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THE EARTHWORMS
AND THEIR ASSOCIATIONS
Research on the Fauna and the Associations of Earthworms of Durmitor, II.

(ANNELIDA, OLIGOCHAETA, LUMBRICIDAE)

ABSTRACT -- *Mršić, N.*, Biološki inštitut Jovana Hadžija, ZRC SAZU, YU-61000 Ljubljana, Novi trg 5. - THE FAUNA OF DURMITOR, 3: The Earthworms and their associations (*Annelida, Oligochaeta, Lumbricidae*). Crnogorska akademija nauka i umjetnosti, Posebna izdanja, knj. 23, Odjelenje prirodnih nauka knj. 14, Titograd, 1990.

A list of 16 species found on Durmitor Mountain, a classification and the structural characteristics of 27 earthworms associations, is given, as well as the ecological characteristics of their biotopes.

IZVLEČEK -- Avtor je podal popis najdenih vrst, opisal ekološke razmere, obdelal klasifikacijo in strukturne lastnosti 27 deževniških cenoz.

Lumbricidae, earthworm associations, Durmitor, Yugoslavia

CONTENTS

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1. INTRODUCTION

As concerns the earthworm fauna, Montenegro represents one of the least researched parts of Yugoslavia. The first data on that taxonomic group from Durmitor were presented by COGNETTI 1906, mentioning three species: *Dendrodrilus rubidus tenuis* (E i s e n 1874), *Aporrectodea smaragdina* R o s a, 1892 and *Lumbricus castaneus* (S a v i g n y, 1826), although, without stating the relevant localities. There exist only three other works referring to the earthworms of Durmitor (MRŠIĆ, 1983, 1984, 1988). These works offer data on individual species, accompanied by information on there spective localities, while two new species, one subspecies and 13 earthworm associations are treated in detail. The literature on the earthworm fauna of Montenegro is somewhat more comprehensive (COGNETTI 1906; KARAMAN 1972; ŠAPKAREV 1975; MRŠIĆ 1983b, 1984b, 1988a).

As an animal group, earthworms represent an important factor in pedozoologic processes, and first of all in the process of mechanical soil treatment (airing, mixing of soil horizons and prevention of erosion prosesses) as well as in the promotion of the microbiologic decomposition of organic substance in the humus and humus-accumulative horizon. They are even more important in high mountain areas where all pedobiologic processes happen to be slower and inhibited by extreme climatic conditions. Beside studying taxonomic problems (we have to date no real survey of the taxa on the territory of Yugoslavia), the biology of earthworms and the importance of these organisms in pedobiologic processes, proper attention should also be dedicated to the study of earthworm associations. An earthworm association represents an ideal object for studying zooassociation problems permiting a satisfactory explanation of the influence of different ecological factors on earthworm species and the structure of earthworm associations. Earthworms and their association are ideal for representing the linkage between phyto- and zooassociations at the biogeoassociational level as they react to ecological conditions in a way similar to that in plants. This type of investigations is new, not only in Yugoslavia but also abroad.

The present work refers to the former association research in Yugoslavia (MRŠIĆ, 1982a,b, 1983a,b, 1984a,b, 1985a,b, 1988a,b, 1989).

Investigations on the earthworms of Durmitor were performed in the years 1980, 1983, 1984 and 1986.

In German basic association units are referred to as "Zönosa", "Gesellschaft", "Assoziation" and in French as "association". In the Englih literature dealing with associations problems most authors use the term "communities" some other the term "associations". Regarding earthworm associations, the expression "association" was also used by the Swedish authors NORDSTRÖM and RUNDGREN (1973), and the English authors EDWARDS and LOFTY (1972). I have so far used the term earthworm "associations" and will continue to do so in the present paper.

2. TAXONOMIC SURVEY AND MATERIAL FROM DURMITOR

In the survey of the material as collected, data on the distribution of the species in Yugoslavia are stated joinly with the general distribution types.

In cases in which the author of a given text did not collect the material by himself, the name of the collector (leg.) is stated in the check-list.

1. **Eisenia lucens** (W a g a, 1857)

Gornja Počivala, Tepca, 1340 m, 25.8.1986, 3 ex., No.3755.

The species has been found throughout Yugoslavia and reveals an Alpine - Dinaric - Carpathian distribution pattern.

2. **Dendrobaena alpina alpina** (R o s a, 1884)

Surdup, 9.6.1983, 7 ex., No. 3012. Kanjon Sušice, 24.8.1986, 1130, 1 ex., No. 3758.

Distribution in Yugoslavia: Slovenia, Croatia, Bosnia - Herzegovina, Montenegro, Serbia and Macedonia. The species reveals an European distribution type.

3. **Dendrobaena byblica** (R o s a, 1893)

Žabljak, 1425 m, 16.8.1980, No. 1164, 1166.

The species has been found throughout Yugoslavia and is of a Transaegean distribution type.

4. **Dendrobaena durmitorensis** M r š i ć, 1988

Barno jezero, 8.6.1983, 13 ex., No. 3029b. Barno jezero, 16.9.1984, 3 ex., No. 3537.

Endemic species, found on Durmitor only.

5. **Dendrobaena montenegrina** M r š i ć, 1988

(*Dendrobaena sasensis* Š a p k a r e v 1983, nom. nud.)

Crno jezero (Lake), 15.6.1984,No. 3029 Bokovac, 8.6.1983, No.3026.

Endemic species, found on Durmitor only.

6. **Dendrobaena octaedra** (S a v i g n y, 1826)

Poljanak, 9.6.1983, 2 ex, No. 3033. Bokovac (Pitomine), 8.6.1983, 5 ex., No. 3030.

The species has been found throughout Yugoslavia an is of an Holarktic distribution type.

7. **Dendrodrilus rubidus tenuis** (E i s e n, 1874)

Savin Kuk, 12.6.1983, 2 ex., No. 3019, 3020. Savin Kuk, 12.6.1983,2 ex., No. 3016, 3021. Poljanak, 9.6.1983, 2 ex., No. 3033 Ališnica, 10.6.1983, 1 ex., No.3031. Veljkova ploča, 15.5.1984, 2 ex., No. 3532. Barno jezero, 16.9.1984, 7 ex., No. 3536. Kanjon Sušice, 24.8.1986, 10 ex., No. 3758, 3763. Gornja Počivala, Tepca, 25.8.1986, 9 ex., No.3755. Aluge, 22.8.1986, 5 ex., No. 3760, 3762. Virak, 23.8.1986, 1 ex., No. 3761. Žabljak, 16.8.1980, No. 1167. Crno jezero, 5.8.1980, No. 1170, 3166.

