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Content and Season Dynamism of Aminoheterotrophes and Aminoautotrophes in some Soil Types of Kosovo and Metohia

KIKOVIĆ D. 1, RAČEVIĆ Vera 2, DELETIĆ N. 1, ĐURIĆ V. 1
1Faculty of Agriculture, Priština;
2Faculty of Agriculture, Belgrade - Zemun.

Abstract

This microbiological study included the three basic soil types of Kosovo and Metohia: Vertisol, Pseudogley, and Dystric Cambisol. The investigation involved microbiological profiles of so the cultivated soils as of the uncultivated (virgin) ones. Aminoautotrophes were better-represented in all the investigated soil types than aminoheterotrophes. The highest content of this microflora was observed in Vertisol, then in Pseudogley, and the lowest one was observed in Dystric Cambisol.

Key words: Microorganism, soil, Vertisol, Pseudogley, Dystric Cambisol.

INTRODUCTION

Microorganisms represent a significant factor of soil biogenity, so their number in soil can reach a few milliards per a gram of absolute dry soil, and that number is greater if microorganisms are smaller (Giljarov, 1950). The zone of plant roots is a centre in which microbial processes and activities take place more intensively, and, in favourable ecological conditions, their effect on soil is largely expressed (Veron, 1953). Aminoheterotrophes are one of the most important microorganism groups in soil, where they actively take part in transformation of nitrogen containing organic compounds. When transform these compounds, microorganisms release to soil an amount of amoniac. The released amount of amoniac depends upon ecological factors, organic matter content, carbon vs. nitrogen ratio, and microflora composition. Nitrogen is very significant for plant nutrition, but it is also necessary for microorganisms, so they, in some cases, can be in a competitive relation with plants regarding nitrogen compounds. Aminoautotrophes, as mineral nitrogen users, mostly are more numerous than aminoheterotrophes, and their prevalence can be explained by their ability of using so mineral nitrogen, as the one of microbial origin - made by amonification, nitrification, and nitrogen fixation. Microorganisms number, based on a row of data from home and foreign papers, is changed not only by the season changes of ecological factors (moisture, temperature, organic matter content, etc.), but also by internal rules of micropopulation development. These changes have a pulsation character and are carried out in short intervals, even within a single day (Aristovskaya, 1965; Milošević, 1967; Hudjakov, 1972). This case can be observed not only in amonificators, but also in all the other microorganism groups.

MATERIAL AND METHODS

The investigation presented in this paper has been carried out on different soil types as follows: the Vertisol location Lajle Selo (Priština), the Pseudogley location Vitomirica (Peć), and the Dystric Cambisol location Tankosić (Uroševac). The investigation involved so the cultivated soils as the uncultivated (virgin) ones. Soil sampling for the mentioned study was done in autumn 1994, winter 1994/95, as well as in spring and summer 1995. For every season sampling we opened new profiles. Samples were taken in the open profile, from different depths as follows: 0-25 cm, 25-50 cm, 50-75 cm, and 75-100 cm. In the laboratory, from the collected samples, were made dilutions, and the dilution of 10-4 was used for inoculation. Inoculation of culture media was carried out by 0.5 ml of inoculum, and all of that was done in three repetitions. We analysed in the studied samples the following microorganisms: -Aminoheterotrophes on meat-peptonic agar (MPA); -Aminoautotrophes on starch-imoniac-nitrate agar. Number of the investigated microorganism groups has been expressed per a gram of absolute dry soil. Results and Discussion

Aminoheterotrophes were well-represented in the investigated Vertisol, which was expected because this soil had favourable physical and chemical properties, and amonificators are one of the most numerous physiological microorganism groups in the total microflora. Cultivated Vertisol had by 16% higher content of this microflora in regard to the uncultivated one.

Regarding vertical arrangement of aminoheterotrophes, their content decreased by depth, which followed arrangement of soil organic matter (Milošević, 1947). The investigated Pseudogley had a lower content of humus matters and unfavourable physical and chemical properties comparing with the investigated
Vertisol. In uncultivated Pseudogley aminoheterotrophs content was slightly lower in regard to uncultivated Vertisol.

However, in cultivated Pseudogley was observed the highest number of amonification microflora among all the investigated soil types. Reason for that certainly was growing of alfalfa for the past three years and larger income of nitrogen-containing organic matter. Uncultivated pseudogley had significantly lower amount of aminoheterotrophs than the cultivated one. The lowest content of aminoheterotrophs was found out in Dystric Cambisol, where the lowest content of humus matters and the worst soil physical and chemical properties were also observed. Uncultivated Dystric Cambisol was significantly richer with aminoheterotrophs than the cultivated one. Aminoautotrophs were better-represented than aminoheterotrophs in all the investigated soil types, which was expected because they used mineral nitrogen as well as the one of the microbial origin got by amonification, nitrification, and nitrogen fixation. The greatest content of aminoautotrophs (tab. 2) among the investigated soil types was observed in Vertisol, and their number was higher in cultivated Vertisol where mineral fertilizers were used for nutrition of the grown plants.

The investigated Pseudogley had a high content of this microflora but, different from Vertisol, a little higher content of aminoautotrophs was observed in uncultivated Pseudogley. Cultivated Pseudogley had approximately the same content of aminoheterotrophs and aminoautotrophs. The lowest content of aminoautotrophs was in the investigated Dystric Cambisol. Cultivated Dystric Cambisol was richer with this microflora than the uncultivated. However, one ought to point out that in cultivated Dystric Cambisol percental part of aminoautotrophs in total microflora was significantly greater with respect to aminoheterotrophs.

**Tab. 1. Season dynamism of aminoheterotrophs (in millions per a gram of absolute dry soil)**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertisol Lapje Selo 0-25</td>
<td>0.270</td>
<td>1.583</td>
<td>3.146</td>
<td>3.967</td>
</tr>
<tr>
<td>25-50</td>
<td>0.571</td>
<td>0.853</td>
<td>1.910</td>
<td>0.339</td>
</tr>
<tr>
<td>50-75</td>
<td>0.244</td>
<td>0.549</td>
<td>1.727</td>
<td>0.326</td>
</tr>
<tr>
<td>75-100</td>
<td>0.356</td>
<td>0.402</td>
<td>0.354</td>
<td>1.202</td>
</tr>
<tr>
<td>0.320</td>
<td>0.342</td>
<td>0.945</td>
<td>0.610</td>
<td></td>
</tr>
</tbody>
</table>

**Tab. 2. Season dynamism of aminoautotrophs (in millions per a gram of absolute dry soil)**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertisol Lapje Selo 0-25</td>
<td>2.800</td>
<td>6.077</td>
<td>8.910</td>
<td>2.913</td>
</tr>
<tr>
<td>25-50</td>
<td>5.059</td>
<td>2.946</td>
<td>8.314</td>
<td>3.011</td>
</tr>
<tr>
<td>50-75</td>
<td>1.976</td>
<td>1.904</td>
<td>4.158</td>
<td>1.185</td>
</tr>
<tr>
<td>75-100</td>
<td>0.451</td>
<td>0.644</td>
<td>3.443</td>
<td>0.666</td>
</tr>
<tr>
<td>0.311</td>
<td>1.351</td>
<td>3.051</td>
<td>0.688</td>
<td></td>
</tr>
</tbody>
</table>

| Pseudogley Vitomirica 0-25 | 6.000  | 5.576  | 12.917 | 3.125  |
| 25-50 | 2.032  | 2.068  | 4.045  | 1.352  |
| 50-75 | 0.703  | 0.518  | 0.818  | 1.919  |
| 75-100| 0.619  | 0.210  | 0.294  | 1.471  |
| 0.216 | 1.045 | 1.590 | 0.067 |

| Dystric Cambisol Tankosici 0-25 | 0.674  | 0.494  | 2.387  | 1.442  |
| 25-50 | 0.415  | 0.143  | 1.298  | 0.159  |
| 50-75 | 0.090  | 0.155  | 0.382  | 0.039  |
| 75-100| 0.067  | 0.157  | 0.081  | 0.033  |
| 0.214 | 0.129 | 0.776 | 0.159 |
CONCLUSION

On the basis of the obtained results concerning seasonal content of amino-heterotrophes and amio-
noautotrophes in Vertisol, Pseudogley, and Dystric Cambisol the following can be pointed out: Content
of aminoautotrophes was higher in all the investigated soil types comparing with aminoheterotrophes. The
highest content of the investigated physiological microorganism groups was observed in Vertisol, and the
lowest one in Dystric Cambisol.

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dgleijnim zemljištima. Mikrobiologija, Vol. 22, No 1. Beo-
grad.

REZIME

ZASTUPLJENOST I SEZONSKA DINAMIKA AMI-
NOHETEROTROFA I AMONIOAUTOTROFA U
NEKIM ZEMLJIŠTIMA KOSOVA I METOHIIJE

KIKOVIĆ D., RAČIĆ VERA2, DELETIĆ N., ĐURIĆ V.
1Poljoprivredni fakultet, Priština; 2Poljoprivredni
fakultet, Beograd - Zemun.

Mikrobiološkim proučavanjima su obuhvaćena
tri osnovna tipa zemljišta Kosova i Metohije, smonica,
pseudoglej i crvenica. Ispitivani su mikrobiološki pro-
fili navedenih tipova zemljišta koja se obuhvaju i koja
nisu obrađivana (devičansko zemljište). Amio-
noautotrofi su kod svih ispitivanih zemljišnih tipova
zastupljeniji od aminoheterotrofa. Najveću zastu-
pljenost ove mikroflore srecemo kod smonice zatim
pseudogleja a najmanju kod crvenice.

Received March, 1997.
Accepted April, 1997.
Content of Amonificators, Cellulose Decomposers, Nitrogen-fixing Bacteria, and Nitrificators in some Soil Types of Kosovo and Metohia

KIKOVIĆ D.¹, RAČEVIĆ VERA², ĐURIĆ V.¹, DELETIĆ N.¹, ŠANTRIĆ LJILJANA¹.
¹Faculty of Agriculture, Priština;
²Faculty of Agriculture, Belgrade - Zemun.

ABSTRACT

This microbiological study included the three basic soil types of Kosovo and Metohia: Vertisol, Pseudogley, and Dystric Cambisol. The investigation involved microbiological profiles of so the cultivated soils as of the uncultivated (virgin) ones. Content of cellulose decomposers and amonificators in the investigated soil types of Kosovo and Metohia was high, but content of nitrogen-fixing bacteria and nitrificators was significantly lower. The highest content of the investigated physiological microorganism groups was observed in Vertisol, then in Pseudogley, and the lowest one was observed in Dystric Cambisol.

Key words: Microorganism, soil, Vertisol, Pseudogley, Dystric Cambisol.

INTRODUCTION

A large number of microorganism species lives in soil, which represents a source of nutritive matters and energy for them, and, at the same time, they change soil chemical properties by their metabolism products. Certainly, in such biocenosis with the interaction relations, they also become changed by the action of environmental factors. Content of particular physiological or systematic species cannot satisfy an investigation aim without analysis of these species season dynamism. One should point out that no physiological species disappears completely from soil micro-population, even when status of a soil is significantly changed. In such cases, changes of some species relation to the others can be observed (Mishustin, 1960). Season changes of microorganism number, as well as the other parameters, depend upon income of fresh organic matter, aeration, humidity, and temperature (Zvjabincev et al., 1981). When humidity is unfavourable, number of bacteria is proportional to the water content (Jones, 1977; Nelson, 1978).

