edwards and Lofty 1972; Reynolds 1973). Other factors such as soil depth and texture, nutrient and food supply and physiographic features can interact with these factors and influence the soil conditions (Guild 1952; Reynolds 1972). It should be emphasized that our present knowledge of the earthworm ecology in Macedonia is very inadequate in regard to earthworm taxonomy. Just recently were few studies provided to the knowledge of ecology on macedonian lumbricids (Šapkarev 1979, 1982, 1983a, 1983b, 1984, 1987). In connection with the preceding lines, in this paper we have comparatively analyzed the structure of earthworm fauna in the soils of six different plant associations in the Skopje valley, the density of populations of the various species, as well as their vertical distribution and their densities in the various soil strata. Simultaneously, some of the more important environmental factors in each vertical stratum were studied.

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SITE CHARACTERISTICS

Skopje's valley comprises relatively a big area with a surface of about 2100 km² in the upper course of the river Vardar. This valley, its border of high mountains, represents a natural geographic region (Fig. 1) very characteristic for Macedonia. In fact, the N. border of the valley is formed by the mountains of Skopska Crna Gora and the S. of the mountain massif of Jacupica. The eastern border of the valley is formed by the hills between rivers Pčinja and Bregalnica, and W. border goes to the massif of Žeden (Jovanović 1931).

The climate of the Skopje's valley is different in its various parts. The greatest part of the valley has mediterranean-continental climate. The lowest part of the valley is at the mouth of the river Pčinja (altitude only 173 m.), and the highest part is on the top of the mountain of Jakupica - Solunska Glava, reaching an altitude of 2540 m.

Our investigations were carried out at five localities:

- Petrovec (grassland ass. *Trifolietwn resupinati balancae* Mic.) with clay sandy loam soil and an altitude of 175 m;

- Katlanovo (arable site and a hill pasture - foed *Saturejo-Thymion* Mic.) with a very low altitude (cca 180-250 m);

Gazi Baba (hill habitat with artificial vegetation and permanently present *Peganum harmala* and *Marrubiwnperegrinum*) on the N-E part of the valley and an altitude of cca 250 m. According to Gračanin (1966) the soil of this site belongs to type of cimet-brown soils. It is clayey to sandy-loam, slightly colloid with middle porousness;

- Skopska Crna Gora at the site „Preslap,, in a beech forest (ass. *Fagetum submontanum macedonicum* Em). The soil of this forest association is clay loam or sandy-clayey to silty. An altitude is 1260 m. The soil of this association is siliceous, slightly acid, brown to sandy clayey.

-Vodno, in forest ass. *Castanetum sativae macedonica* Rud. It is very limited forest association which soil is siliceous. The soil is clay loam or silty clayey. Altitude is cca 800m.