The species has been found throughout Yugoslavia. Cosmopolitan.

8. a) **Octolasion lacteum lacteum** (O e r l e y, 1881)

Bokovac (Pitomine), 8.6.1983, 10 ex., No. 3030. Srablje jezero, 15.6.1983, 2

ex., No. 3024. Crno jezero, 7.6.1983, 4 ex., No. 3024. Valovito jezero, 15.6.1983, 2 ex., No. 3004. Barno jezero, 8.6.1983, 9 ex., No. 3027,3028. Crepuljna poljana, 9.6.1983, 3 ex., No. 3035. Sedlo, 15.6.1983, 13 ex, No. 3003–3007. Kanjon Sušice, 24.8.1986, 3 ex., No. 3758. Kanjon Sušice 26.8.1986, 8 ex., No. 3754. Gornja Počivala, Tepca, 25.8.1986, 9 ex., No. 3755. Aluge, 22.8.1986, 1 ex., No. 3760.

The species has been found throughout Yugoslavia. Cosmopolitan.

8. b) **Octolasion lacteum gigantheum** M r š i ć, 1982

Modro jezero, 15.6.1983, 4 ex., No. 3009. Crna poda, 13.9.1984, 5 ex., No. 3539.

Distribution in Yugoslavia: Bosnia –Herzegovina, Montenegro, Serbia and Macedonia. Balcan distribution type.

9. **Octodrilus lissaensis** (M i c h a e l s e n, 1891)

Kanjon Sušice, 8.1986, 2 ex., No.3754.

Distribution in Yugoslavia: Slovenia, Croatia, Montenegro and Macedonia. Alpine–Dinaric–Carpathian distribution type.

10. **Octodrilus transpadanus** (R o s a, 1884)

Savin Kuk, 12.6.1983, 2 ex., No. 3023. Ališnica, 10.6.1983, 2 ex., No.3013, 3014. Crepuljna poljana, 9.6.1983, 1 ex., No. bb. Bobotov Kuk, 14.9.1984, 4 ex., No. 3528. Surutka, 14.9.1984, 4 ex., No. 3531. Indjini dolovi, 15.5.1984, 4 ex., No. 3530. Zeleni Vir–Surutka, 14.9.1984, 1 ex., No. 3533.

The species has been found throughout Yugoslavia. Palearktic distribution type.

11. **Allolobophora (?) eiseni** (L e v i n s e n, 1884)

Ališnica, 10.6.1983, 1 ex., No. 3013. Surdup, 9.6.1983, 4 ex., No. 3012. Gornja Počivala, Tepca, 25.8.1986, 1 ex., No. 3757. Kanjon Sušice, 24.8.1986,37, No.3757.

Distribution in Yugoslavia: Slovenia, Croatia, Bosnia – Herzegovina, Montenegro, and Macedonia. Holarktic distribution type.

12. **Aporrectodea (A.) rosea rosea** (S a v i g n y, 1826)

Modro jezero, 15.6.1983, 24 ex., No. 3010, 3011. Srablje jezero, 15.6.1983, CN46, 8 ex., No. 3001, 3002 Crno jezero, 7.6.1983, 32 ex., No. 3022, 3024. Valovito jezero, 15.6.1983, 4ex., No. 3000. Barno jezero, 8.6.1983, 3 ex., No. 3025. Sedlo, 15.6.1983, 4 ex., No. 3005–3007. Đurđevića Tara, 13.9.1984, 1 ex., No. 3535. Crna Poda, 13.9.1984, 20 ex., No. 3540, 3541. pod Bobotovim kukom, 14.9.1984, 2 ex., No. 2534. Kanjon Sušice, 24.8.1986, 2 ex., No. 3758. Virak, 23.8.1986, 1 ex., No. 3761.

The species has been found throughout Yugoslavia. Cosmopolitan.

13. **Aporrectodea (A.) smaragdina (R o s a, 1892)**

Savin Kuk, 12.6.1983, 18 ex., No. 3015, 3017. Ališnica, 10.6.1983, Ališnica, 10.6.1983, 2 ex., No. 3013. Bobotov Kuk, 14.9.1984, 12 ex., No.3528. Zupci (Surutka), 14.9.1984, 2 ex., No. 3530. Indjini dolovi, 15.5.1984, 2 ex., No. 3530. pod

Bobotovim kukom, 14.9.1984, 2100–2200 m, 1 ex., No. 2534. Zeleni Vir–Surutka, 14.9.1984, 2 ex., No. 3533. Gornja Počivala, Tepca, 25.8.1986, 2 ex., No. 3755. Virak, 23.8.1986, 1 ex., No. 3761.

The species has been found throughout Yugoslavia.

Alpine–Dinaric–Carpathian distribution type.

14. **Eiseniella tetraedra tetraedra** (S a v i g n y, 1826)

Modro jezero, 15.6.1983, 5 ex., No. 3008.

The species has been found throughout Yugoslavia. Cosmopolitan.

15. **Lumbricus castaneus** (S a v i g n y, 1826)

Modro jezero, 15.6.1983, 4 ex., No. 3011. Savin Kuk, 12.6.1983, 4 ex., No. 3021. Poljanak, 9.6.1983, 3 ex., No. 3032. Crno jezero, 7.6.1983, 4 ex., No. 3022. Ališnica, 10.6.1983, 10 ex., No. 3013, 3033, 3031 Surdup, 9.6.1983, 4 ex., No. 3012. Crepuljna poljana, 9.6.1983, 3 ex., No. 3094. Veljkova ploča, 15.5.1984, 4 ex., No. 3532.

Distribution in Yugoslavia: Slovenia, Croatia, Bosnia – Herzegovina, Montenegro and Macedonia. Holarktic distribution type.

16. **Lumbricus rubellus** H o f f m e i s t e r, 1843

Barno jezero, 16.9.1984, 2 ex., No. 3536. Kanjon Sušice, 24.8.1986, 8 ex., No. 3763. Kanjon Sušice, 26.8.1986, 1 ex., No. 3763. Gornja Počivala, Tepca, 25.8.1986, 4 ex., No. 3756, 3759. Aluge, 22.8.1986, 4 ex., No. 3760, 3762.

The species has been found throughout Yugoslavia. Holarktic distribution type.

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On Durmitor 16 species of earthworm have been found, representing 45% of the fauna registered in Montenegro (33 species) and 13% of the total number of the 132 taxa recorded in Yugoslavia. This small number of species from Durmitor is due to extreme ecological conditions of the area. With the exception of endemic species, all other taxa were found in different Montenegrin localities (outside the Durmitor area).