MATERIAL AND METHODS

The investigation presented in this paper has been carried out on different soil types as follows: the Vertisol location Laplje Selo (Priština), the Pseudogley location Vlomirica (Peć), and the Dystric Cambisol location Tankosić (Uroševac). The investigation involved the cultivated soils as the uncultivated (virgin) ones. Soil sampling for the mentioned study was done in autumn 1994, winter 1994/95, as well as in spring and summer 1995. For every season sampling we opened new profiles. Samples were taken in the open profile, from different depths as follows: 0-25 cm, 25-50 cm, 50-75 cm, and 75-100 cm. In the laboratory, from the collected samples, were made dilutions, and the dilution of 10-4 was used for inoculation. Inoculation of culture media was carried out by 0.5 ml of inoculum, and all of that was done in three repetitions. We analysed in the studied samples the following microorganisms: Amonificators on meat-peptone agar (MPA); Cellulose decomposers on silica gel with the standard solution for cellulose decomposers and filter paper as the only carbon source; Azoobacterium sp. on silica gel with the proper standard solution without nitrogen, and with manit as the only carbon source; Nitrificators (nitrite and nitrate bacteria) with the proper standard solution for nitrite or nitrate bacteria, and with calcium carbonate. Number of microorganisms has been expressed per a gram of absolute dry soil for amonificators, and as a percent of fertile soil granules for cellulose decomposers, nitrogen-fixing bacteria, and nitrificators.

RESULTS AND DISCUSSION

Amonificators, as one of the most numerous physiological groups of microorganisms, were relatively low-represented in Vertisol during the autumn and winter periods. Amonification microflora increase in spring and summer was, among others, a result of increased activity of the other microorganism groups, especially cellulose decomposers, as well as of increased protein mass produced by these microorganisms and higher plants root system secretions.
Amonification microflora on MPA is always represented by a smaller number than the total microflora on soil agar and, therefore, it is reasonable to separate this microorganism group from the total microflora, because impressive differences concerning quantitative and qualitative composition of these groups can be observed (Todorović et al., 1972). We can observe, comparing amonification microflora of uncultivated and cultivated Vertisol, that it was better represented in cultivated soil. Spores of amonificators followed the observed season dynamism, but always with a lower number. The higher amonificator number of the investigated soil types was observed in cultivated Pseudogley, where allafa had been grown for the last three years. Root secretions of legume plants certainly influenced the increased number of amonification microflora in the total microflora, which was better represented in Vertisol. Uncultivated pseudogley had significantly lower amonificator content in regard to the cultivated one.

Table 2. Season dynamism of amonificators in Pseudogley (Vitomirica) (in millions per a gram of absolute dry soil)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>1.826</td>
<td>2.429</td>
<td>3.247</td>
<td>1.569</td>
<td>1.803</td>
<td>2.541</td>
<td>0.914</td>
<td>0.683</td>
<td>0.672</td>
<td>0.914</td>
<td>0.683</td>
<td>0.672</td>
</tr>
<tr>
<td>25-50</td>
<td>0.315</td>
<td>0.652</td>
<td>0.974</td>
<td>0.466</td>
<td>0.304</td>
<td>1.104</td>
<td>0.320</td>
<td>0.440</td>
<td>0.617</td>
<td>0.320</td>
<td>0.440</td>
<td>0.617</td>
</tr>
<tr>
<td>50-75</td>
<td>0.205</td>
<td>0.893</td>
<td>0.412</td>
<td>0.134</td>
<td>1.077</td>
<td>0.181</td>
<td>0.100</td>
<td>0.142</td>
<td>0.054</td>
<td>0.100</td>
<td>0.142</td>
<td>0.054</td>
</tr>
<tr>
<td>75-100</td>
<td>0.146</td>
<td>0.033</td>
<td>0.102</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
</tr>
</tbody>
</table>

The investigated Dystric Cambisol had significantly lower content of amonification microflora than Vertisol and Pseudogley (tab. 3). In this location we observed significantly higher content of amonification microflora in uncultivated soil.

Table 3. Season dynamism of amonificators in Dystric Cambisol (Tankosić) (in millions per a gram of absolute dry soil)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>0.325</td>
<td>0.404</td>
<td>1.172</td>
<td>1.338</td>
<td>1.151</td>
<td>0.274</td>
<td>0.433</td>
<td>0.549</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-50</td>
<td>0.622</td>
<td>0.058</td>
<td>0.198</td>
<td>0.182</td>
<td>0.104</td>
<td>0.190</td>
<td>0.045</td>
<td>0.190</td>
<td>0.045</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-75</td>
<td>0.068</td>
<td>0.057</td>
<td>0.102</td>
<td>0.101</td>
<td>0.012</td>
<td>0.092</td>
<td>0.139</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75-100</td>
<td>0.232</td>
<td>0.015</td>
<td>0.015</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td>0.022</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cellulose decomposers were well-represented in all the investigated soil types, and their highest number was observed in surface layers, but that number decreased by depth, which followed the arrangement of organic matter and oxygen also decreasing by depth (Todorović, 1968).

Table 4. Season dynamism of cellulose decomposers (in percent of fertile soil granules)

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25</td>
<td>88</td>
<td>28</td>
<td>94</td>
<td>100</td>
<td>20</td>
<td>90</td>
<td>50</td>
<td>30</td>
<td>70</td>
<td>50</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>25-50</td>
<td>22</td>
<td>12</td>
<td>62</td>
<td>82</td>
<td>20</td>
<td>96</td>
<td>32</td>
<td>16</td>
<td>86</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>50-75</td>
<td>24</td>
<td>12</td>
<td>42</td>
<td>20</td>
<td>12</td>
<td>88</td>
<td>32</td>
<td>16</td>
<td>86</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>75-100</td>
<td>8</td>
<td>0</td>
<td>24</td>
<td>8</td>
<td>4</td>
<td>96</td>
<td>32</td>
<td>16</td>
<td>86</td>
<td>40</td>
<td>20</td>
<td>80</td>
</tr>
</tbody>
</table>

The main cellulose decomposers, which had a neutral pH value, were bacteria, in Pseudogley with an acid pH fungi were significantly greater involved in cellulose transformation, and in Dystric Cambisol with a very acid pH the main cellulose transformers were fungi. In all the three investigated soils we met a higher content of cellulose decomposers in cultivated soil comparing with the uncultivated one. Mishustin (1974) stated that mineral fertilizers carried in cultivated soil influenced significantly on microorganisms content and composition.

Free aerobic nitrogen-fixing bacteria (Azotobacter sp.) were represented by a low number in the all investigated soil types (tab. 5). In the Vertisol location content of Azotobacter sp. was higher in cultivated soil, but in the Pseudogley and Dystric Cambisol locations was observed a little higher number of this microflora in uncultivated soil which was not expected, because this type of nitrogen fixation was characteristic for cultivated and aerated soils. Nitrifiers, as a very significant physiological group for transformation of ammonia to nitrates and, for that reason, for nitrogen retaining in soil, were relatively well-represented. They analysed both nitrite and nitrate bacteria and, on the basis of the obtained results, we can say that content...
of nitrite bacteria was a little higher. The greatest nitrificators content was observed in Vertisol, where the total microbial activity was also the greatest. Cultivated Vertisol had a higher content of nitrification microflora. The investigated Pseudogley and Dystric Cambisol had a lower nitrifiers content in comparison with Vertisol.

Table 6. Season dynamics of nitrifiers. (in percent of fertile soil granules)

<table>
<thead>
<tr>
<th>UNCULTIVATED SOIL</th>
<th>CULTIVATED SOIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertisol Luplje Sol</td>
<td>Nitrate bacteria</td>
</tr>
<tr>
<td>depth</td>
<td>autumn</td>
</tr>
<tr>
<td>0-25</td>
<td>00 10</td>
</tr>
<tr>
<td>25-50</td>
<td>00 4</td>
</tr>
<tr>
<td>50-75</td>
<td>00 0</td>
</tr>
<tr>
<td>75-100</td>
<td>00 0</td>
</tr>
<tr>
<td>Nitrite bacteria</td>
<td></td>
</tr>
<tr>
<td>0-25</td>
<td>00 6</td>
</tr>
<tr>
<td>25-50</td>
<td>00 10</td>
</tr>
<tr>
<td>50-75</td>
<td>00 16</td>
</tr>
<tr>
<td>75-100</td>
<td>00 0</td>
</tr>
<tr>
<td>Pseudogley Vitimirić</td>
<td>Nitrate bacteria</td>
</tr>
<tr>
<td>depth</td>
<td>autumn</td>
</tr>
<tr>
<td>0-25</td>
<td>00 1</td>
</tr>
<tr>
<td>25-50</td>
<td>00 4</td>
</tr>
<tr>
<td>50-75</td>
<td>00 0</td>
</tr>
<tr>
<td>75-100</td>
<td>00 0</td>
</tr>
<tr>
<td>Dystric Cambisol Tanakosi</td>
<td>Nitrate bacteria</td>
</tr>
<tr>
<td>depth</td>
<td>autumn</td>
</tr>
<tr>
<td>0-25</td>
<td>00 0</td>
</tr>
<tr>
<td>25-50</td>
<td>00 0</td>
</tr>
<tr>
<td>50-75</td>
<td>00 0</td>
</tr>
<tr>
<td>75-100</td>
<td>00 0</td>
</tr>
<tr>
<td>Nitrite bacteria</td>
<td></td>
</tr>
<tr>
<td>0-25</td>
<td>00 0</td>
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<tr>
<td>25-50</td>
<td>00 0</td>
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<tr>
<td>50-75</td>
<td>00 1</td>
</tr>
<tr>
<td>75-100</td>
<td>00 0</td>
</tr>
</tbody>
</table>

CONCLUSION

On the basis of the obtained results concerning seasonal content of amonificators, cellulose decomposers, free aerobe nitrogen-fixing bacteria (Azotobacterium sp.), and nitrifiers in Vertisol, Pseudogley and Dystric Cambisol, the following might be pointed out: The highest content of the investigated physiological groups in uncultivated soil was observed in Vertisol. In cultivated soil the highest amonificators content was observed in Pseudogley, where had been grown alfalfa for the last three years and where incom of fresh nitrogen-containing organic matter had been greater. That means a grown crop and applied agronomic measures have the effect on microorganism content and activity.

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REZIME

ZASTUPLJENOST, AMONIFIKATORA, CELULORIZATA, AZOTOFIKSATORA I NITRIFIKATORA U NEKIM ZEMLJIŠNIM TIPOVIMA KOSOVA I METOHIEJE

KIKOVIC Đ., RAĐENIĆ Vera2, ĐURIĆ V., DELETIĆ N., ŠANTRIĆ Ljiljana1.
1Poljoprivredni fakultet, Priština; 2Poljoprivredni fakultet, Beograd - Zemun.

Mikrobiološkim proučavanjima su obuhvaćena tri osnovna tipa zemljišta Kosova i Metohije, smonica, pseudoglej i crvenica. Ispitivan i su mikrobiološki profil navedenih tipova zemljišta koja se obrađuju i koja nisu obrađivana (devičansko zemljište). Celulolizatori i amonifikatori su dobro zastupljeni kod ispitivanih zemljišnih tipova Kosova i Metohije dok su azotofiksatori i nitrifikatori znatno manje zastupljeni. Najveću zastupljenost proučavanih fizioloških grupa mikroorganizma srećemo kod smonice, zatim pseudogleja, a najmanje ih je kod crvenice.