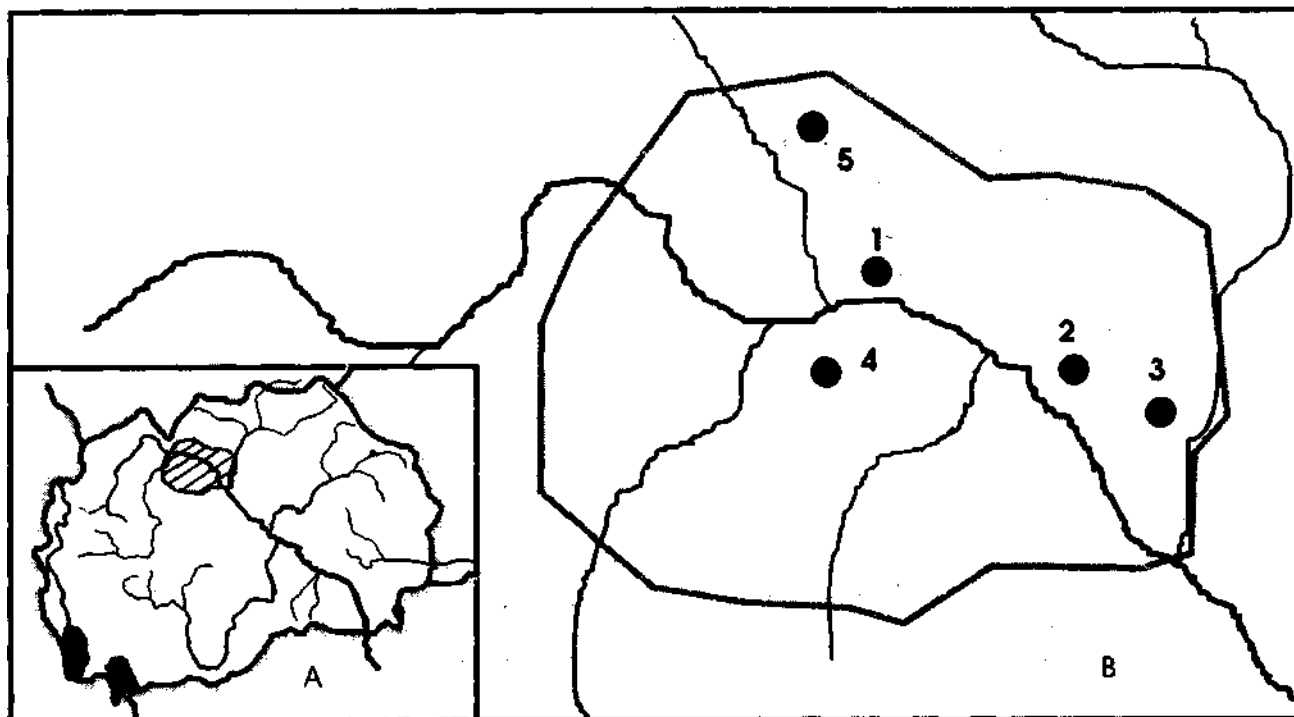


Fig. 1. Location of Skopje valley in Macedonia
A. Schematic map of the Republic of Macedonia with the Skopje valley;
B. Skopje valley sketch with the position of the examined localities
1. Gazi-Baba 2. Petrovec 3. Katlanovo 4. Vodno 5. Skopska Crna Gora

Сл. 1. Скопската Котлина во Македонија
А. Шематски прикажано карта на Република Македонија со локација на Скопската Котлина; Б. Скопската Котлина со положбата на испитуваните локалитети 1. ГазиБаба 2. Петровец 3. Катланово 4. Водно 5. Скопска Црна Гора

MATERIALS AND METHODS

Sampling was performed in April 1978 from different soil types with different vegetations. Quantitative samples of earthworms (50 cm x 50 cm each side) were taken from every 10 cm stratum to a depth of 40 cm in three sites of six localities, for a total of 72 samples. The lumbricid specimens were handsorted and stored in 4% formalin solution of each stratum separately.

Temperature, moisture content, soil structure, porosity, hydrogen ion concentration (pH) and contents of humus were studied in the soil strata examined. The following methods were used: the texture of soil by the method of sedimentation, the

porosity of the soil in regard to total contents of the pores by Gračanin, the contents of humus with the permanganate method by Kotzmann, and pH-value with potentiometer MA 5701 - Iskra.

The structural features of the examined communities, such as abundance, dominance and frequency are by Tischler (1949). Estimation of the similarity of the examined earthworm communities was with equation by Marčevski and Steinhaus (1959) whereas index of the species diversity in each biotope was estimated separately by means of the equation by Shannon-Wiener (1949).

RESULTS

The researches of the earthworm communities and the more important environmental factors were performed in spring (second half of April) 1978 on six different biotopes from five localities in Skopje valley. The following results of these investigations were obtained.

Environmental factors

The soil temperature varied in the surface stratum (0-10 cm) from 8.2°C at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora to 13.6°C in ass. *Trifolietum resupinati balancae* in Petrovec village; stratum 10-20 cm depth from 7.9°C at ass. *Fagetum submontanum macedonicum* to 12.9°C in arable soil from the village of Katlanovo; on the stratum 20-30 cm depth - from 8.1°C at ass. *Fagetum submontanum macedonicum* to 11.7°C at ass. *Trifolietum resupinati balancae*; finally on the stratum 30-40 cm depth from 8.1°C from ass. *Fagetum submontanum macedonicum* to 12.0°C at ass. *Trifolietum resupinati balancae*. That means the highest temperature were at ass. *Trifolietum resupinati balancae* (from 11.7°C to 13.6°C) and the lowest at ass. *Fagetum subalpinum macedonicum* from 7.9°C to 8.2°C (Tab.1).

In the same table the data of the moisture content in soils with various plant associations are given. In the surface stratum (0-10 cm) from 27.3 % at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora to 34.9 % in pasture soil at village of Katlanovo; in the stratum 10-20 cm depth - 19.6% in the pasture soil of Katlanovo village to 29.4% at ass. *Castanetum sativae macedonicum* on Vodno; in the stratum 20-30 cm depth - from 21.8% at ass. *Castanetum sativae macedonicum* on Vodno to 3.5% at ass. *Trifolietum resupinati balancae* in

village of Katlanovo; in the stratum 30-40 cm depth - from 19.4% at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora to 31.3 % at ass. *Trifolietum resupinati typicum* at village of Petrovec.