Of the 16 species recorded on Durmitor, four are Cosmopolitan, one is Palearktic, four are Holarktic, one is Balcan, one is Europaean, one is Transaegean, whereas the remaining three reveal an Alpine–Dinaric–Carpathian and two an endemic distribution type.

It is interesting to note that according to the composition of these species, Durmitor most closely resembles the earthworm fauna of the Julian Alps (a similarity ranging up to 60%). Most of the species are cosmopolites, or wide spread with only two endemic to Durmitor.

3. BASIC ECOLOGICAL PARTICULARITIES OF THE BIOTOPES

For each biotope (Fig.1) the following information is given: date of the earthworm collection, vegetation type, altitude, soil type, geological substrate, number of earthworm associations (from the author's collection) and the UTM number.

1. The area surrounding Crno jezero, June 7, 1983, pasture vegetation of the *Nardetum* type, 1420 m, ranker soil on a mixed substratum, clastic sediments and limestone, No.22, CN47.

2. The area around Pitomine (Bokovac water spring), June 8, 1983, pasture vegetation of the *Festuco-Brometea* type, 1520 m, rendzina soil on limestone, No.16, CN48.

3. Barno jezero, June 8, 1983, forest *Piceetum excelsae croaticum*, 1480 m, eutric brown soils on clastic sediments, No.24, CN48.

4. Crepuljna poljana, June 9, 1983, pasture of the *Elyno-Seslerietea* type, 1650–1740 m, rendzina, limestone, No.27 CN47.

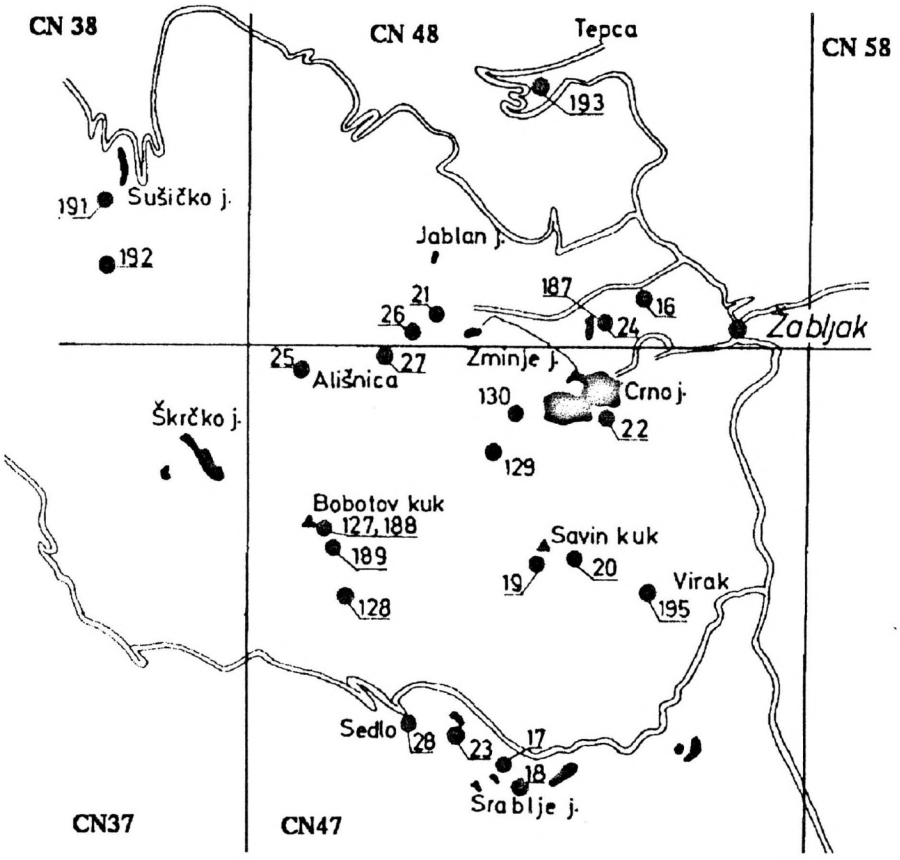

Fig. 1. Survey map of the research areas of Durmitor.
The numbers used in the figure correspond to them in the dendrogram (fig. 2)

Sl. 1. Pregledna karta raziskanega območja Durmitora.
Uporabljene so enake številke kot pri cenozah v dendrogramu (fig.2)

5. Poljanak, June 9, 1983, forest of the *Piceetum excelsae croaticum* type, 1530 m, rendzina, limestone, No.21, CN48.

6. Surdup, June 1983, forest of the *Fagetum montenegrinum subalpinum*, rendzina soil, limestone, No.26, CN47, 1590–1650 m.

7. Ališnica, June 10, 1983, pasture of the *Elyno–Seslerietea* 1920–2020 m, rendzina and colluvial soils on limestone, No. 25, CN47.

8. Savin Kuk, June 12, 1983, pasture of the *Elyno–Seslerietea*, 2000–2150 m, rendzina and lithosols on limestones, No.19, CN47.

9. Savin Kuk, June 12, 1983, pasture of the *Elyno–Seslerietea*, 2150–2250 m, rendzina and lithosols on limestones, No.20, CN47.

10. Sedlo, June 15, 1983, pasture vegetation of the *Elyno–Seslerietea*, 1800–1940 m, rendzina on limestone, No.28, CN47.

11. Valovito jezero, June 15, 1983, pasture vegetation of the *Nardetum* type, 1680–1800 m, rendzina and colluvial soils on limestone, No.23, CN47.

12. Srablje jezero, June 15, 1983, pasture vegetation of the *Nardetum* type, 1630–1800 m, rendzina and colluvial soils on limestone and flysch, No.18, CN47.

13. Modro jezero, June 15, 1983, forest of *Fagetum montenegrinum montanum*, rendzina and colluvial soils on limestone and flysch, No.17, CN47, 1620 - 1640 m.

14. Đurđevića Tara, 13.9.1984, forest of *Pinetum heldraichii*, 1300 m, rendzina on limestone, No.125, CN67.

15. Crna poda, 13.9.1984, forest of *Pinetum nigrae*, 850m, brown soil, limestone, No.126, CN76.

16. Bobotov Kuk, 14.9.1984, pasture vegetation of *Elyno–Seslerietea*, 2200–2300 m, rendzina soil, limestone, No. 127, CN47.

17. Zupci (Surutka), 14.9.1984, pasture vegetation of *Elyno–Seslerietea*, 2000–2100 m, rendzina soil, limestone, No.128,CN47.