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Peryphyton Algae in the System of Djeravica Lakes on the Spring Branch of Erenik

UROŠEVIĆ Violeta,
University of Priština, Faculty of Natural Sciences, Department of Biology, Priština, Yugoslavia

ABSTRACT

During 1996 the presence of peryphyton in three lakes and two arms of the lakes, and in 6 localities of Djeravica lakes, was explored. Total of 239 peryphyton taxon were established: Cyanophyta - 15, Pyrrophyta - 1, Bacillariophyta - 102, Euglenophyta - 10 and Chlorophyta - 111. Each locality is characterized by various structures of Peryphyton (53 - 115 taxons), and by feature of taxons linking with some localities. Qualitative and quantitative dominant Bacillariophyta was the only one present with 5 common taxons: Cymbella gracilis, Frustulia rhomboides var. saxonica f. undulata, Nodium affine var. amphyrhinchus, Pinnularia borealis and Tabelaria flocculosa, present in each locality. Total 48 indicator species were established by saprobological analysis: (xenosaprobic 12, oligosaprobic 15 and betamesosaprobic 21) which are the indicators for water purity. This is confirmed by calculated saprobity index (1,18 - 1,40) and water bonity (I and I - II class).

Key words: Algae, Peryphyton, Djeravica glacial lakes, Saprobity

INTRODUCTION

In the geographic and geologic system Dinaridi spread from Mt. Triglav to the Zeta plain with Skadar lake and to the Metohija valley. Kosmat (1924) included in the Dinaridi a wide Vardar area toward the north-east, which is, according to Cvijić (1924), a transitional area. The south-east border of Dinaridi toward the Rodope massif spread through Thessaloniki bay - South Morava. Dinaridi faces Rodope massif on the line of Medovski bay - Zeta and Skadar plain - Metohija valley (Cvijić, 1899). The main feature of this area, in morphological sense, is limestone as the base that makes the characteristically landscape of karst. This karst consists of carbonate rocks: limestone and dolomites, which crack easily and dissolve equally in the water. In these waters, as the main feature of its mineralisation, is the presence of bicarbonate - calcium - magnesium hardness of water. According to Petrlik (1975) among 180 observed waters of this area, only the one consisted of firmness bellow 100 mg/l of CaCO₃, and 23 waters consisted of firmness from 220 - 880 mg/l, and with alkalinity from 135 - 230 mg/l, giving great sulfate hardness.

The Prokletije Mt. takes a special place in the Dinaridi massive. Marković (1955) explored the area of the Prokletije and marked a group of massive as a separate entirety. It spread from the south and southwest of Dečanska Bistrica toward the west and northwest. It includes Dečanska Mt., Junička Mt. with Rosa Zogo, Vokša Mt., Djeravica Mt., Bogičevica Mt., Maja Rops, Pasji Vrh and Marjaš Mt. Because of intensive glaciation which took place in recent geological past, on these mountains, many mountain lakes used to exist. The proof for this are the traces of old lake beds and plateau of lake bottoms in the places where they do not exist today. But some of them are still present: Djeravica lakes, Nedžinatko, Rdsko and 20 others which are smaller. They are all of glacial origin. They were formed through glacial erosion of soft paleolithic rocks. The surfaces where the waters collect are small and their variations in level depend on precipitation and melting of snow.

Fig. 1. Geografical position of Djeravica Lake
Sl. 1. Geografski položaj jezera na Deravici
The object of our exploring were lakes in Djeravica Mt. complex (2656 m). These lakes are divided into two river basins. On line of lakes consists of spring branch of Kožnjarska Bistrica. The other line consists of spring branch of Erenik. Both rivers flow into the Belt Drin which then flow into the Adriatic sea.

In this paper peryphyton algae which are present in spring branch of Erenik were treated. That complex consists of three lakes: Malo Djeravičko jezero (2360 m), Veliko Djeravičko jezero (2309 m) and Lokva (2270 m). We have also treated the algae from the arms of those lakes.

On geological-tectonic map of Kosovo and Metohija (Industroprojekt, Zagreb, 1974) we can see that Djeravica massive, where these lakes are located, mostly consist of gabbro and diabases and its south slopes consist of rocks mixed out of schists, limestone and dolomites. In pedological sense Djeravica massiv consist of bare rock while the lakes bellow lie on typical rendzina on compact limestone (Pavićević et al., 1974). Because of highly interesting problems some biological researches on high mountain lakes in this part of the Dinaridi were carried out. Petković Smilja and Petković Stevan (1971) did some researching of plankton communities present in Visitor lake. Petković Sm. (1981) also researched of phytoplankton present in Ridsko lake and Bukumirsko lake (Petković S., 1984). The living world of Djeravica lake hasn’t been explored yet, so we decided to do research on peryphyton algae present in these lakes.

**MATERIAL AND METHODS**

The fauna Section of the Faculty of natural Sciences in Priština (Serbia) have organised one week field trip for biologists which were joined experts for environmental protection from Beograd and Novi Sad: Parallel to this, collecting of material used for analysis of algae was carried out. Collecting of peryphyton took place from 30th of July to 4th of August in 1996.

*Fig. 2. Small Djeravica lake*

*Sl. 2. Malo Djeravičko jezero*

*Fig. 3. Big Djeravica lake*

*Sl. 3. Veliko Djeravičko jezero*

I am using the opportunity to thanks my colleague Gordana Ristić, biology student, for her help.

Six localities were explored: 1. Malo Djeravičko lake (2360 m), which is heart-shaped, 50 m in its length, 40 m wide and 20 - 50 cm deep (Fig. 2); Veliko Djeravičko lake (2309 m), 260 m long, 130 m wide and about 8 m deep (Fig. 3); 3. An arm of Veliko Djeravičko lake located 4 m further; 4. An arm of Veliko Djeravičko lake located toward the Lokva lake; 5. Lokva lake (2270 m), 30 m long, 16 m wide and 60 cm deep (Fig. 4); 6. An arm of Lokva lake which is 3

*Fig. 4. Lake Lokva*

*Sl. 4. Jezero Lokva*
RESULTS AND DISCUSSION

During our research on peryphiton, which took place during 1996 on 6 localities of Djeravica lakes and their arms, we have established a total of 239 taxa (Tab. 2). We have classified them in the following sections: Cyanophyta - 15 taxa (6,3%), Pyrrophyta - 1 taxon (0,4%), Bacillariophyta - 102 taxa (42,6%), Euglenophyta - 10 taxa (4,2%) and Chlorophyta - 111 taxa (65,5%). The Bacillariophyta representatives were dominant in each sample, except the Veliko Djeravica lakes where the community of Bacillariophyta - Chlorophyta was equally present with 46 taxa (Fig. 5). Wealth and variety in flora of algae separately reflected through each locality (53 - 115 taxa). But, they were also reflected through the feature of taxa connection in individual locality. Related to this, Malo Djeravčko lake, located on the highest height above sea level (2360 m), have the lowest pH value (7,3), high water temperature (16,0°C) and the biggest number of established taxa (46) tied only with this locality. Veliko Djeravčko lakes is the biggest (260 x 130 m) and the deepest (8 m) one of all in the complex. It is on the second place in number of taxa (94) and taxa characteristic only for this locality (23). It is the reaches locality in flora of Cyanophyta representatives with 9 established taxa. As locality number 3 we marked an arm located 4 m further from Veliko Djeravčko lake. Proximity and connection of localities number 2 and 3 (Tab. 1) is confirmed by small differences in water temperature (1,0°C) and by their pH reaction (0,1 pH units). The differences in structure (77 taxa), decreasing number of taxon (17) and connection of new taxon related to this locality were quite clear. Euglenophyta present in this locality with its 9 taxa takes a special place. Trachelomonas intermedia species together with 7 individually represented taxa of this section which are typical only for this point, were highly present.

Tab. 1. Physical features of water in Djeravica lakes system:

<table>
<thead>
<tr>
<th>LOCALITIES</th>
<th>°C</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malo Djeravčko lake</td>
<td>16,0</td>
<td>7,3</td>
</tr>
<tr>
<td>Veliko Djeravčko lake</td>
<td>10,0</td>
<td>7,7</td>
</tr>
<tr>
<td>Arm of the V. Dj. lake</td>
<td>11,0</td>
<td>7,8</td>
</tr>
<tr>
<td>Arm of the V. Dj. lake</td>
<td>15,0</td>
<td>8,2</td>
</tr>
<tr>
<td>Lokva lake</td>
<td>17,0</td>
<td>8,1</td>
</tr>
<tr>
<td>Arm of the Lokva lake</td>
<td>15,0</td>
<td>7,9</td>
</tr>
</tbody>
</table>
Tab. 2. The systematic inventory of established taxa of periphyton and frequency (scale 1-5) of some species that are the indicators of water saprobity in the complex of Derawica lakes, August 1996.

<table>
<thead>
<tr>
<th>CYANOPHYTA</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calothrix parietina (NÁG.) THURET.</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Chroococcus cohaerens (BRÉB.) (NÁG)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chroococcus limneticus LEMM.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chroococcus turgidus (KÜTZ) NÁG.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cyanothece aeruginosa (NÁG. KROM.)</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dichotrix gypsophila (KÜTZ.) BORN et FLAH</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Merismopedia tenissima LEMM.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td>b</td>
<td></td>
</tr>
<tr>
<td>Microcystis elabens (MENEGH.) KÜTZ.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Oscillatoria anguina (BORY) GOM.</td>
<td>1</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Oscillatoria borneti ZUKAL</td>
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<td></td>
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<td>1</td>
<td></td>
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<tr>
<td>Phormidium autumnale (AG.) GOM.</td>
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<td></td>
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<tr>
<td>Synechococcus aeruginosus NÁG.</td>
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<td></td>
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<tr>
<td>Stigonema informe KÜTZ.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Tolypothrix distorta KÜTZ.</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Tolypothrix lanta WART.</td>
<td>1</td>
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</tr>
<tr>
<td>PYRROPHYTA</td>
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<td></td>
<td></td>
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<tr>
<td>Peridinium wilei HUITF. &amp; KAAS.</td>
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<td></td>
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<tr>
<td>BACILLARIOPHYTA</td>
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<tr>
<td>Amphora ovalis KÜTZ.</td>
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<tr>
<td>Amphora ovalis var. pediculus EHR.</td>
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<tr>
<td>Anomooneis serians var. braehysta (BRÉB.) HUS</td>
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<td>1</td>
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<td>1</td>
<td>X</td>
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<tr>
<td>Caloneis alpestris CL.</td>
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<td>1</td>
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<tr>
<td>Caloneis bacillum (GRUN.) MER.</td>
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<td>1</td>
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<td></td>
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<td>X</td>
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<tr>
<td>Coratoneis arcaeis (EHR.) KÜTZ.</td>
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<td></td>
<td></td>
<td></td>
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<td>X</td>
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</tr>
<tr>
<td>Cyclorella bodanica EULENST.</td>
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<td>1</td>
<td>3</td>
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<td>Cymbella cistula (HEMP.) GRUN.</td>
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<tr>
<td>Cymbella cymbiformis (AG/KÜTZ) V.H.</td>
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<tr>
<td>Cymbella gracilis (RABENH.) CL.</td>
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<td>1</td>
<td>1</td>
<td>3</td>
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<td>X</td>
</tr>
<tr>
<td>Cymbella bebricista (GREG.) GRUN.</td>
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<tr>
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<td>Cymbella perpusilla A. CL.</td>
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<td>Cymbella ventricosa KÜTZ.</td>
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<tr>
<td>Diatoma anceps (EHR.) KIRCHEN.</td>
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<td></td>
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<tr>
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<tr>
<td>Ennottia arcus var. bidens GRUN.</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Ennottia bidensula W. SM.</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ennottia bigibba KÜTZ.</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ennottia bigibba var. pumila GRUN.</td>
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<tr>
<td>Ennottia diodon EHR.</td>
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<td><em>Pediasia braunii</em> WARTM.</td>
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<td><em>Penium spirastriatum</em> BARKER</td>
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<td><em>Pleurostaonia minutum</em> (RALFS.) DELP.</td>
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<td><em>Semenesimus sp.</em></td>
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<td><em>Staurastrum diplanctatum</em> De NOT</td>
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<td><em>Staurastrum gribaldii</em> SKUJA</td>
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Cca. 180 m long arm of Veliko Djeravičko lake, located only few meters beneath Lokva lake, is marked as locality number 4. Its water has fast flow because of altitude drop about 30 m and bottom overgrown with mose. Water temperature was high (15.0°C) for mountain conditions, but it had the highest pH value (8.2) which points out on mild alkaline milieu. It is highly possible that this type of ecological conditions restrict the survival of larger types of algae, but also causes species adaptation to this specific conditions. In addition to this conclusion we added fact that its waters were very poor in flora, 53 taxons of individually represented algae and 18 taxons related to this locality only. Comparing with other two lakes the altitude of Lokva lake is the lowest (2270 m). The lake is well insolated and the highest temperature of water (170°C) is caused by dark muddy bottom. Sixty two separately present taxons and two frequently present xenosaprobiic species: Cymbella gracilis and Navicula rotula, were found in calm waters of the Lokva lake. From the total number of found species, only 8 taxons were typical for this locality. Locality number 6 is situated few meters from the flow out of Lokva lake. Comparing with the arms number 3 and 4 where the number of taxons drastically decreases in comparison with previous locality, the number of taxons in this locality is increasing (60 taxons) for 18 taxons in comparison with Lokva lake. In communities of Bacillariophyta (4 taxons), Chlorophyta (7 taxons) and Euglenophyta (1 taxon) 12 new taxons which are characteristic only for the conditions of this domicile were established. Clear, clean and by appearance lifeless waters of Djeravica lakes, are very rich in separately present taxons, but on the other hand only 5 taxons (2%) of total structure were common for all localities: Cymbella gracilis, Frustulìa rhomboides var.
REFERENCES