In the Tab.2 are given texture and porosity in soils with various plant associations. In the surface stratum (0-10 cm) the porosity varied from 35.8 % at ass. *Trifolietum resupinati typicum* in the village of Petrovec to 55.2% on the hill of Gazi-Baba; in the stratum 10-20 cm depth - from 41.2% at ass. *Trifolietum resupinati typicum* in village of Petrovec to 61.8 % in ass. *Fagetum submontanum macedonicum* in Skopje's Monte-Negro; in the stratum 20-30 cm depth - from 42.9 % at ass. *Trifolietum resupinati typicum* in Petrovec to 65.6% at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora in the stratum 30-40 cm depth - from 44.1 % at ass. *Castanetum sativae macedonicum* in Vodno to 50.9% at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora.

Finally, in the Tab. 3 humus and pH-value in soils with various plant associations are given. The percentage of humus in the surface stratum (0-10 cm) was from 1.7 in the hill soil of Gazi-Baba to 6.7 in pasture soil in the village of Katlanovo. In the stratum 10-20 cm depth - from 1.5% on the hill of Gazi-Baba to 4.7 % at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora; in the stratum 20-30 cm depth - from 1.3 % on the hill of Gazi-Baba to 3.9 % at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora; in the stratum 30-40 cm depth - from 1.1 % at ass. *Trifolietum resupinati balancae* in Petrovec to 3.6% in pasture soil in the village of Katlanovo. The pH-value in the surface stratum varied from 5.8 at ass. *Castanetum sativae macedonicum* in Vodno to 7.4 in arable soil

Tab. 1. The temperature (in °C) and the moisture content (in percent) in soils with various plant associations Таб. 1. Температура (во °C) и содржина на влага (во %) во почви со различни растителни асоцијации

Locality and plant association	Temperature (soil strata in cm)				Moisture (soil strata in cm)			
	0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
hill of Gazi Baba	11.5	11.8	11.3	11.6	28.7	26.6	25.5	27.3
village of Petrovec ass. <i>Trifolietum resupinati balancae</i>	13.6	12.9	11.7	12.0	32.2	28.2	30.5	31.3
village of Katlanovo arable soil	12.1	11.6	11.2	11.7	29.9	20.7	26.2	27.4
village of Katlanovo pasture soil	10.8	11.2	10.7	10.6	34.9	19.6	26.0	29.1
Vodno ass. <i>Castanetum sativae macedonicum</i>					33.8	29.4	21.8	22.6
Skopska Crna Gora ass. <i>Fagetum submontanum macedonicum</i>	8.2	7.9	8.1	8.2	27.3	23.9	21.9	19.4

Tab. 2. Texture and Porousness (in percent) in in soils with various plant associations Таб. 2. Текстура и порозност (во %) во почви со различни растителни асоцијации

Locality and plant association		Texture (soil strata in cm)				Porousness (soil strata in cm)			
		0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
hill of Gazi Baba	I	25.8	23.5	20.8	14.3	55.2	54.9	53.1	49.3
	II	23.3	19.6	16.5	11.4				
	III & IV	50.9	56.9	62.7	74.3				
village of Petrovec ass. <i>Trifolietum resupinati balancae</i>	I	30.1	28.2	29.9	30.2	35.8	41.2	42.9	44.6
	II	31.9	37.7	27.6	28.8				
	III & IV	39.0	34.5	42.5	41.0				
village of Katlanovo arable soil	I	26.8	30.6	30.4	29.7				
	II	35.6	32.9	30.5	30.8				
	III & IV	37.6	36.5	39.1	39.5				
village of Katlanovo pasture soil	I	32.9	30.0	32.1	32.9				
	II	36.8	38.2	37.9	36.8				
	III & IV	28.3	31.8	30.3	30.3				
Vodno ass. <i>Castanetum sativae macedonicum</i>						48.3	47.8	43.8	44.1
Skopska Crna Gora ass. <i>Fagetum submontanum macedonicum</i>	I	30.8	37.4	39.0	41.8	47.5	61.8	65.6	50.9
	II	29.7	19.5	16.9	11.7				
	III & IV	39.5	43.1	44.1	46.5				

in Katlanovo; in the stratum 10-20 cm depth - from 5.5 at ass. *Castanetum sativae macedonicum* in Vodno to 7.2 in arable soil in Katlanovo; in the stratum 20-30 cm depth - from 4.9 at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora to 7.3 in arable soil of Katlanovo; in the

stratum 30-40 cm depth - from 4.8 at ass. *Fagetum submontanum macedonicum* in Skopska Crna Gora to 7.3 at ass. *Trifolietum resupinati balancae* in Petrovec and arable soil in Katlanovo.