18. Indjini dolovi, 15.5.1984, pasture vegetation of *Elyno–Seslerietea*, 1660–1700 m, rendzina soil, limestone, No. 129, CN47.

19. Veljkova ploča, 15.5.1984, pasture vegetation of *Elyno–Seslerietea*, 1660–1700 m, rendzina soil, limestone, No.130, CN47.

20. Barno jezero, 16.9.1984, forest of *Abieti–Fagetum*, 1400–1500 m, rendzina soil, limestone, No.187, CN48.

21. Bobotov Kuk, 14.9.1984, pasture vegetation of *Elyno–Seslerietea*, 2100–2200 m, rendzina soil on limestone, No. 188, CN47.

22. Zeleni Vir, 14.9.1984, pasture vegetation of *Elyno–Seslerietea*, 2028 m, rendzina soil on limestone, No.189, CN47.

23. Sušički kanjon, 24.8.1986, forest of *Abieti–Fagetum*, 1130 m, rendzina soil on limestone, No.191, CN38.

24. Sušički kanjon, 24.8.1986, forest of *Abieti–Fagetum*, 1120–1200 m, rendzina soil on limestone, No.192, CN38.

25. Gornja Počivala, Tepca, 25.8.1986, forest of *Abieti–Fagetum*, 1340 m, rendzina soil on limestone, No.193, CN48.

26. Aluge, 22. 8.1986, forest of *Fagetum montanum*, 1480 m, rendzina soil on limestone, No.194, CN57.

27. Virak, 23.8.1986, pasture vegetation of *Nardetum* type, 1580 m, rendzina soil on limestone, No.195, CN47.

4. RESEARCH ON THE EARTHWORM ASSOCIATIONS

The structure of an earthworm association is not sufficiently described with the composition of a given combination of species. Therefore, qualitative and quantitative analysis were carried out regarding the density of various populations, their spacial arrangement, the frequency of the species concerned, as well as the degree of coherence of the said species in a particular type of associations. All structural characteristics of the 27 associations are shown (by comparison) in Table 1, so that it is not necessary to comment their individual structural characteristics.

Data on the dominance degree of species are analysed and interpreted in dendrograms, as well as the categories of dominance, according to ZAJONC (1981) and MRŠIĆ (1982a), which differ from dominance degrees used in entomology.

over 75% eudominant species
50-74% dominant species
25-49% subdominant species
10-24% recendent species
0-9% subrecendent species

5. DIVERSITY AND EVENNESS INDEXES

The earthworm associations are directly interdependent regarding the stability of the ecosystems and the index of diverstity value. The earthworm diversity is well pronounced in developed associations approaching their climax. Thediversity index was calculated according to Shannon-Weaver's formula (1963):

$$Hi = -\sum P_i \log_e P_i$$

N = total number of specimens of one association
Ni = total number of specimens of a given species
Pi = Ni/N

A scale is applied in interpreting the results to determine the diversity index:

0 - 0,5 low diversity values
0,5-1,0 mean diversity values
> 1,0 high diversity values

The index showing dominance distribution of species in certain associations is refered to as evenness index. It attains minimal values when a species play a dominant role in an association, whereas the others remain recedent or subrecedent. The evenness index was calculated by applying the following formula (Piely 1966):

$$e = \frac{H_i}{\log_e S}$$

S = number of species

Also this index is indicated by the following scale:

0-0,3 low index values
0,3-0,65 mean index values
0,65-0,99 high values of the evenness index

The index of diversity and the evenness index were calculated in order to show to what extent the 27 associations are developed and/ or to what degree the development of an association had been influenced by edaphic and climatic factors. A particular attention was paid to the limiting factors. Table 1 (see at the end of the text) is a survey of values of the diversity and the evenness indices. In the majority of associations hight or medium values for both indices means that the earthworm associations on Durmitor have atttain their climax with respect to current ecological conditions.

6. CLASSIFICATION OF THE EARTHWORM ASSOCIATIONS

In the Mountain Durmitor area 27 earthworm associations were studied.

The similarity of one association to another was calculated by two means: the similarity index according to SORENSEN and the Renkonen number. There are several mathematical formulas enabling the calculation of the similarity between two or more earthworm associations. The establishment of conditions regarding the similarity and the classification of these associations is primarly based on the species composition within the associations itself. In other words, using all available mathematical calculations only the qualitative (specific) composition of the earthworm associations is taken into account. It is, therefore, perfectly irrelevant which mathematical formulae is chosen. The similarity index according to SORENSEN (1948) was applied to only calculate the similarity between analyzed communities.

In addition to the above mentioned mathematical expressions, there is also the dominance similarity coefficient according to RENKONEN (1938), referred in the present text as the Renkonen number. This value is most suitable in calculating association similarities, cited in numerous papers dealing with problems regarding earthworm associations (MRŠIĆ 1982 a, b, 1983 a, b, 1984 a, b, 1985a, b, 1988). The advantage of this calculation is in the fact that the Renkonen number takes into account both the association of species (qualitative relationships among earthworm associations) compared, as well as the dominance values of species common to both associations (quantitative relationships among associations). The methods of calculating the Rekonen number and grouping the studied associations (classification) have been used in all of the above mentioned papers. The only novelty in this procedure is the fact that the similarity among the different associations and arranging these associations into groups (classification), was performed with the help of computer (Commodore and recently Atari ST). The program was prepared in cooperation with my colleague M. BREBERINA.

Fig. 2 and 4 show two schematized instances of earthworm associations classification, based on the similarity index (Fig. 4) and the Renkonen number (Fig. 2).

The two mentioned dendrograms mutually differ. The classification of earthworm associations based on the Renkonen number shows that associations characterized by same or similar ecological factors form specific groups. This means that by analysing such a dendrogram it should be possible to determine the ecological factors

influencing the formation of a particular association type. The analysis of the classification of the earthworm associations based on the calculation of the similarity index reveals that associations are grouped with respect to specific (faunistic) composition, so that the classification may be applied in zoogeographic analysis as well.

Hereinafter is an analysis of both dendrograms of the Durmitor earthworm associations.

7. ANALYSIS OF THE DENDROGRAM BASED ON THE RENKONEN NUMBER (Fig. 2)

The 27 associations may be divided into 5 main groups (references 1 to 5), all revealing more then 50% similarity to all associations, implying that these associations have undergone the same genesis, i.e. that they have developed under similar ecological conditions including climate, exposition, vegetation, soil type and geological substrate.