Cvijić J., 1924. Geomorfologija, Knj. 1, Beograd.


REZIME

OBRAŠTAJNE ALGE U SISTEMU DERAVIČKIH JEZERA NA IZVORIŠNOM KRAKU ERENICA
UROŠEVIĆ Violeta

U letnjem periodu 1996. godine istraživane su obraštajne alge glacijalnih jezera (Malo Deravićko, Veliko Deravićko i Jezero Lokva) i otoke (dve otoke na tri lokaliteta) u kompleksu Deravičkih jezera (Fig. 1 - 4). Istraživani lokaliteti razlikovali su se međusobno u kvalitativnom i kvantitativnom sastavu obraštajnih algi i nezнатно u fizičkim faktorima sredine (Tab. 1 i Tab. 2). Flori algi bila je bogata a brojem taksona dominirali su predstavnici razdela Chlorophyta (111 taksona) i Bacillariophyta (102 taksona). Razdeli Cyanophyta, Euglenophyta i Pyrophyta bili su slabije zastupljeni. Od jezera najbogatiju floru i vegetaciju obraštajnih alg imalo je (Fig. 5) Malo Deravićko (115 taksona), koje je najviše locirano (2360 m n.m.), ima najnižu pH vrednost vode (7,3) i najveći broj taksona (46), vezanih samo za ovaj lokalitet. Florno najsrošašnija u taksonima (53) je otoka velikog Deravičkog jezera, pre uliva u Jezero Lokva (lokalitet 4). Voda do ovog lokaliteta ima visinski pad od oko 30 m, brzi protok i najveću vrednost aktivne reakcije (pH 8,2). To pokazuje da dejstvo faktora sredine omogućava i reakciju zajednice alg na specifične uslove života, ali, istovremeno, deluje ograničavajuće na brojnu zastupljenost taksona u obraštaju. Istraživana glacijalna jezera i njihove otoke u kompleksu planine Deravice (2656 m n.m.) imaju visinski položaj (2360 - 2270 m n.m.) koji ih svrstava u najviša jezera Jugoslavije. Za klimatske prilike koje karakterišu takva područja na istraživanim lokalitetima Deravice utvrdili smo relativno visoke temperature vode (10,0 - 17,00 C). Njihove visoke vrednosti možemo dovesti u vezu sa jugoistočnom ekspozicijom jezera, dobroj osušćenosti, ali je verovatno da najsnažniji uticaj ima tamna podloga koju čine stene vulkanskog porekla izgradjene pretežno od gabra. Na dobar kvalitet vode ovih jezera i njihovih otoke (I i II i- II klase) ukazuju alge indikatori saprobnosti vode (kseno 12, oligo 15, beta 21), njihova učestalost po lokalitetima i izraženata saprobnost koja ne prelazi vrednost indeksa od 1,40. Na osnovu iznjenih rezultata možemo zaključiti da kompleks Deravičkih jezera i njihovih otoke predstavlja izuzetno bogatu životnu sredinu obraštajnih alg. Ova jezera treba i dalje istraživati sa više aspekata, a kao retka prirodna blaga sačuvati i zaštiti.

Translated by Nikoleta Bašić

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Contribution to the Flora of Djeravica Mountain (I)

1Krišović Zoran and 2Ranđelović Novica
1Institute of Biology, Faculty of Natural Sciences and Mathematics, University of Priština
2Faculty of Technology Leskovac, University of Niš

ABSTRACT

The authors started studying the flora of Mt. Djeravica in 1978 on mapping the vegetation of the Mt. Prokletije. On this occasion they are presenting a part of results from that research.

Key words: Vascular plants, Djeravica Mt.

INTRODUCTION

Mt. Djeravica belongs to the volcanic massif of the central Prokletije. It stretches between 42 and 43° of the northern geographical latitude and between 20 and 21° of the eastern geographical longitude. From the Metohia plain (500 m above sea level) to the peak of Mt. Djeravica (2656 m) there is a height difference of 2156 meters. The geological substratum of Mt. Djeravica is made of the silicates (diabase, gabbro, granite), while from the southern side one of the smaller ridges is made of the limestones (dolomites). From foot to peak the soil, too, is zonally developed. Among the most wide-spread types are the brown podsol, sour humus, and the humus silicates. With the difference in height there are encountered the various types of climate, from foot to peak: the changed Mediterranean climate, moderate continental climate, mountain climate, and Arctic and Alpine climate.

As a result of the interaction of the various geological features, pedological composition and climatic conditions there has developed the diversified vegetation (Tab. 1) and also the very interesting diversity of the flora with numerous endemic and relict species.

MATERIAL AND METHODS


RESULTS AND DISCUSSION

During floristical investigations of Mt. Djeravica following species was found (species have been listed in the alphabetical order):

Acer campestro L.
A. heldreichii Orph.
A. pseudoplatanus L.
A. tataricum L.
Achillea tanacetifolia All.
Aconitum lasannae Rchb.
Agrostis rupestris All.
Ajuga genevensis L.
Alopecurus gerardii Vill.
Alyssum montanum L. ssp. scardicum (Wettst.) Hay.

<table>
<thead>
<tr>
<th>Silicates</th>
<th>Limestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranunculon crenata Lakušić 1966</td>
<td>Pinetum biberichii breticum Blečić 1959</td>
</tr>
<tr>
<td>Seslerion comosae Ht. 1935</td>
<td>Sosero autumnalis-Fagetum ( \text{Ht. 1950} ) M. Wraber 1957</td>
</tr>
<tr>
<td>Jasionion orbiculatae Lakušić 1966</td>
<td>Sosero-Ostryetum Ht. et H-Ić 1950</td>
</tr>
<tr>
<td>Bruckenthalion spiculifolii Ht. 1949</td>
<td>Fagetum moesiaca mothulatum Bleč et Lakušić 1970</td>
</tr>
<tr>
<td>Pinetum peucis breticum Lakušić 1974</td>
<td>Dioecologia-Carpetum orientalis Blečić et Lakušić 1966</td>
</tr>
<tr>
<td>Piceo-Pinetum peucis Lakušić 1965</td>
<td>Querceto-Castanietum submediterraneum Wraber 1954</td>
</tr>
<tr>
<td>Abiet-Fagetum moesiaca B. Jov. 1953</td>
<td>Querceto-Castanietum moesiaca Glišćic</td>
</tr>
<tr>
<td>Querceto-Acorion bicani Lakušić 1974</td>
<td>Salicetum albo-frafitis s.l.</td>
</tr>
</tbody>
</table>

Table 1. The vegetation belts of Mt. Djeravica (Lakušić et al. 1974)
Androsace bedreantba Gris.
Anemone narcisiflora L.
A. nemorosa L.
Angelica pancicii Vandas
Antennaria dioica (L.) Gäertn.
Antennaria carpathica Willd.
Aphyllis montana L.
Arabis alpina L. ssp. flavescens (Gris.) Hay.
Artemisia petrosa (Baumg.) Fritsch
Asarum europaeum L.
Asperula longiflora W.K. var. condensata Heldr.
A. cynanchica L.
Asperula bellidiflora (L.) Scop.
Atamantha turbit (L.) Broch. ssp. baywaldii
(Boh. et Uchr.) Tutin
Avena versicolor Vill.
Barbarea balcana Panč.
Brickenthalia spiculifolia (Salisb.) Rchb.
Calamintha alpina (L.) Lam.
C. grandiflora (L.) Mch.
C. vulgaris (L.) Druce
Campanula scheuchzeri Vill.
Carex atrata L.
C. leveis Küt.
Cardamine glauca Spreng. f. pumila
(O.F.Schult.) Dunjic
Carduus scardicus (Gris.) Wettst.
Carpinus orientalis Mill.
Caryum rupestre Boiss. et Heldr.
Centaurea nervosa Willd.
C. splendens L.
C. triumfettii All.
Cerastium cerastoides Britton
C. lanatum Lam.
Colutea arborescens L.
Corydalis solida (L.) Sw. ssp. densiflora
(Persl.) Hay.
Corydalis trifida Chtel.
Coronilla emerus L.
Coronilla avellan L.
C. colurna L.
Crataegus monogyna Jacq.
Crocos vernus Herb.
Daphne mezereum L.
Deschampsia flexuosa Trin.
Diandus deltoides L.
D. paniculii Vel.
D. sylvestris Ewulf.
Draba korabensis Küm. et Deg.
D. scardica (Gris.) Deg. et Döfl.
Drosera octopetala L.
Edraianthus graminifolius (L.) DC. subvar.
baldacii (L.) DC.
E. montenegrinus Horak
Erigeron polymorphus Scop.
E. uniflorus L.
Euphrasia minima Jacq.
Festuca amelobystina L.
F. duriuscula L.
F. balleri All.
F. paniculata (L.) Sch. et Thell.
F. violacea Gaud.
Fraxinus excelsior L.
F. ornus L.
Genista ovata W.K.
Gentiana asclepiadea L.
G. kochiana Perr. et Song.
G. nivea L.
G. puncatula L.
G. utriculosa L.
G. vertic L.
Geranium coeruleatum Schur.
G. sylvaticum L.
Geum coccineum S.S.
G. montanum L. f. minor (pers.) Bmg.
Globularia cordifolia L. ssp. bellidifolia
(Ten.) Wettst.
Jasione orbiculata Gris.
Juniperus nana Willd.
Juglans regia L.
Juncus trifidus L.
J. monanthes Jacq.
Knausia midzorensis Form.
Leontodon montanus Lam. var. rilaensis
(Hay.) Gajic
Leucorchis friealidii (Hampe) Schlechter
Lilium albanicum Gris.
L. martagon L.
Linum elegans Spr. ex Boiss.
Melampyrum scardicum Wettst.
Melittis meleagris L.
Minuartia recurva (All.) Schinz. et Thell.
Moneses uniflora (L.) A. Gray
Monotropa hypopitys L.
Myosurus murale Rchb.
Nardus stricta L.
Onobrychis montana DC. ssp. scardica
(Gris.) Ball.
Oxyria digyna (L.) Hill.
Pedicularis petiolaris Ten.
Phyteuma confluens A. Kern.
Plantago atrata Hoppe
Poa nemoralis L.
P. pumila Host.
P. violacea Bell.
Pinguicula lepiceras Rchb.
Polystichum lonchitis (L.) Roth.
Potentilla ternata K. Koch
Pulsatilla montana (Hoppe) Rchb.
P. vernalis L.
Polygonum alpinum All.
P. viviparum L.
Presanthes purpurea L.
Primula minima L.
Ramischia secunda (L.) Opiz
Ranunculus crenatus W.K.
CONCLUSION

On the basis of the many years' (and still insufficient) research, the authors are of the following opinion: - floristically, Mt. Djeravica is one of the most interesting mountains within the Prokletije complex; - by partial literary and field (in 1978, 1987 and 1996) research work there has been collected the ample material, on the basis of which 159 species have been identified in this paper; - it is necessary to continue this work, because Mt. Djeravica area is very rich in the above species.