Tab. 3. Humus (in percent) and pH - value in soils with various plant associations
 Таб. 3. Хумус (во %) и рН - вредност во почви со различни растителни асоцијации

Locality and plant association	Humus				pH - value			
	(soil strata in cm)				(soil strata in cm)			
	0-10	10-20	20-30	30-40	0-10	10-20	20-30	30-40
hill of Gazi Baba	1.7	1.5	1.3	1.2	6.5	6.6	6.4	6.4
village of Petrovec ass. <i>Trifolietum resupinati balancae</i>	4.1	1.6	1.5	1.1	6.7	6.9	7.1	7.3
village of Katlanovo arable soil	3.2	2.9	2.9	2.7	7.4	7.2	7.3	7.3
village of Katlanovo pasture soil	6.7	4.1	3.5	3.6	7.1	7.0	7.2	7.0
Vodno ass. <i>Castanetum sativae macedonicum</i>	5.1	3.8	2.7	1.8	5.8	5.5	5.3	5.4
Skopska Crna Gora ass. <i>Fagetum submontanum macedonicum</i>	6.5	4.7	3.9	3.4	5.9	5.6	4.9	4.8

Species composition

Eight species of lumbricids in six explored earthworm communities in the soil of various plant associations of the Skopje Valley were established. All of them are cosmopolitan (*Aporrectodea rosea*, *A. caliginosa trapezoides*, *Octolasion lacteum*, *Eiseniafoetida* and *Lumbricus rubellus*) except *Octodrilus complanatus* (distributed mainly in South Europe and North Africa), *Dendrobaena attemsi* (distributed in Europe) and *Serbiona dofleini* (distributed in Macedonia, southern part of Serbia and northern part of Greece).

From the table 4 it can be seen that the soil of Gazi-Baba hill was populated with 3 lumbricid species (two cosmopolitan and one endemic species), and the soil of ass. *Fagetum submontanum macedonicum* in the Skopska Crna Gora - with 4 lumbricid species of which only *Octodrilus complanatus* is distributed in South Europe and North Africa, all other three species are cosmopolitan. All other soils of four different associations were populated with five lumbricid species.

Aporrectodea rosea was presents in the all explored soils, which was in this regard followed by *Octolasion lacteum* and *Lumbricus rubellus*, which were absent only in the soil of Gazi-Baba. *Aporrectodea caliginosa* was absent in the soil of forest communities. Endemic *Serbiona dofleini* was present in the soil of Gazi-Baba, in the soil of foed *Saturejo Thymion* and in the soil of ass. *Castanetum*

sativae macedonicum. Cosmopolitan *Eiseniafoetida* was populated in the cultivable soils (field and meadow). Finally, european species *Dendrobaena attemsi* and *Octodrilus complanatus* were found just in one soil type, the former was in the soil of ass. *Castanetum sativae macedonicum* and the latter in the soil of ass. *Fagetum submontanum macedonicum*.

Population density

The population density of the species present in the composition of the earthworm communities in the soils of different explored associations was different. So dominant species were:

- in hill soil of Gazi-Baba was *Serbiona dofleini*,
- in a meadow of Petrovec was *Octolasion lacteum*;
- in an arable soil of Katlanovo was *Lumbricus rubellus*;
- in a hill pasture of Katlanovo, in a beech forest of Skopska Crna Gora and in a chestnut wood of Vodno was *Aporrectodea rosea*.

Their abundance were ranged from 10.8 ind • m⁻² for *Lumbricus rubellus*, 18.8 ind • m⁻² for *Octolasion lacteum*, 20.8 ind • m⁻² for *Serbiona dofleini* to 22.0 ind • m⁻² for *Aporrectodea rosea* (see Tab.2).