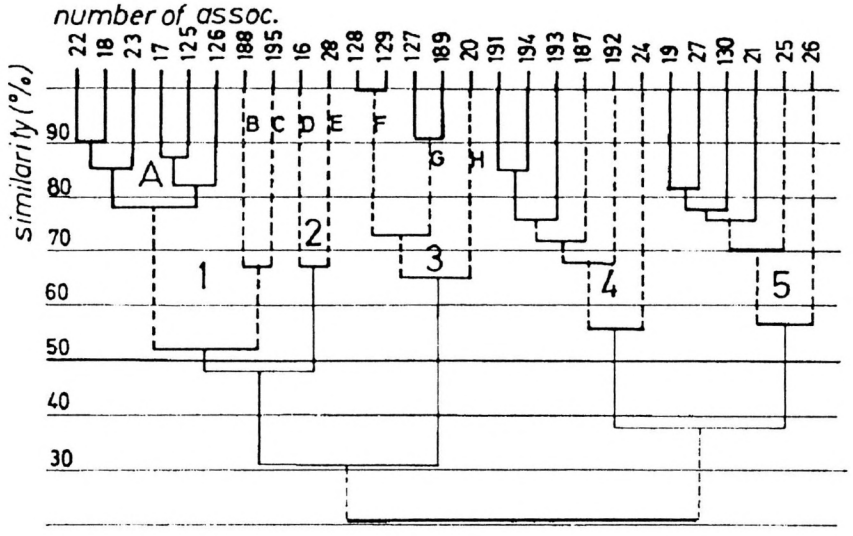

Fig. 2. Schematized display of the classification of earthworm associationss of Durmitor, based on the Renkonen number.

Sl. 2. Shematiziran prikaz klasifikacije deževniških cenoz Durmitora na podlagi izračuna renkonenovega števila.

The first group of associations (reference 1) represents the **"rosea"** type of associations (syntaxonomy according to MRŠIĆ,1984, etc.). In case of that associations the edificatory species *Aporrectodea rosea* is always eudominant to dominant. *A. rosea* is an almost cosmopolitan species with an outstanding ecological plasticity. This species is euryhumic, eubiotic and indifferent to the contents of humus substances. The group is divided in two. The first subgroup belongs to the "rosea" association

subtype. In this subgroup (reference A), the first three associations encompass a differential group *Octolasion lacteum*, characteristic of pasture habitats (in this case a pasture of the *Nardetum* type). The differential species of the three remaining associations are *O. lacteum gigantheum*, *Lumbricus castaneus* or *A. rosea*. They develop in forests of the *Fagetum subalpinum* or *Pinetum nigrae* type. The soil of the former mentioned associations is leached and acid, which with respect to the soil type means that its structure is influenced by edaphic factors. Consequently, these associations belong to an extrazonal association type. The soil has developed on limestone with insertions of flysch or else it is deep leached brown soil, accumulating in canyons (marked erosion, colluvium).

Each of the other two associations (reference B,C), though belonging to the **"rosea"** associations type, has a subtype of its own. The first association belongs to the **"smaragdina"** and the second one to the **"smaragdina/rubidus"** subtype. In both associations the edaphic conditions still represent a "limiting factor", although the influence of zonal associations elements (species) already felt.

Such types and subtypes of extrazonal associations may also be encountered in other parts of Yugoslavia implaying that they are not restricted solily to Durmitor. As concerns species , these associations are quite poor.

The second group of associations consists of two associations belonging to the **"lacteum"** type. They are typical mountain "pasture" associations. The species composition of this type of associations is influenced by most heterogeneous ecological factors. These associations (reference B) are represented by the **"octaedra"** associations subtype. There is also another typical pasture species, *Dendrobaena octaedra*. The association referred to under C is, in fact, an altitudinal variant of the first group of associations group, belonging to the subtype **"montenegrina"**. Its differential species is *Dendrobaena montenegrina*, endemic to Durmitor. Both associations display an azonal character. The first type and subtype (b) are also found in other areas of Yugoslavia. From the species point of view, these associations are very poor.

The third group of associations represents the "smaragdina" association type, and is divided into three subgroups (references F, G, H).

The first subgroup belongs to the **"transpadanus"** association subtype. The differential species of the association is *Octodrilus transpadanus* of the transaegean distribution type. The species is euryhumic, eubiotic, preferring a soil rich in humus. It is a surface species living in humus-accumulative horizons and feeding on organic substance in different stages of decay. These are typical hiland zonal associations of Durmitor. The edificatory and dominant species is *O. transpadanus* (dominant) with *Aporrectodea smaragdina*, also as edificatory, but subdominant species.

The second subgroup of associations (H) is of the **"smaragdina"** subtype and is treated as a **"transpadanus"** variant. These two associations are zonal and characteristics for the mountainous Dinaric areas of Durmitor, Zelengora, Velebit etc. Both subgroups of associations are genetically very close, which also applies to the last mentionned association of the third subgroup.

The third subgroup includes only associations of the **"smaragdina"** type, subtype and variant. This association forms part of a highly heterogeneous group of associations (considering the biotope in which they developed). It is developed in the entire

Dinaric system with *A. smaragdina* as an edificatory and differential species. It is accompanied by *Dendrodrilus rubidus*, a species characteristic for extreme climatic conditions (alpine) displaying zonal character.

The fourth association group (reference 4) represents the **"rubidus"** type of associations. This is a group of montane associations of a zonal character in which the edificatory species is *Dendrodrilus rubidus* ranging from eudominant to subdominant. Taking into account the presence of the other species, primarly the differential ones, this group falls into four subgroups.