REFERENCES


REZIME

PRILOG FLORI PLANINE DERAVICE (I)

KRIVOŠIĆ1 Zoran i RANDOLOVIĆ2 Novica

1Institut za biologiju, Prirodo-matematički fakultet, Univerzitet u Prištini 2Tehnološki fakultet Leskovac, Univerzitet u Nišu

Vulkanski masiv Deravice pripada centralnim Prokletijama. Proteže se između 42-43o severne geografske širine i 20-21o istočne geografske dužine. Od metolijeske ranine (500 m n.v.) do vrha Deravice (2656 m n.v.) postoji visinska razlika od 2156 m. Geološku podlogu Deravice čine silikati (dižabaz, gabro, granit), dok sa južne strane jedan manji greben je građen od kreučnaka (dolomiti). Od podnožja prema vrhu i zemljište je zonalno razvijeno. Među najrasprostranjenijim tipovima su smeđa podzolasta zemljišta, pa kiseluhumusna zemljišta i humusna silikatna zemljišta. Na visinskoj razlici susrećemo različite tipove klime. Od podnožja ka vrhu: izmenjenošilernarska klima, umereno kontinentalna klima, planinska klima, arktoklipska klima. Kao rezultat interakcije raznovrsnih abi-

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August Aspect of the High-mountain Vascular Flora of the Djeravica Volcanic Massif

AMIDZIC Lidija and KRIVOSEJ Zoran
Institute of nature Conservation of Serbia, - Faculty of Mathematics, University of Pristina
Faculty of Mathematics and Natural Sciences, University of Pristina

ABSTRACT


Djeravica occupies large part of the central Prokletije territory, representing the highest mountain massif of Yugoslavia and the largest silicate massif of southeastern Dinarides too. Due to its inaccessibility, high-mountain flora of the highest volcanic parts of Djeravica has been fragmentarily studied only. Thus, the paper represents an attempt of its overall presentation.

Key words: Djeravica, volcanic massif, flora

INTRODUCTIONS

Prokletije represents the huge mountain system in the Balkan peninsula, located between the Dinarides continuing toward northwest, the Sar - Pindus mountain system at southeast and Rhodopes at east and northeast. These "South-European Alps" consists of some 40 marking wholes divided by deep valleys and gorges. Yugoslav, the southwestern Prokletije respectively, are divided into the northern, Mid and southern mountain group. Djeravica belongs to the southern group, representing the highest massif of Yugoslav Prokletije, but, at the same time, the largest massif of the southeastern Dinarides too. This massif, with its eastern and northeastern sides, inclines pyramidal above the Metohian flat reaching the height of 2,656 m/a/s/l.

The toothed peaks, sloppy cliffs, spurious circues, moraines and numerous glacial lakes of the highest parts of Djeravica are the characteristics of its glacial morphology that gives a specific severe appearance. From the geologic point, the largest part of the massif's high-mountain zone is made of diabase and gabbro. The northern part of the slope is made of granite only, while, toward south, it continues with zone of schist, marble limestone and dolomites. Although rocky ground and bare rock masses predominate, shallow pedologic substrate, represented by humus silicate soil on diabase and gabbro, acid humus silicate soil on granite and hydrogen humus soil around the high-mountain tresava, appear in the zone from place to place.

High-mountain area of Djeravica is characterized by the domination of Prokletije variant of Arctic-Alpine climate, within which, a climate of firm snow and ice in northern exposed circues and snow packs conditioned locally - morphologically, expresses its full severeness.

Specific flora presenting the results of, not only, severe environment, but the historical factor, specific geographic position and anthropo-genic influence too, appears in such frames of the surrounding area. Unfortunately, the flora of Djeravica, at present, has been researched partially only. This, precisely, induced our interest to implement some more detailed research of its most attractive part that covers the massif of Velika (Great) Djeravica and its west circue with Veliko and Malo (Great and Small) Djeravica lakes in.

MATERIAL AND METHODS

Herbal material from Djeravica was collected and herbariumed by the beginning of August 1996. The check-up of the herbariumed material was done with the assistance of voluminous literature for the determination of vascular flora. Determination of floral elements affiliation was done according to M. Gajic (1980).

RESULTS AND DISCUSSION

The area, from which the herbal material was collected, covers a spacious west circue of Djeravica with the Veliko (2,309 m/a/s/l) and Malo (2,360 m/a/s/l) Djeravica lakes, as well as, from the ridge of surrounding crests. Velika (Great) Djeravica (2,656 m/a/s/l) with its marking inclination above the Great lake, Veliki Krs (Great Rocks 2,502 m/a/s/l) with its vertical rocks above the spring part of Erenik river and the saddles, so called, Zeleni Krs (Green Rocks 2,505 m/a/s/l) of the northwestern direction connecting Crni Krs (Black Rocks) with Velika (Great) Djeravica, Dominate within the bordering crest.
According to the latest field research (Mijatovic, 1997), the bottom of the circue with the Veliko (Great) and Malo (Small) Djeravica lakes in, as well as, the system of high-mountain meadow bogs with Lokva as the largest, are made of gabbro spreading toward west in the bottom of Velika (Great) Djeravica up to the bottom of Crni Krš (Black Rocks). The diabase gradually developed from gabbro, are significantly more dispersed, primarily making up Velika (Great) Djeravica massif and surrounding crests. On the circue borders, especially toward the Zeleni Krš (Green Rocks) saddle, diabase and gabbro gradually transfer into green schist belonging to eastern part of Paleozoic series.

**Figure 1.** A part of Djeravica with florist research made.

**Figure 2.** Peak of Velika Djeravica

**Slika 1.** Deo Deravice na kojem su obavljena floristička istraživanja R 1:25000

**Slika 2.** Vrh Velike Dervaise

**Figure 3.** Veliko and Malo Djeravica lake

**Slika 3.** Veliko i Malo Deravičko jezero

**Figure 4.** One of the recent Snow-packs of Djeravica

**Slika 4.** Jedan od recentnih snežnika Deravice
From the biogeographic point, the area belongs to Dinaride province that is connected with the highest regions of Dinaride mountains of Durmitor, Bjelasica, Komovi, Prokletije. Also, the area covers eco-systems of mountain turfs, snow-packs and rocks, especially in the cirkuses (Stevanovic, 1995). The province belongs to Mid-European mountain sub-region of Mid-South-European mountain biogeographic region that is analogue to high-mountain and Nordic tundra biome, i.e., to Alpine - High-Nordic rocks grounds, pastures, snow-packs and rocky meadows (Matvejev, Puncer, 1989).

Within the area mentioned, the vegetation of high-mountain turfs and meadow bogs, rocky grounds, snow-packs and in the rock-cracks is developed and has the structure of eco-tone due to mosaic schedule, providing the registration, by the beginning of August, of 107 species of vascular flora, affiliated into 36 families:

Fam. Ophioglosaceae
  Botrychium lunaria (L.) Sch.
  Fam. Hypolepidiaceae
  Pteridium aquilinum (L.) Kuhn.
  Fam. Aspleniaceae
  Asplenium trichomanes L.
  Fam. Athyriaceae
  Cystopteris fragilis (L.) Bernh.
  Fam. Aspidiaceae
  Polystichum lonchitis (L.) Roth.
  Fam. Cupresaceae
  Juniperus sibirica Burgs.
  Fam. Ranunculaceae
  Ranunculus montanus Willd.
  Ranunculus nemorosis DC.
  Ranunculus crenatus W.K.
  Fam. Caryophyllaceae
  Paronychia kapela (Haq.)Kern.
  Cerastium alpinum L.
  Cerastium lanatum Lam.
  Cerastium cerastoides (L.) Brilt.
  Minuartia recurva (All.) Sch. et Thell.
  Dianthus cruentus Gris.
  Dianthus deltoides L.
  Silene vulgaris (Moench)Garcke
  Silene sendinerti (Boiss.) Jord. et Pan.
  Silene deoerleri Nik., Lak., Stev. et Bul.
  Silene pusilla WK. subsp. monachorum (Vis.)Neum. Scleranthus annus L.
  Fam. Polygonaceae
  Rumex acetosella L.
  Fam. Plumbaginaceae
  Armeria alpina (DC.) Willd.
  Fam. Hypericaceae
  Hypericum alpinum W.K
  Fam. Brassicaceae
  Cardamine glauca Sprng.
  Draba korabensis Kum. et Deg.
  Barbarea balcanica Panč.
  Arabis alpina L. var. flavescens Gris.
  Fam. Vaccinaceae
  Vaccinium uliginosum L.
  Vaccinium myrtillus L.
  Fam. Empetraceae
  Empetrum nigrum L.
  Fam. Primulaceae
  Androsace bedræntba Gris.
  Primula minima L.
  Fam. Rosaceae
  Geum montanum L.
  Potentilla ternata K.Koch.
  Fam. Malaceae
  Cotoneaster integrifolius Med.
  Fam. Crassulaceae
  Jovibarba beuffelli A. et D. Love
  Sempervivium kosanini Vraeg.
  Sedum hispanicum L.
  Sedum acre L.
  Fam. Saxifragaceae
  Saxifraga pedemontana All. subsp. cymosa (W.K.)Engel.
  Saxifraga moschata Wulf.
  Saxifraga aizoon Jacq.
  Saxifraga adscendens L. ssp. adscendens Hay.
  Saxifraga carpatica Rchb.
  Saxifraga rotundifolia L.
  Fam. Fabaceae
  Trifolium repens L.
  Lotus corniculatus L.
  Fam. Oenotheraceae
  Epilobium anagallidifolium Lam.
  Fam. Geraniaceae
  Geranium cordaeatum Shur.
  Fam. Apiaceae
  Ligusticum mutellina (L.)Crantz.
  Pimpinella alpina Host.
Fam. Gentianaceae

*Gentiana kochiana* Perr. et Song
*Gentiana punctata* L.
*Gentianella crispa* (Vis.) Holub f. crispa

Fam. Rubiaceae

*Galium anisophyllum* Vill.
*Galium elongatum* Vill.
*Asperula cynanchica* L.

Fam. Boraginaceae

*Myosotis alpestris* Schm.

Fam. Scrophulariaceae

*Veronica bellidoides* L.
*Veronica teucrium* L.
*Wulfenia blecicci* R. Lak.
*Pedicularis verticillata* L.
*Scrophularia vernalis* L.
*Euphrasia minima* Jacq.

Fam. Lentibulariaceae

*Pinguiicula vulgaris* L.

Fam. Lamiaee

*Lamium gargaricum* L.
*Ajuga pyramidalis* L.
*Calamintha alpina* (L.) Lam. subsp. alpina
*Thymus ceblerioides* Vis.