The density of the whole lumbricid fauna was the greatest (64.4 ind • m⁻²) in the soil of hill pasture

Tab. 4. Present or absent of lumbricids in soils of plant associations

Таб. 4. Присутност или отсућност на лумбрициди во почви од растителни асоијацији

SOILS Lumbricids	Soils of plant associations					
	1	2	3	4	5	6
<i>Serbiona doffleini</i>	+	-	-	+	+	-
<i>Aporrectodea rosea</i>	+	+	+	+	+	+
<i>A. caliginosa trapezoides</i>	+	+	+	+	-	-
<i>Octolasion lacteum</i>	-	+	+	+	+	+
<i>Octodrilus complanatus</i>	-	-	-	-	-	+
<i>Lumbricus rubellus</i>	-	+	+	+	+	+
<i>Eisenia foetida</i>	-	+	+	-	-	-
<i>Dendrobaena attemsi</i> ?	-	-	-	-	+	-

1. Gazi Baba 2. ass. *Trifolietum resupinati balancae* 3. Arable soil 4. foed *Saturejo Thymion*
 5. ass. *Castanetum sativae macedonicum* 6. ass. *Fagetum submontanum macedonicum*

(foed *Saturejo-Thymion*), and then in the soil of ass. *Trifolietum resupinati balancae* (49.0 ind • m⁻²), in the arable soil of Katlanovo (35.0 ind • m⁻²), in ass. *Castanetum sativae macedonicum* (33.9 ind ■ m⁻²), in the soil of the hill of Gazi-Baba with 31.6 ind • m⁻² and finally in ass. *Fagetum submontanum macedonicum* with only 22.1 ind ■ m⁻².

Vertical distribution

One month investigations for the depth distribution of the earthworms presented in the soil of examined plant associations had shown that the earthworms penetrated into the soil strata to 30 cm depth, with one exception for an arable soil from Katlanovo (to 20 cm depth).

During the examined month of the 1978., the density of populations of the present species in all investigated types of soils with the depth mainly decreases (Tab.5). Four species (*Lumbricus rubellus*, *Eisenia foetida*, *Dendrobaena attemsi* and *Aporrectodea caliginosa trapezoides*) were found only on the surface stratum (0-10 cm). *Aporrectodea*

rosea was mostly registered in all three strata (0-10, 10-20 and 20-30 cm), *Octolasion lacteum* mostly in the two upper strata and *Serbiona doffleini* mostly in the two lower strata.

Whole amount of lumbricid individuals in average of all investigated sites was 71.3% for the stratum 0-10 cm, 25.0% for the stratum 10-20 cm and 3.7% for the stratum 20-30 cm. The highest percent of individuals (89.8%) in the surface stratum (0-10) cm was concentrated in a meadow from Petrovec and in an arable soil from Katlanovo, whilst the lowest percent was registered on the hill pasture from Katlanovo - 54.1 % only. At the stratum 10-20 cm the highest percent (39.7) was noticed on the hill pasture from Katlanovo and in ass. *Fagetum submontanum macedonicum* from Skopska Crna Gora (35.3%), whilst the lowest percent in the meadow from Petrovec (only 8.2%). At the stratum 20-30 cm the highest percent (6.3) was found in ass. *Fagetum submontanum macedonicum* from Skopska Crna Gora, whilst the lowest one (2.0%) in the meadow from Petrovec.

DISCUSSION

The research of lumbricid fauna in the valley of Skopje has included some natural (forest and pastures) and artificial (cultivated meadow, arables) ecosystems. The soils of these ecosystems were populated with 3 (Gazi-Baba), 4 (Skopska Crna Gora) and 5 species (Petrovec, Katlanovo and Vodno). A similar case with small in numbers of species was registered on the same or similar ecosystems in this valley (Naumovski, 1981) or other valleys in

Macedonia (Šapkarev 1979, 1982, 1987). Something like this was stated out of Macedonia, for example in Baranja, Croatia (Pivar, Šapkarev and Gjugjar 1980) and in Šumadija, Serbia (Stojanović and Karaman 1993). Studiiig earthworm communities in various forest ecosystems from the Romanian Carpathians, PopV.V. (1987) had established a presence of small numbers of lumbricid species of all examined communities (mainly 3 species)