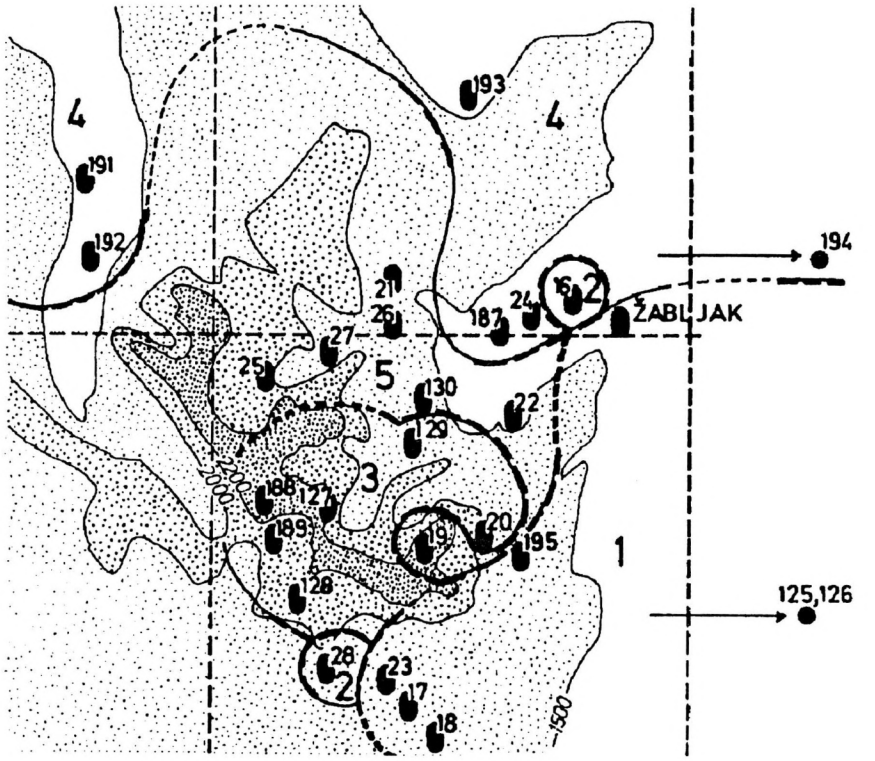

Fig. 3. Survey map of the localities in which the earthworm associations were studied. Encircled are those associations that belong to the same group. The numbers used in the figure are identical with those in the dendrogram (Fig.2) and the same references are used for the different associations in the dendrogram and in the text.

Sl. 3. Pregledna karta lokalitet z raziskanimi cenozami. Obkrožene so tiste cenoze (na eni teritoriji), ki pripadajo v isto skupino (cenoz). Uporabljene so enake številke, kot pri skupinah cenoz v dendrogramu in iste oznake za posamezne cenoze v dendrogramu in tekstu.

The first subgroup is of the **"rubellus"** association subtype developed in forest biotopes of the *Abieti-Fagetum* or *Fagetum montanum* type, rich in undecayed organic substances, with prevailing unfavourable climatic conditions, shallow soil and pedoclimatic soildrought. The differential species is *Lumbricus rubellus*.

The second subgroup is represented by only one association of the **"durmitorensis/rubellus"** subtype, which differential species are *L. rubellus* and *Dendrobaena durmitorensis*, endemic to Durmitor and known only in that area. The association is developed in a forest of the *Abieti-Fagetum* type ajoining Barno jezero (lake). It is genetically very close to the designated association (the fourth subgroup in this association group), which belongs to the **"durmitorensis"** association subtype.

The third subgroup is represented by only one association of the **"rubidus"** subtype with *rubidus* as an eudominant and differential species.

All associations of this group belong to zonal associations of the Dinaric system montane forests.

The last, fifth group, comprises associations of the **"castaneus"** type. The edificatory and differential species in this case is *Lumbricus castaneus* as eudominant to subdominant in some associations. So far, this association type is known only on Durmitor. There are zonal associations of highland pastures, distinct from similar associations in Slovenia where they have developed exclusively in forest biotopes, which may be divided into three subgroups.

The first subgroup comprises associations of the **"rubidus"** type with four associations that have developed on the nortern (shady) slopes of the montane-subalpine belt.

In higher areas a very similar association of the **"transpadanus/smaragdina"** type is developed, which by its composition slightly resembles of the associations of the third group. However, *L. castaneus* is still a dominant species in this association.

A special subtype of the **"alpina"** association is developed in the lower parts of the subalpine zone populated by this group of associations, namely, in the *Fagetum subalpinum* forest type.

As evident from Fig.3, in which the associations of a particular group are encircled, different association types are connected with given Durmitor areas. Those groups of associations whose similarity was calculated on the basis of the Renkonen number, were subject to analysis. Therefore, it may be seen that the first group of associations with *A. rosea* as dominant species is spread on the southern slopes of Durmitor, on the southern side of the plateau in the vicinity of Žabljak and in the Tara Canyon (reference 1). A probable cause of similarity is the more markedly thermophilous character of this area. However, in a broader sense, the principal characteristics of this part of Durmitor are deeper and more leached soils on which the *A. rosea* species has found an excellent biotope. The group of associations bearing reference number 2 (in the dendrogram calculated according to Renkonen) also has *A. rosea* as the dominant species, but in one of the associations *O. lacteum* prevails over the other species (Sedlo) and in another one (Bokovac) the endemic species *D. montenegrina*. Both species are characteristic for meadow and pasture biotopes. The third group of associations (reference 3) is developed in the high-mountain parts of Durmitor with two dominating species, *A. smaragdina* and *O.transpadanus*, characte-

rized by raw humus and extreme climatic conditions. This area, reffered to under 4, is populated by the associations whose dominant species is either *D. rubidus* or *D. alpina*, the two species inhabiting raw humus in different types of forest biotopes, rich in organic material. A specific area dominated by an endemic species, namely, *D. durmitorensis*, is immediately adjacent to the Barno jezero. This area referred to under 5 is characterized by associations with the species *L. castaneus*. These associations are developed in forests of the*Piceetum* and *Fagetum subalpine* type, and partially of the *Abieti-Fagetum*-type. The area is somewhat more thermophilous than the high-mountainous region of Durmitor.

8. ANALYSIS OF THE DENDROGRAM BASED ON THE SIMILARITY INDEX (Fig. 4)

In the dendrogram drawn by calculating the similarity index according to Sorensen, the associations are grouped in a different way, namely, into 4 basic groups. Each of them displays a common similarity of more than 50%. The classification of associations based on the calculation of similarity index is a method applied only in the case of a zoogeographic and biogeographic analysis that takes into account only the specific composition of the associations, regardless the actual (dominant) presence of a particular species.

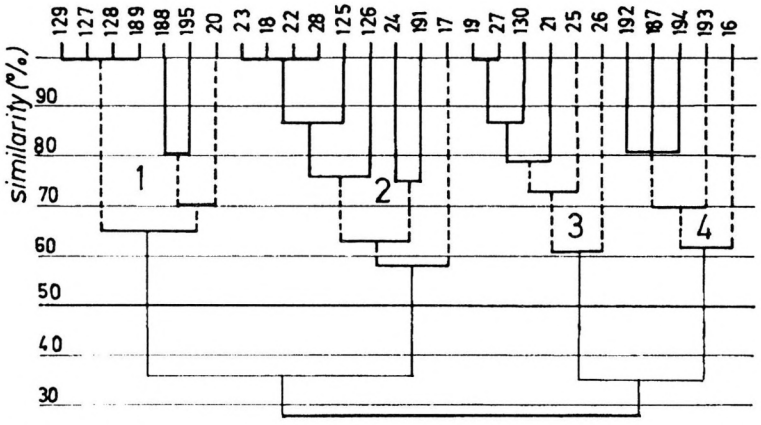

Fig. 4. Schematized display of the classification of earthworm associations of Durmitor, based on the similarity index.