Fam. Campanulaceae A. L. Juss.

*Phyteuma confusum* A. Kern.
*Phyteuma pseudodoriculare* Pant.
*Edraianthus monenegrinus* Horak.
*Campanula rotundifolia* L.

Fam. Asteraceae

*Homogyne alpina* Cass.
*Anthemis carpatica* Willd.
*Achillea lingulata* W.K.
*Antennaria dioica* (L.) Goerth.
*Erigeron uniflorus* L.
*Centaura myosuroides* Willd.
*Artemisia petrosa* (Baumg.) Frits.
*Adenostyles alliaria* (Gouan) Kern.
*Hypochaeris maculata* L. subsp. pelivanovicii
Petrov. var. korinicensis Hay.
*Hieracium gutbickiamum* Heg. et Heer.
*Leontodon montanus* Lam. var. rilaensis (Hay.)

Gajić

*Taraxacum officinale* Web., Wigg.
*Senecio carpaticus* Herb.

Fam. Liliaceae

*Veratrum album* L.

Fam. Alliaceae

*Allium sibiricum* L.

Fam. Juncaceae

*Juncus trifidus* L.
*Luzula sudetica* (Willd.) DC.
*Luzula spicata* (L.) Lam.

Fam. Cyperaceae

*Carex sempervirens* Vill.
*Carex curvula* All.
*Carex atrata* L.

Fam. Poaceae

*Nardus stricta* L.
*Poa bulbosa* L. f. vivipara
*Poa ursina* Vel.
*Poa pumila* Host.
*Agrostis rupestris* All.
*Alopecurus gerardii* Vill.
*Avena versicolor* Vill.
*Deschampsia caespitosa* (L.) J普.
*Festuca scardica* Gris.
*Festuca varia* Haenke
*Festuca alpestris* Sink.
*Sesleria conosa* Vel.

The list enclosed indicates that the largest number of species are presented in the family of Asteraceae (13 species), Poaceae (12 species) and Caryophyllaceae (12 species).

The analysis of this part of the Djeravica high-mountain flora indicates the greatest presence of the Mid-European mountain elements (MEM) with 37 species, 34.58% respectively. The South-European mountain (SEM) elements further dominate with 26 registered species making up 24.30% (Figure 1). The Euro-Asian (EU - 14.02%), the Arctic - Alpine (Ar.-Alp. - 6.54%), the Circum-Polar (CIRP - 6.54%), the Circum-Boreal (CIRB - 5.61%), Holo-Arctic (HOL - 3.74%), the Boreal-Sub-Boreal (0.93%) flora elements, as well as, the cosmopolites (3.74%), follow up. The domination of the Mid-European mountain plants, that migrated to the Balkan, through the Alps, during the last glaciation, together with the Circum-Boreal and the Arctic-Alpine species, indicates the glacial, refugee character of this part of Prokletije. However, ancient Tertiary oro-phytes also implemented their continued development on Djeravica, proved by a significant participation of the South-European mountain species, mostly of an endemic character. Especially significant are, as follows: Prokletije (Silene doerfleri, Wulfenia blecicci), Dinarides (Edrianthus monenegrinus, Silene pusilla ssp. Monachorum), Dinarides - Balkan endemic (Phyteuma pseudodoriculare, Hipochoeris masculata ssp. Pelivanovicici, Poa ursina, Festuca scardica, Semprevium kosaninii, Silene sendtneri), but, also, Carpathian - Balkan sub-endemic (Jovibarba heuffelli, Anthemis carpatica, Saxifraga pedemontana ssp. Cy-
mosa, Lamiunum garanicum). A significant inflow of the Euro-Asian, Hol-Arctic and cosmopolitan elements simultaneously confirms the openness of the area toward wider influences, contributing to their florist resource.

**CONCLUSION**

Djeravica represents the highest massif of Yugoslav part of Prokletije and of Yugoslavia as a whole too, but, also is the largest silicate massif of the southeastern Dinardies too.

In the highest parts of the massif, mostly built of diabase and gabbro, glacial morphology dominates and Prokletije type of Arctic - Alpine climate prevails. Within significantly severely high-mountain conditions, by the beginning of August, the presence of 107 species of vascular flora, grouped in 36 families, were registered. The largest number of the species belongs to the Mid-European mountain, the South-European mountain, the Euro-Asian and the Arctic - Alpine elements.

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**REZIME**

AVGUSTOVSKI ASPEKT VISOKOPLANINSKE VASKULARNE FLORE VULKANSKIH MASIVA DERAVICE

Amidžić1 Lidlja i Kravošij2 Zorin

1 Zavod za zaštitu prirode Srbije, Prirodno - matematički fakultet Univerziteta u Prištini

2 Prirodno - matematički fakultet Univerziteta u Prištini

Prokletije predstavljaju najgorostasniji planinski sistem na Balkanskom poluostrvu smešten između Dinarida koje se na njih nastavljaju prema severozapadu, Sarško - pindskog planinskog sistema na jugoistočku i Rodopu na istoku i severoistočku. Ovi "južnoevropski Alpi" sastoje se od oko 40 markantnih celina raspravljenih dubokim dolinama i klišurama, Jugoslovenske, odnosno, severozapadne Prokletije, dele se na Severnu, Srednju i Južnu planinsku grupu. Deravica pripada Južnoj grupi predstavljajući najviši masiv jugoslovenskih Prokletija i Jugoslavije, ali i najveći silikatni masiv jugoistočnih Dinarida. Ovaj masiv se svojim istočnim i severoistočnim stranama piramidalno izdiže iznad meteoljske ravnice dosežući visinu od 2656 m.

Nazubljeni vrhovi, smeri ljilje, prostrani cirkvi, morene i mnogobrojna glacialna jezera najviših de-
lova Deravice, odraz su njene glacijalne morfologije koja joj daje specifičan surov izgled. U geološkom pogledu najveći dio visokoplaničke zone masiva je izgrađen od dijabaza i gabra. Jedino do severnog padina izgrađuje granit na koji se prema jugu nastavlja zona škriljaca, mermerastih krečnjaka i dolomita. Mađa preovlađuju kamenjari i površine gotovih stenskih masa, u ovoj se zoni mozaično javlja i plitak pedološki supstrat predstavljen humusnim silikatnim zemljištima na dijabazu i gabru, kiselim humusnim silikatnim zemljištima na granitu i hidrogenom humusnim zemljištima oko visokoplaničkih tresa (Lakušić, R. et al., 1974).

Visokoplanički pojas Deravice se karakterište dominacijom proktetijske varijante arkto-alpske klime u okviru koje svoju punu surovost pokazuje lokalno morfološko uslovljeno klima većnog snega i leda u severno eksponiranim cirkovima sa recentnim snežanicima.

Prostor sa kojeg je sakupljan bijen materijal obuhvata prostani zapadni cirk Deravice u kojem je smešteno Veliko (2309 m n.v.) i Malo (2360 m n.v.) Deravički jezero kao i venac okolnih grebenja. U okviru ovog obodnog grebena dominira masiv Velike Deravice (2656 m n.v.) koji se markantno izdiže iznad Velikog jezera, Črni krš (2592 m n.v.) sa svojim vertikalnim liticama iznad izvorišnog dela Erenika i pre-sedlina, tokozvan, Zeleni krš (2505 m n.v.) severozapadnog pravca pružanja koja povezuje Črni krš sa Velikom Deravicom.

Prema najnovijim terenskim istraživanjima (Mićojević, 1997), dno cirksa u kojem se nalaze Veliko i Malo Deravičko jezero, kao i sistem visokoplaničkih livadskih tresa sa Lokvom kao najvećem, izgrađen je od gabra i koji se od podnožja Velike Deravice pružaju prema zapadu, do podnožja Crnog krša. Dijabazi, koji su se postepeno razvili od gabra, imaju znatno veće rasprostranjenje gradeći pre svega, Masiv Velike Deravice i okolne grebenje. Po obodu cirksa, posebno u pravcu presedline Zeleni krš, dijabazi i gabra postepeno prelaze u zelene škriljice koji pripadaju istočnom delu paleozojske serije.


U okviru navedenog prostora razvijena je vegetacija visokoplaničkih rudina, livadskih tresa, kamenjara, snežanika i u pukotinama stena koja usled mozaičnog rasporeda ima strukturu ekotona u kojem je početkom avgusta registrovano 107 vrsta vaskularne flore svrstanih u 36 familija. Na najvećim brojen vrsta su zastupljene familije Asteraceae (15 vrsta), Caryophyllaceae (12 vrsta) i Poaceae (12 vrsta).

Analiza visokoplaničke flore ovog dela Deravice pokazuje da su najzastupljeniji srednjeevropski planinski elementi (SEP) prisutni sa 37 vrsta, odnosno, 34,58%. Iza njih dominiraju južnoevropski planinski elementi (JEP) koji sa 26 registrovanih vrsta čine 24,30% (sl. 1). Sljede evroazijski (EVR - 14,02%), arktičko - alpski (Arkt - Alp - 6,54%), cirkumpolarni (CIRK - 6,54%), cirkumborealni (CIRKBOR - 5,61%), holarktički (HOL - 3,74%), borealno - subborealni (0,93%) i elementi flore kao i kosmopoliti (3,74%). Dominacija srednjeevropskih planinskih biljaka koje su na Balkan migrirale preko Alpa tokom zadnje glaciacije, zajedno sa cirkumborealnim i arktičko - alpskim vrstama, ukazuje na glacialno-refugijalni karakter ovog dela Prokletjesa. Međutim, na Deravici su svoj kontinuirani razvoj ostvarile i drevne tercijske orlošite o čemu vjerojatno značajno učešće vrsta južnoevropskih planinskih vrsta koje uglavnom imaju endemično obeležje. Posebno su značajni proktetijski (Silene doerffleri, Wulfenia blecici), dinarski (Edravanthus montenegrinus, Silene fusilis sp. monacorum), dinarsko-balkanski endemiti (Phyteuma pseudoboricula, Hipochoeris maculata sp. pelvianovici, Poa urnsa, Pesuca scaratica, Semprevivum kosaninti, Silene sendlneri), ali i kardato-balkanski subendemiti (Jovibarba bejfolii, Anthemis carpatica, Saxifraga pedemontana sp. cymosa, Lamium garrancicum). Značajan uticaj evroazijskih, holarktičkih i kosmopolitnih elemenata istovremeno govori o otvorenom ovog prostora prema mnogo širim uticajima što doprinosi njihovom florističkom bogatstvu.

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Saxifragetum cymosae - a New Chasm-phyte Community on the Metohian Prokletije

1AMIDZIC Lidija and 2 STEVANOVIC Vladimir
1The Institute for Protection of Nature of Serbia, Faculty of Mathematics and Natural Sciences, University of Pristina
2Institute of Botany and Botanical Garden, Faculty of Biology, University of Belgrade

ABSTRACT


Key words: new association, Djeravica, Prokletije

INTRODUCTION

The grandiose massif of Prokletije, properly named by Cvijic as The Balkan Alps, has always attracted the botanists. During the expeditions, dating the end of the past and the beginning of this century, over 20 new species were described by scientists, of which, the majority percentage were the local endemic dispersed on this mountain massif only. Also, great number of new communities of endemic character were described within the vegetation research.