Tab. 5. The structure of lumbricid synusia in the different soil types ($N \cdot m^{-2}$) • x
 Таб. 5. Структура на лумбрицидни синузии во различни типови почви ($N \cdot m^{-2}$)-x

plant associations растителни заедници	Lumbricid species	soil strata in cm			
		0 - 10	10 - 20	20 - 30	Total
hill soil - Gazi-Baba ридска почва	<i>Serbiona doleini</i>	10.8	8.0	2.0	20.8
	<i>Aporrectodea rosea</i>	4.0	2.8	-	6.8
	<i>A.caliginosa trapezoides</i>	4.0	-	-	4.0
	Total	18.8	10.8	2.0	31.6
ass. <i>Trifolietum resupinati</i> <i>balancae</i> - Petrovec	<i>Aporrectodea rosea</i>	8.0	-	-	8.0
	<i>A.caliginosa trapezoides</i>	6.8	-	-	6.8
	<i>Octolasion lacteum</i>	13.2	4.0	1.0	18.2
	<i>Lumbricus rubellus</i>	4.0	-	-	4.0
	<i>Eisenia foetida</i>	12.0	-	-	12.0
	Total	44.0	4.0	1.0	49.0
arable soil - Katlanovo обработлива почва	<i>Aporrectodea rosea</i>	6.8	2.0	-	8.8
	<i>A.caliginosa trapezoides</i>	3.4	-	-	3.4
	<i>Octolasion lacteum</i>	-	4.0	-	4.0
	<i>Lumbricus rubellus</i>	10.8	-	-	10.8
	<i>Eisenia foetida</i>	8.0	-	-	8.0
	Total	29.0	6.0	-	35.0
foed <i>Saturejo Thymion</i> - Katlanovo	<i>Serbiona doleini</i>	-	8.0	2.0	10.0
	<i>Aporrectodea rosea</i>	13.2	6.8	2.0	22.0
	<i>A.caliginosa trapezoides</i>	6.8	-	-	6.8
	<i>Octolasion lacteum</i>	8.0	10.8	-	18.8
	<i>Lumbricus rubellus</i>	6.8	-	-	6.8
	Total	34.8	25.6	4.0	64.4
ass <i>Castanetum sativae</i> <i>macedonicum</i> - Vodno	<i>Serbiona doleini</i>	-	2.0	-	2.0
	<i>Aporrectodea rosea</i>	12.0	4.0	1.0	17.0
	<i>Octolasion lacteum</i>	6.9	2.0	-	8.9
	<i>Lumbricus rubellus</i>	4.0	-	-	4.0
	<i>Dendrobaena attemsi</i>	2.0	-	-	2.0
	Total	24.9	8.0	1.0	33.9
ass. <i>Fagetum submonta-</i> <i>num macedonicum</i> - Skopska Crna Gora	<i>Aporrectodea rosea</i>	6.9	2.3	1.4	11.1
	<i>Octolasion lacteum</i>	4.0	3.0	-	7.0
	<i>Octodrilus complanatus</i>	-	2.0	-	2.0
	<i>Lumbricus rubellus</i>	2.0	-	-	2.0
	Total	12.9	7.8	1.4	22.1

except of that or beech forest ecosystem with rendzines (6 species).

Also, relatively small population densities in the natural and artificial ecosystems were established (Tab.4) with the present investigations, as well as with the mentioned other investigations. An exception was stated for the beech forest ecosystem of the Romanian Carpathians (Pop.V.V.1987).

The structural features of the examined communities are presented according to Tischler (1949). It is obviously that the most abundant, almost dominant and the most frequent in both, cultivated and natural, ecosystems was *Aporrectodea rosea*. On the contrary, *Dendrobaena attemsi* (only in the soil of ass. *Castanetum sativae macedonicum*) and *Octodrilus complanatus* (only in the soil of ass. *Fagetum submontanum macedonicum*) were present only in one of examined ecosystems (Tab.6).

Quotient of similarity shows the similarity of biotops or ecosystems on the basis the composition of their communities. Less or more number of the same species in two communities point out to less or more similarity between them. So, between cultivated biotops, meadow and arable soil there is no difference in the lumbricid composition of their communities, i.e. they are identical ($S = 100\%$), whilst between natural ecosystems, beech and chestnut forests, quotient of similarity shows less similarity ($S = 50\%$), calculated according Marczewski and Steinhaus (1959). It can be said that more similar are the synusia of cultivated soils than ones of natural soils.