Sl. 4. Shematiziran prikaz klasifikacije deževniških cenoz Durmitora na podlagi indeksa podobnosti.

The first group (reference 1) comprises associations encountered in the whole Dinaric system as well as the Alps, belonging to the **"smaragdina"** association type.

The second group of associations (reference 2) is of the **"rosea"** type. These associations, found throughout Yugoslavia, are conditioned edaphically, and therefore cannot be used for biogeographic analysis.

The 3rd and the 4th association groups are of most interest. The third group of the **"castaneus"** type has so far been encountered nowhere alse but on Durmitor. These associations developed in the central part of Durmitor, i. e. in the subalpine and alpine climatic zone.

The fourth group of associations of the **"rubidus"** type may be found in some mountain and high-mountain areas of the Alps and the Dinaric system where it develops under most unfavourable climatic conditions. On Durmitor this group also includes "endemic" associations, with species endemic to Durmitor.

The analysis of a dendrogram based on the similarity index is aimless, unless a comparison is made with other parts of Yugoslavia, with investigation results comprising the entire territory of the country, which means that the dominance degree of individual species cannot be taken into account. The comparison of the Renkonen number and the similarity index was discussed in one of the previous papers (MRŠIĆ, 1983a)

9. RESEARCH RESULTS

As concerns the earthworm fauna, Montenegro represents one of the least researched parts of Yugoslavia.

The present work refers to former association research in Yugoslavia (MRŠIĆ 1982a,b,1983a,b,1984a,b,1985a,b, 1988a,b, 1989).

On Durmitor 16 species were found, representing 45% of the registered Montenegro fauna (33 species) and 13% of the entire earthworm fauna of Yugoslavia (132 taxa). The small number of the species found is due to extreme ecological conditions on Durmitor. With the exception of endemic species, all other species were recorded in different Montenegrin localities (outside the Durmitor area).

Of the 16 species as found on Durmitor, four are cosmopolitan, one is Palerktic, four are Holarktic, one is Balcanic, one Europaean and one Transaegean, whereas three reveal an Alpine-Dinaric-Carpathian and two an endemic distribution type.

It is interesting to note that by its species composition Durmitor most closely resembles the earthworm fauna of the Julian Alps (a similarity ranging up to 60%). Most of these species are cosmopolites, many are wide spread andnly two are endemic for Durmitor.

The structure of the earthworm association is not sufficiently described if only the composition of a certain combination of species is given. All structural characteristics of the 27 earthworm are shown (by comparison) in Table 1, so that it is not necessary to comment on their individual structural characteristics. Dominance of individual species is calculated by Haydeman's formula (1953), dominance degrees are determined according to ZAJONC (1981), and MRŠIĆ (1982), said digrees differing from tose used in entomology.

Earthworm associations are directly interdependent with the stability of the ecosystem and the value of the index of diverstity. The earthworm diversity is well pronounced in developed associations approaching their climax. The diversity index was calculated according to Shannon-Weaver's formula (1963).

The index showing dominance distribution of species in certain associations is

refered to as evenness index. It attains minimal values when a species plays a dominant role in an association, whereas the others are recedent or subrecedent. The evenness index was calculated by applying Piely's 1966 formula.

The diversity and the evenness indexes were calculated to show to what extent the 27 associations were developed and/or to what degree the development of an association had been influenced by edaphic and climatic factors. A particular attention was paid to limiting factors. Table 1 gives a survey of the diversity and the evenness index values. In almost all associations high or medium values of both indices are stated, meaning that the earthworm associations on Durmitor have attend their climax with respect to the actual ecological conditions.

The similarity of one association to another was calculated in two ways: by the similarity index according to SORENSEN and by the Renkonen number. A comparision of both calculation metods once again led to the conclusion that the use of the Renkonen number represents a better way – a belief so far expressed in numerous papers dealing with problems of earthworms associations (MRŠIĆ 1982 a, b, 1983 a, b, 1984 a, b, 1985 a, b, 1988 a,b, 1989). The advantage of this calculation lies in the fact that the Renkonen number takes into account both the association of species (qualitative relationships among earthworm associations), also compared with the dominance values of the species common to both associations (quantitative relationships among associations).

Fig. 2 and 4 represent two schematized instances of earthworm associations classification, based on the similarity index (Fig.4) and the Renkonen number (Fig. 2). Presented is an analysis of both dendrograms of the classification of earthworm associations from Durmitor.

As evident from Fig.3, in which the associations of a particular group are encircled, different association type are linked with given Durmitor areas. The anlaysis was based on those groups of associations whose mutual similarity was calculated by means of the Renkonen number, also enabling an ecological analysis of these areas.

10. INDEX TO TAXA

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DEŽEVNIKI IN NJIHOVE ZDRUŽBE

Raziskave faune in deževniških združb Durmitora, Crna Gora, II.

(ANNELIDA, OLIGOCHAETA, LUMBRICIDAE)

N a r c i s MRŠIĆ

P o v z e t e k

Med vsemi območji Jugoslavije je najmanj raziskana favna deževnikov Crne Gore. Delo je nadaljevanje cenotskih raziskav Jugoslavije (MRŠIĆ 1982a,b,1983a,b,1984a,b,1985a,b, 1988a,b, 1989). Na Durmitoru sem našel 16 vrst, kar predstavlja 45% registrirane favne Crne Gore in 13% celotne favne deževnikov Jugoslavije. Vzrok malega števila najdenih vrst je v ekstremnih ekoloških pogojih na Durmitoru. Zanimivo je, da je po vrstni sestavi Durmitor najbolj podoben favni deževnikov Julijskih Alp v Sloveniji (celo 60% podobnost). Večina najdenih vrst je kozmopolitskih. V materialu z Durmitora sta najdeni in opisani samo dve endemni vrsti.

Struktura deževniških cenoz ni dovolj opredeljena samo s sestavo določene kombinacije vrst. Zaradi tega sem vse pomembne strukturne lastnosti 27 deževniških cenoz podal primerjalno (tab.1), strukturnih značilnosti posameznih cenoz nisem posebej komentiral. Dominantnost posameznih vrst sem izračunaval po formuli Haydemana (1953), dominančne stopnje določal po ZAJONC-u1981, MRŠIĆU 1982, ki se razlikujejo od dominančnih stopenj, ki jih uporabljajo v entomofavni.