Present analyses of the Balkan high-mountain flora indicated that the great massif of Prokletije, on Yugoslavia and Albania border, is the richest on the Peninsula. The flora recorded at the heights over 1500 m only, accounts for over 700 species of vascular plants (Stevanovic, V., 1996). However, although thanks to numerous papers (Bladacc, A., 1900, Hayek, A., 1917, Kosanin, N., 1922, Grebenscikov, O., 1943, Diklic, et Nikolic, 1961, Rudski, I., 1949, Stevanovic, V., 1996, Jankovic M. M., 1958, Kusan, F., 1953, Blecic, V., 1961, Lakusic, R., 1968, Cernjavski, P., 1974) on the plant world of the massif most of the facts are relatively known, the fact is that, Prokletije is still one of the least researched mountains on the Balkan Peninsula from the florist and vegetation point. The reason for is not because of less visits to the mountain, but, first of all, in its size and area, as well as, in its inaccessibility and severe relief of dramatic plasics.

One of the least researched parts of Prokletije is the grandiose massif of Djeravica, whose high-mountain flora and vegetation, except in one paper (Lakusic, R., Gragic, P. et Medjedovic, S., 1974), was at present only partially presented, within the frame of general presentations of the overall area of Prokletije, the Dinarides, respectively. This paper presents the contribution to more concrete and precise introduction to a very complex and diverse high-mountain vegetation of this hardly accessible part of Prokletije.

MATERIAL AND METHODS

The phyto-cenologic research of the Djeravica high-mountain vegetation were done by a standard method of Zurich - Montpelier School (Brown-Blanquet, 1952). The floral element analysis was done on the basis of Walter & Struck (1970) division, amended by Landault & Hess et Hirzel (1967–1972) and Stevanovic (1992). The plant living forms were given according to Ellenberg & Mueller - Dambois (1967).

RESULTS AND DISCUSSION

Representing a part of South-eastern Dinarides, Prokletije, as "the most giant mountain group on the Balkan Peninsula" (Cvijic, 1913), belongs to a wider area of the Mediterranean zone of younger range mountains.

These are the mountains located at the border of the Adriatic Sea in the central part of the Balkan Peninsula. Yugoslav, northwestern Prokletije respectively, are divided into the Northern, the Mid, and the Southern mountain group.

The volcanic massif of Djeravica with Bjelic, Karanfil, Trojon, Popadia and Bogicevica as general oro-morphological zones, makes up the Southern mountain group, building up the range 70 km long, along the border of Albania. Rising above the Metohian flat up to the height of 2,656 m, the mountain range represents the tallest silicate massif of the Southeastern Dinarides, but, the tallest massif of Yugoslavia too. The
### Tab.1

**Asocijacija**

<table>
<thead>
<tr>
<th>NUMBER OF SAMPLE</th>
<th>REDNI BROJ SNIMKA</th>
<th>LOCALITY LOKALITET</th>
<th>SIZE OF SAMPLE (m²)</th>
<th>VELIČINA SNIMKA (m²)</th>
<th>ALTITUTE (m)</th>
<th>NADMORSKA VISINA (m)</th>
<th>SLOPE (°)</th>
<th>NAGIB TERENA (°)</th>
<th>EXPOSURE EKSPozICIJA</th>
<th>ROCK OF SUBSTRATUM GEOLOŠKA PODLOGA</th>
<th>GENERAL COVERAGE (%)</th>
<th>OPŠTA POKROVNOST (%)</th>
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**CHARACTERISTIC COMBINATION OF SPECIES (KARAKTERIŠTICA KOMBINACIJA VRSTA)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Coverage</th>
</tr>
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<tbody>
<tr>
<td>Saxifraga pedemontana All. ssp. cymosa</td>
<td>1.2 1.2 1.2 3.3 1.2 1.2 +.2 1.2 2.2 +.1 +.1 +</td>
</tr>
<tr>
<td>Saxifraga moschata Wulf.</td>
<td>1.2 +.1 +.1 2.2 +.2 +.1 + +.1 + 1.2</td>
</tr>
<tr>
<td>Juncus trifidus L.</td>
<td>+.1 +.1 +.1 1.2 +.2</td>
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<tr>
<td>Cardamine glauca Spreng</td>
<td>+ + 1.2 + 1.2 + 1.2 +</td>
</tr>
<tr>
<td>Other Species</td>
<td></td>
</tr>
<tr>
<td>Jovibarba heuffelii A. et D. Love</td>
<td>+ + +.1 +.1 1.2 +</td>
</tr>
<tr>
<td>Veronica bellidioides L.</td>
<td>+ + + + + + 1.1 1.1</td>
</tr>
<tr>
<td>Anthemis carpatica Willd.</td>
<td>+ + + + + + + + +</td>
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<tr>
<td>Festuca alpestris Simk.</td>
<td>+.1 + +.1 + +.1 +</td>
</tr>
<tr>
<td>Minuartia recurva (All.) Sch. et Thell</td>
<td>+.1 + +.2 +.2 +.2 +</td>
</tr>
<tr>
<td>Saxifraga aizoon Jacq.</td>
<td>1.2 +.2 +.2 1.2 +.2 +.1</td>
</tr>
<tr>
<td>Saxifraga rotundifolia L.</td>
<td>+.1 2.2 1.2 + + +</td>
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<tr>
<td>Cerastium alpinum L.</td>
<td>+ + +.1 + + + +</td>
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<tr>
<td>Sempervivum kosaninii Praeg.</td>
<td>2.2 +.1 1.2 + +</td>
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**CONSTANCY CLASS (PRISUTNOST)**

<table>
<thead>
<tr>
<th>Species</th>
<th>Coverage</th>
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<tbody>
<tr>
<td>Ch herb pulv</td>
<td>V SEP (karp-balk)</td>
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<td>Ch herb pulv</td>
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<td>H caesp</td>
<td>IV ARKT.-ALP</td>
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<td>Ch herb caesp</td>
<td>IV JEP</td>
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<tr>
<td>H ros succ</td>
<td>III JEP (karp-balk)</td>
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<td>H ros</td>
<td>III SEP</td>
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<tr>
<td>Ch suffr</td>
<td>III JEP (karp-balk)</td>
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<tr>
<td>H caesp</td>
<td>III SEP</td>
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<td>Ch suffr pulv</td>
<td>III SEP</td>
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<td>H pulv.</td>
<td>III ARKT.-ALP</td>
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<td>H ros</td>
<td>III SEP</td>
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<tr>
<td>Ch herb caesp</td>
<td>II ARKT.-ALP</td>
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<tr>
<td>H ros.suce</td>
<td>II JEP (din-balk)</td>
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<td>Species</td>
<td>Percentage</td>
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<tr>
<td>Sedum acre L.</td>
<td>+.2</td>
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<tr>
<td>Senecio carpanicus Herb.</td>
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<tr>
<td>Pedicularis verticillata L.</td>
<td>+</td>
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<tr>
<td>Galium anisophyllum Vill.</td>
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<tr>
<td>Cerastium cerastoides L. Br.</td>
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<tr>
<td>Festuca varia Haenke</td>
<td>+.1</td>
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<tr>
<td>Festuca scardica Gris.</td>
<td>+.1</td>
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<tr>
<td>Cetraria islandica L. (ch)</td>
<td>+.1</td>
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<tr>
<td>Cetraria nivalis L. (ch)</td>
<td>+.1</td>
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<tr>
<td>Silene pusilla W.K. ssp. monachorum</td>
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<tr>
<td>Cystopteris fragilis (L.) Bernh.</td>
<td>+</td>
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<tr>
<td>Ranunculus crenatus W.K.</td>
<td>2.3</td>
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<tr>
<td>Saxifraga adscendens L.</td>
<td>+.2</td>
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<tr>
<td>Asplenium trichomanes L.</td>
<td>+.1</td>
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<tr>
<td>Polystichum lonchitis (L.) Roth.</td>
<td>+.1</td>
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<td>Pteridium aquilinum (L.) Kohn.</td>
<td>1.2</td>
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<tr>
<td>Avena versicolor Vill.</td>
<td>+.1</td>
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<tr>
<td>Juniperus sibirica Burgs.</td>
<td>+.1</td>
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<tr>
<td>Antennaria dioica (L.) Gortn.</td>
<td>+.2</td>
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<tr>
<td>Dianthus deltoides L.</td>
<td>+</td>
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<tr>
<td>Armeria alpina (DC) Willd.</td>
<td>+</td>
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<tr>
<td>Achillea lingulata W.K.</td>
<td>+</td>
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<tr>
<td>Sedum hispanicum L.</td>
<td>+.1</td>
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<tr>
<td>Draba korabensis Kum.et Deg.</td>
<td>+</td>
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<tr>
<td>Poa bulbosa L.f. vivipara</td>
<td>+.1</td>
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<tr>
<td>Edraianthus montene grinus Horak.</td>
<td>+.1</td>
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<tr>
<td>Saxifraga carpatica Rchb.</td>
<td>+</td>
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<tr>
<td>Euphrasia minima Jacq.</td>
<td>+</td>
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<tr>
<td>Vaccinium myrtillus L.</td>
<td>+.2</td>
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<tr>
<td>Artemisia petrosa (Baumg) Frits.</td>
<td>+</td>
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</tbody>
</table>

Species occurring in one stand only (vrste zabeležene samo u jednom snimku): Ligusticum mutellina (L.) Crantz 1 (+), Centaurea nervosa Willd. 2 (+), Paronychia kapela (Haçq.) Kern. 5 (+.1), Scleranthus annuus L. 6 (+.1), Geum montanum L.7 (+), Silene sendneri (Boiss) Jord. et Pan. 8 (+.1), Silene doerfleri Nik., Lak., Stev. et Bul. 9 (+.1), Hypericum alpinum W.K. 9 (+), Luzula sudetica (Willd.) DC 10 (+), Thymus cherlerioides Vis. 12 (+).
community of Saxifragetum cymosae ass. nova refers to these tallest parts of Djeravica precisely.

Natural frames, the chasm-phyte community mentioned develops in, are made of the silicate rock cracks and of the rock mass cracks in the spacious Western Djeravica circle with the Veliko /The Great/ (2,309 m a/s/l) and Malo /The Small/ (2,360 m a/s/l) Djeravicko lakes settled in. He whole surrounding is characterized by severe glacial morphology, whose characteristic is not only the glacial lakes, but also the tooted peaks, sloppy cliffs, cirques and moraines. The circle bottom, with the lakes and the high-mountain meadow bogs settled in, is made of gabbro, spreading from the bottom of Velika Djeravica westward, to the bottom of Crni Krš. The diabase, developed from the gabbro gradually, is significantly more dispersed, first of all, making up the massif of Velika Djeravica (2,656 m a/s/l) and surrounding mountain ranges. Along the circle borders, especially in the direction of the Zeleni Krš saddle, the diabase and gabbro are gradually transferred into green schist (Mijatovic, 1997). However, the area of silicate rock mass is partially incorporated by the dolomitic limestone, contributing to its more complex geologic foundation. Although, rocky ground and bare rocky mass parts predominate the area, a mosaic-like distributed, shallow pedologic substrate, presented with humus silicate soil on the diabase and gabbro in hydrogen humus soils around the high-mountain bogs is also present (Lakusic, 1974).

The tallest parts of Djeravica, from the point of climate, are characterized by the domination of the Arctic - Alpine climate, within which, a locally and morphologically conditioned climate of firm snow and ice expresses its full-scale severeness in the northern exposed circles with recent neves.

The association of Saxifragetum cymosae occupies the western, southwestern, northern and eastern expositions with an inclination of 5 to 80, on the heights ranging from 2,320 to 2,656 m. It is mainly located in rock cracks and dispersed stone blocks of Velika Djeravica, covering its peak. However, it is fragmentarily incorporated in the rock cracks of the bottom of Crni and Zeleni Krš, mosaic-like mixing with the communities of turfs, neves and meadow bogs.