The degree of stability of every one ecosystem represents an important factor for an influence by man to it. As the degree of stability is in direct interdependence with index of species diversity

calculations of mentioned index for each ecosystem were carried out separately. Mentioned index at logarithmic formula treats the relation of the total number of species and the total number of individuals. It was calculated with the formula by Shanon-Wiener (1963). It is known that is the index greater so much the stability of the explored ecosystems is greater. From our investigated ecosystems, hill soil of Gazi-Baba and ass. *Fagetum submontanum macedonicum* of Skopska Crna Gora there are the lowest, i.e. 0.87 resp. 1.14 of the index. A higher index was noted in the plant associations: ass. *Cas-*

tanetumsativaemacedonicum of Vodno, in ass. *Trifolietum resupinati balancae* of Petrovec and in the hill pasture (foed *Saturejo-Thymion* of Katlanovo with index 1.28 resp. 1.49. The highest index was registered in arable soil in Katlanovo with 1.52. Soil temperature and moisture content are considered to be of major importance in regulating lumbricid activity, occurrence and behaviour (Satchel 1967, Lee 1985). Since these two factors were not examined over a longer period of time, we can state only that they were favourable in stated time period.

Tab. 6. Survey of abundance (A), dominance (D) and frequency (F) of the present lumbricid species in cultivated and natural ecosystems in Skopje's valley Таб. 6. Обилност (A), доминантност (D) и фреквентност (F) на присутните лумбрицидни видовиво култивирани и природни екосистеми на Скопска Котлина

ВИДОВИ SPECIES	Cultivated 1 2 3			Natural 4 5 6 ^x		
	A ind·m ⁻²	D %	F %	A ind·m ⁻²	D %	F %
<i>Aporrectodea rosea</i>	1) 6.8 2) 8.0 7.9 3) 8.8	21.5 16.3 21.0 25.2	100	4) 22.0 5) 17.0 16.7 6) 11.6	34.2 50.1 44.8 50.2	100
<i>A. caliginosa trapezoides</i>	4.0 6.8 4.7 3.4	12.7 13.9 12.1 9.7	100	- 6.8 2.3 -	10.6 - 3.5 -	33.3
<i>Serbionia doleini</i>	20.8 - 6.9 -	65.8 - 22.0 -	33.3	10.0 2.0 4.0 -	- 15.5 7.1 5.9	66.6
<i>Octolasion lacteum</i>	- 18.2 7.4 4.0	- 37.2 16.2 11.4	66.6	18.8 8.9 11.6 7.0	29.2 26.3 29.1 31.7	100
<i>Octodrilus complanatus</i>	- - 0 -	- - 0 -	0	- - 0.7 2.0	- - 0.7 9.0	33.3
<i>Lumbricus rubellus</i>	- 4.0 4.9 10.8	- 8.2 13.0 30.9	66.6	6.8 4.0 4.1 2.0	10.6 11.8 10.5 9.0	100
<i>Eisenia foetida</i>	- 12.0 7.0 2.0	- 24.5 15.8 22.9	66.6	- - 0 -	- - 0 -	0
<i>Dendrobaena attemsi</i>	- - 0 -	- - 0 -	0	- 2.0 0.7 -	- 5.9 2.0 -	33.3

^x 1) hill of Gazi-Baba 2) meadow of Petrovec 3) arable soil of Katlanov 4) hill pasture of Katlanovo
5) chestnut wood of Vodno 6) beech forest of Skopska Crna Gora

CONCLUSIONS

The results obtained with these investigations, briefly, could be summarized in the following:

-the soil temperature was from 7.9 C to 13.6°C. The soil strata were much warm up in

meadow - Petrovec and a little - in the soil of beech forest - Skopska Crna Gora. Specially expressed changes vertically in the soil strata were not noticed

- the moisture content in the soil strata was the greatest in the surface stratum of hill pasture - Katlanovo (34.9%) and the smallest (27.3%) in the surface stratum of the beech forest - Skopje's Monte-Negro. The content of moisture gradually decreases with the depth.

in the content of humus were registered much greater differences. So, for example, 1.2-1.7 % in the soil of the hill of Gazi-Baba to 3.4- 6.5% in the soil strata of beech forest - Skopje's Monte-Negro. The content of humus decreases with the depth;

- pH-value in the soil strata was 4.8-5.9 in forest ecosystems and 7.0-7.4 in pasture and arable soil - Katlanovo. Vertically pH-value weakly decreases with the depth;

- eight lumbricid species in the soil from six plant associations were registered. Five of them are cosmopolitan, one is european, one is southeuropean and one is endemic species;

- in the synusia of earthworms participate from three on the hill Gazi-Baba, four in the soil of

beech forest - Skopska Crna Gora to five species in other plant associations;

- the most abundant, almost dominant and the most frequent *v/a* *Aporrectodea rosea*. *Dendrobaena attemsi* and *Octodrilus complanatus* were registered only in one of examined associations;