Stabilnost ekosistema v tem primeru cenoz deževnikov in vrednosti indeksa vrstne diverzitete sta v neposredni soodvisnosti. Vrstna diverziteta deževnikov je velika v razvitih, klimaksnih cenozah. Indeks vrstne diverzitete sem izračunal po formuli SHANNON-WEVARJA (1963).

Indeks, ki nam pokaže dominantno porazdelitev vrst v določeni cenozi, imenujemo indeks dominančne porazdelitve. Minimalne vrednosti ima takrat, ko v cenozi izrazito dominira ena vrsta, druge pa so recendentne ali subrecendentne. Indeks dominančne porazdelitve sem izračunal po PIELY-u (1966).

Indeks vrstne diverzitete in indeks enakomernosti porazdelitve sem izračunaval, da bi ugotavljal v kolikšni meri so posamezne cenoze razvite in v kolikšni meri so na razvoj posameznih cenoz vplivali edafski in klimatski dejavniki. Tu predvsem mislim na takoimenovane "limitirajoče" dejavnike.

Na tabeli 1 je prikazan pregled vrednosti indeksa vrstne diverzitete in indeksa enakomernosti porazdelitve. Skoraj pri vseh cenozah so visoke ali srednje vrednosti obeh indeksov, kar pomeni, glede na trenutne ekološke razmere, da so deževniške cenoze na Durmitoru v svojem klimaksnem stadiju.

Podobnost med cenozami sem izračunaval na dva načina in pri tem sem uporabil Indeks podobnosti po Sorensenu in renkonenovo število. S primerjavo med obema načinoma izračunavanja sorodnostnih razmer med cenozami se je ponovno izkazalo, da je uporaba renkonenovega števila najboljši način izračunavanja, o čem sem pa že pisal v številnih prispevkih, kjer obravnavam cenotsko problematiko deževnikov (MRŠIĆ 1982 a, b,1983 a, b, 1984 a, b, 1985 a, b). Prednost tega izračunavanja je v tem, da renkonenovo število upošteva po eni strani vrstno sestavo (kvalitativne razmere med deževniškimi cenozami) in po drugi strani vrednosti dominance skupnih vrst iz obeh primerjanih cenozah (kvantitativne razmere med cenozami).

Na sliki 2 in 4 je shematizirana prikaz klasifikacije deževniških cenoz na podlagi izračuna Indeksa podobnosti (Sl. 4) in renkonenovega števila (Sl. 2). Podana je analiza obeh dendrogramov klasifikacije deževniških cenoz Durmitora. Na karti (Sl. 3) so cenoze posameznih skupin obkrožene v eno območje. Analiza karte je pokazala obstoj povezanosti med posameznimi tipi cenoz z določenimi predeli na Durmitoru. Analiza je narejena s skupinami cenoz, med katerimi je izračunana podobnost na podlagi renkonenovega števila. Narejena je tudi ekološka analiza teh območij.

Tab. 1.– Certain structural characteristics of the earthworm associations of Durmitor.
1: number of associations, 2: species, 3: number of collected specimens, 4: dominance degree, 5: diversity index, 6: evenness index

Nekatere strukturne lastnosti deževniški cenoz Durmitora.
1: številka cenoze, 2: vrste, 3: število nabranih osebkov, 4: stopnja dominantnosti, 5: indeks vrstne diverzitete in 6: indeks dominančne porazdelitve

Nr.	1	2	3	4	5	6
1.	1	O. lacteum	10	50	1.05	0.95
		D. octaedra	5	25		
		D. montenegrina	5	25		
2.	17	A. rosea	24	75	0.64	0.58
		O. lacteum gigantheum	4	12.5		
		L. castaneus	4	12.5		
3.	18	A. rosea	8	80	0.50	0.72
		O. lacteum	2	20		
4.	19	L. castaneus	4	50	1.05	0.96
		D. rubidus	2	25		
		O. transpadanus	2	25		
5.	20	D. rubidus	2	10	0.33	0.48
		A. smaragdina	18	90		
6.	21	L. castaneus	3	43	1.08	0.98
		D. rubidus	2	27.5		
		D. octaedra	2	27.5		
7.	22	A. rosea	32	80	0.64	0.58
		O. lacteum	4	10		
		L. castaneus	4	10		
8.	23	A. rosea	4	67	0.64	0.92
		O. lacteum	2	33		
9.	24	A. rosea	3	12	0.96	0.87
		D. rubidus	9	36		
		D. durmitorensis	13	52		
10	25	L. castaneus	10	64	1.15	0.71
		D. rubidus	1	6		
		O. transpadanus	2	12		
		A. smaragdina	2	12		
		A. eiseni	1	6		
11.	26	L. castaneus	4	27	1.06	0.96
		D. alpina	7	46		
		A. eiseni	4	27		
12.	27	L. castaneus	3	43	1.00	0.91
		D. rubidus	3	43		
		O. transpadanus	1	14		

Nr.	1	2	3	4	5	6
13.	28	A. rosea	4	24	0.56	0.81
		O. lacteum	13	76		
14.	125	A. rosea	1	1	0.0	0.0
15.	126	A. rosea	20	80	0.5	0.7
		O. lacteum gigantheum	5	20		
16.	127	O. transpadanus	4	25	0.35	0.5
		A. smaragdina	12	75		
17.	128	A. smaragdina	2	33	0.64	0.92
		O. transpadanus	4	67		
18.	129	A. smaragdina	2	33	0.64	0.92
		O. transpadanus	4	67		
19.	130	L. castaneus	4	67	0.64	0.92
		D. rubidus	2	33		
20.	187	D. rubidus	7	17	0.96	0.87
		L. rubellus	2	25		
		D. durmitorensis	3	58		
21.	188	A. smaragdina	1	50	0.70	1.00
		A. rosea	1	50		
22.	189	O. transpadanus	1	33	0.64	0.92
		A. smaragdina	2	67		
23.	191	A. rosea	2	8	1.33	0.83
		O. lacteum	3	13		
		D. rubidus	10	42		
		D. alpina	1	4		
		L. rubellus	8	33		
24.	192	D. rubidus	8	89	0.34	0.49
		L. rubellus	1	11		
25.	193	D. rubidus	9	56	1.10	0.79
		A. smaragdina	2	13		
		A. eiseni	1	5		
		L. rubellus	4	26		
26.	194	O. lacteum	1	10	0.94	0.86
		D. rubidus	5	50		
		L. rubellus	4	40		
27.	195	A. rosea	1	33	1.11	1.00
		D. rubidus	1	33		
		A. smaragdina	1	33		

(Primljeno u redakciji: 15. 12. 1988.)