- the sinusia were not only with a small qualitative composition, but with a small quantity;

- the population density of the more abundant species was in average from 10.8 ind/m² for *Lumbricus rubellus*, 18.2 for *Octolasion lacteum* to 22.0 ind • m² for *Aporrectodea rosea*;

the density of whole lumbricid fauna was from 22.1 ind • m² in the soil of the beech forest to 64.4 ind • m² in the soil of hill pasture;

- the penetration of the earthworms from the explored plant associations was to 30 cm depth. The greatest density was registered in the surface stratum and with the depth it decreases;

- the influence by man to examined ecosystems is obvious what certainly express the negative influence to the fauna of earthworms also.

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ЗАЕДНИЦИ ОД ДОЖДОВНИ ЦРВИ (*OLIGOCHAETA.LUMBRICIDAE*) ВО ПОЧВА ОД РАЗЛИЧНИ РАСТИТЕЛНИ ЗАЕДНИЦИ ВО СКОПСКАТА КОТЛИНА, МАКЕДОНИЈА

Ј.А.ШАПКАРЕВ

Институт по биологија, ПМФ, п.ф. 162, Скопје

РЕЗИМЕ

Во април 1978 година од шест различни растителни заедници во локалитетите Петровец, Катланово, Гази-Баба, Водно и Скопска Црна Гора од Скопската Котлина, беа земани почвени квантитативни проби со цел да се проучи лумбрицидната фауна и да се испитаат некои поважни еколошки фактори.

Добиените резултати од овие истражувања, во кратко, би можеле да се сведат на следново:

- почвената температура се движеше од 7,9 °C до 13,6 °C. Почвените слоеви беа најмногу загреани во ливада кај Петровец, а најниско - во почвата од букова шума кај Скопска Црна Гора. Некоја посебно изразена промена вертикално во почвените слоеви не беше забележана;

- содржина на влага во почвените слоеви беше највисоко регистрирана во површинските слоеви и тоа од 34,9% во ридско пасиште кај Катланово, а најниска - 27,3% во букова шума на Скопска Црна Гора. Вертикално во почвените слоеви беше забележано неправилно или правилно намалување на влажноста со длабочината;

- во содржината на хумус беа забележани поголеми разлики. Најмал процент беше регистриран во почвата на ридот Гази-Баба (1,2-1,7%), а најголем - во буковата шума на Скопска Црна Гора (3,4 до 6,5%). Вертикално содржината на хумус се намалува;

- рН-вредноста се движеше од слабо кисела во шумските екосистеми (4,8 до 5,9) до слабо алкална кај природното пасиште и обработливата површина од Катланово (7,0 до 7,4). Со длабочината во почвата рН-вредноста слабо опаѓа;

- осум лумбрицидни видови во почвата од шест различни растителни заедници беа регистрирани.

Пет од нив се космополитски, еден е европски, еден јужно европски и еден ендемичен вид;

- во синузиите на дождовните црви учествуваа од три кај ридот Гази-Баба, четири кај буковата шума на Скопска Црна Гора до по пет видови кај останатите четири растителни заедници;

- најабундантна, скоро доминантна и најфреквентна *QeuiAporrectodea rosea*. *Dendrobaena attemsi* и *Octodrilus complanatus* беа регистрирани само во по една од исцитуваните растителни заедници;

- покрај слабата квалитативна застапеност во составот на синузиите од дождовните црви, очигледна беше и слабата квантитативна застапеност;

- еднообразната и сиромашната фауна на дождовните црви беше поизразена во култивираниот отколку во природните екосистеми;

- густината на популациите во поабундантните видови се движеше во просек од 10,8 *изLumbricus rubellus*, 18,2 за *Octolasion lacteum* до 22,0 ind • m² за *Aporrectodea rosea*.

- густина на населбата на целата фауна на дождовните црви се движеше во рамките на $22,1 \text{ ind} \cdot \text{m}^{-2}$ во почвата од буковата шума кај Скопска Црна Гора до $64,4 \text{ ind} \cdot \text{m}^{-2}$ во почвата од ридско пасиште кај Катланово; - пенетрацијата на дождовните црви во почвите од испитуваните растителни заедници изнесуваше до 30 cm длабочина. Најгуста населба беше остварена во површинскиот слој и со длабочината таа опаѓа;

-очигледно е антропогеното дејство врз испитуваните екосистеми што секако има негативно дејство и врз лумбрицидната фауна.