Based on 13 phytoso-enologic surveys, some 43 species were registered in the community (Table 1). The Saxifraga pedemontana All. Ssp. Cymosa (Waldest. Et Kit.) Engl., Saxifraga moschata Wulf., Juncus trifidus L. and Cardamine glauca Spreng make a characteristic group. The Jovibarba heuffeli A. et D. Love, Veronica bellidioides L., Anthemis carpathica Willd., Festuca alpestris Sink., Minuartia recurva (All.) Sch. Et Thrll., Saxifraga aizoon Jacq. And Saxifraga rautundifolia L. are joining the above as the most present.

The living form spectrum indicated the domination of chasm-phyte - chemi-crypto-phyte character of the Saxifragetum cymosae community. Namely, the two living forms were presented in the overall spectrum with 93.6%, while the share of nano-planerophytes, tero-phytes and geo-phytes were insignificantly low (Figure 1). Such a living form spectrum is characteristic for the vegetation of the high-mountain cold regions and, somewhat, corresponds to the living form spectrum of the Arctic and Alpine regions. The predominance of the chasm-phyte - chemi-crypto-phyte composition of the community is derived from the fact that, here we deal with the chasm-phyte vegetation of the Alpine zone's silicate rocks. The living form specifics of the chasm-phyte community is reflected in the great presence of the clod-like and pillow-like chame-phytes (Chl herb caesp, Chl herb pulv) and the clod-like chemi-crypto-phytes (H caesp) taking part with some 55% in the overall living form spectrum. A negligible small number of tero-phytes (T) and geo-phytes (G) is brought in connection with, not only the absence of adequate micro-residence for the development of the living forms, but, also, with extreme climatic conditions predominating over the residence of the community.

The species of cold Arctic - Boreal and Alpine (Mid-European mountain) region play a dominant role in the horologue spectrum of the community. The species share in the overall floral element spectrum amounts to over 75% (Figure 2). Relatively high presence of the Arctic - Alpine elements (14.5%) is especially interesting and indicative, indicating the glacial character of the community. If a significant percentage of the Mid-European mountain plants (42.8%), that dispersed from the Alps toward the Balkan Peninsula during the glaciation, is added, as well as a certain number (10, 2%) of the species of Circum-Boreal dispersion, that, in most cases, use to have similar history as the Arctic - Alpine species had, then, a real picture of the community horologue spectrum is obtained. However, having in mind, the mountains of Western and Central Balkan, with Prokletije belonging to, present the encounter place of various genetic and migration elements, it is natural to expect other floral elements too. The ones, regarding their dispersion, gravitating to the South-European mountains, and, generally speaking, considered to be within the group of Oro-Mediterranean species, are especially considered. As a rule, these species are presented with the endemic taxonomies, created from the ancient Tertiary orophytes. There 29% of such species in the community of Saxifragetum cymosae, and the ones being mostly emphasized among, are the Dinariides (Edrianthus montenegrinus, Silene pusilla ssp. Monachorum), the Dinaride - Balkan's (Festuca scardica, Semprevivum kosianii, Silene sendnieri) and the Prokletije species (Silene doerfleri), as well as, the sub-endemic Carpathian - Balkan elements (Jovibarba heuffeli, Anthemis carpathica). The ratio of Mid-European mountain (MEM), the Arctic - Alpine (Art. - Alp.) and Circum - Boreal (Circ - Bor.) on one side and, the South-European mountain (SEM), including the species of en-
denic dispersion, on the other, amounts to almost 4 : 1. The above is an additional indicator of the Mid-European community character and its glacial-refugee character, too.

The determination of the Saxifragetum cymosae association's syntaxo-nomic position is somewhat difficult due to the presence of the surrounding communities around the neves (Ranunculus crenatus, Cardamine glauca), the turfs (Festuca alpestris, Festuca scardica, Festuca varia, Veronica bellidioidei, Dianthus deltoides, Armeria alpina, Euphrasia carpathica, Minuartia recurva, Senecio carpathicus, Antennaria dioica, Saxifraga carpathica, Artemisia petrosa, Juncus trifidus, Avena versicolor) and juniper bush soil (Juniperus sibirica, Vaccinium myrtillus) whose syntaxo-nomic affiliation should be precisely determined. However, if the Saxifraga pedemontana and Saxifraga moschata species domination, as well as, the characteristic species combination together with the complex of all the ecological conditions, the community develops in, are considered, it can be stated that the respective belong to the group of Saxifragion cymosae Lakusic, 1968, of the order of Androsacetalia vandelli Br. - Bl. 1926, of the class of Asplenietea trichomanis Br. - Bl. 1954, that are present in the high-mountain zone of the Balkan Peninsula silicate massifs.

CONCLUSION

Saxifragetum cymosae ass. nova chasm-phyte community occupies the Alpine zone highest parts of the Prokletije silicate massif of Djeravica. The living form spectrum indicates its chame-phyte - chemi-crypto-phyte character. Such a spectrum is characteristic for the cold region vegetation and, more or less, corresponds to the Arctic and Alpine region living form spectra. The Mid-European mountainous, the Arctic-Alpine, the South-European mountainous and Circumboreal flora elements dominate in the community horologue spectrum. Their relation indicates the community Mid-European and glacial-refugee character. From the syntaxo-nomic point, Saxifragetum cymosae ass. nova community belongs to the group of Saxifragion cymosae Lakusic, 1968, of the order of Androsacetalia vandelli Br. - Bl. 1926, of the class of Asplenietea trichomanis Br. - Bl. 1954, that are present in the high-mountain zone of the Central Balkan.

Fig. 1. Saxifraga pedemontana All. subsp. cymosae. (W. et K.) Engl.
Fig. 2. Saxifraga capatica Rchb.

Fig. 3. Life-forms spectrum of the community Saxifragetum cymosae
Sli. 3. Spektar životnih form zajednice Saxifragetum cymosae

Fig. 4. Chorological spectrum of the community Saxifragetum cymosae
Sli. 4. Spektar florih elemenata zajednice Saxifragetum cymosae
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REZIME

SAXIFRAGETUM CYMOSAE - NOVA HAZMOFIJSKA ZAJEDNICA NA METOHIJSKIM PROKLETIJAMA

AMIDIĆ LIDJIA I STEVANOVIC VLADIMIR

Zavod za zaštitu prirode Srbije, Odsek za biologiju PMF - a Univerziteta u Prištini Institut za botaniku i Botaničke bašte Biološkog fakulteta Univerziteta u Beogradu

Dosadašnje analize balkanske visokoplanske flore su pokazale da je veliki masiv Prokletije, najbogatiji na poštu, odnosno, iako se zbiljavaju brojnim radovima o biljnom svetu ovog masiva relativno dosta zna, ostaje činjenica da su Prokletije jedan od najslablje floristički i vegetaciji proučenih planinskih sistema na Balkanskom poluostrovu. Razlog tome ne leži samo u njihovoj relativno slaboj posećenosti, već, pre svega, u njihovoj veličini i nepristupačnom i surovom reljefu deformatične plastike.

Jedan od najslabije proučenih delova Prokletija je grandiozni masiv Deravice čija je visokoplaninska flora i vegetacija osim u jednom radu (Lakušić, Grčić et Mededović, 1974.), do sada prikazana samo parcialno, u okviru opštega prikaza Prokletija, odnosno, Dinarida.

Upravo na ovom grandioznim masivu registrovali smo prisustvo hazmoftske zajednice Saxifragetum cymosae - ass. nova koja koja zauzima jugozapadne, severne i istočne ekspozicije nagiba 5 do 80 u visinskom dijapazonu od 2320 do 2656 m. Uglavnom se javlja u pukotinama stena i razbacanim blokovima Velike Deravice izgrađene iz dijapaza, prekrivajući i njen vih. Međutim, fragmentarno se omećuje i u pukotine stena u podnožju Crnog i Zelenog koša možaženo se smanjujući sa zajednicama rudina, snežanika i livadskih tresava.


Spektar životnih formi je pokazao dominaciju lanetifotski - hemikruptofotskog karaktera zajednice. Naime, u ukupnom spektu ove dve životne forme zastupljene su sa 93,6%, dok je zanemarlivo mali udeo nanofanerofita, terofita i geofita. Ovakav spektar životnih formi karakterište je za vegetaciju visokoplaninskih hladnih predela i u izvesnom smislu korespondira.
sa spektrom životnih formi arktičkih i alpskih predela. Pretežno hamefisko - hemikriptofitski sastav zajednica proizilazi i iz činjenice da se radi o hazmajofitskoj vegetaciji alipske zone silikatnih stena. Specifičnost životnih formi ogleda se u velikoj zastupljenosti busenastih i jastučastih hamefita i busenastih hemikriptofita koje učestvaju sa oko 55% u ukupnom spektlu životnih formi zajednice Saxifragetum cymbosae. Zanemarljivo mali broj terofita i geofita dovodi se u vezu ne samo sa odsustvom adekvatnih mikrostaništa, već i ekstremnim klimatskim uslovima koji vladaju na stanštima ove zajednice.

U horološkom spektlu zajednice dominantnu ulogu imaju vrste hladnih i arktičko - borealnih i alpskih (srednjeevropskih planinskih) regiona. Ove vrste učestvuju sa preko 75% u ukupnom spektlu flornih elemenata. Posebno je interesantno i indikativno relativno veliko prisustvo arktičko - alipskih elemenata (14,3%) koji ukazuju na glacijalni karakter ove zajednice. Ako dodamo i značajan procenat srednjeevropskih planinskih biljaka (42,8%) koje su svoje širene s Alpa prema Balkanu ostvarile tokom glaciacije, kao i određen broj (10,2%) vrsta cirkumborealnog rasprostranjenja koje su, u većini slučajeva, imale sličnu istoriju kao i arktičko - alipske vrste, dobija se prava slika o horološkom spektlu ove zajednice. Međutim, imačući u vidu činjenicu da su planine Zapadnog i Centralnog Balkana kojima pripadaju i Prokletije mesto susreta različitih geno - i migro-elemenata, prirodnje se očekivati i druge florne elemente, posebno one koji svojim rasprostranjencem gravitiraju planinama južne Evrope i koje se svrstavaju u grupu oronederteranskih vrsta u širem smislu. Po pravilu ove vrste predstavljene su endlessnim taksonima nastalim od drevnih tercijarnih orošita. Takvih vrsta u zajednici Saxifragetum cymbosae ima 20,4% a među njima se naročito ističu dinarske, dinarsko - balkanske i prokletijske vrste, kao i subendemični karpatsko - balkanski elementi. Odnos srednjeevropskih planinskih (SEP), arkto - alipskih (ARKT-ALP) i cirkumborealnih (CIRK-BOR) s jedne, i južnoevropskih planinskih (JEP) s druge strane, iznosi gotovo 4 : 1. To je još jedan pokazatelj srednjeevropskog karaktera zajednice i njenog glacijalnog refugijalnog karaktera.


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Peroxisome and Katalase Enzymes Activities in Corn and Wheat Seedlings in the Conditions of Experimental Intoxication with Pb-Acetate

Filipović Radmila and Jablanović M.
Department of Biology, Faculty of Science, University of Pristina, Yugoslavia

ABSTRACT

Measurements of peroxide and katalase enzymes activities in corn (Zea mays L. var. domestic white) and wheat (Triticum vulgare L. var. grain) plantlets in the conditions of experimental intoxication with different concentrations of Pb-acetate ($10^{-5}$, $10^{-4}$, $10^{-3}$, $10^{-2}$ and $2 \times 10^{-2}$ M) for different periods of time (0, 24, 48 and 72 hrs. after treatment) were taken. Gasometric method was used for determination of katalase activity, and for peroxides activity we have used reaction of benzidine oxidation with enzyme effect. The highest activity of peroxides and katalase was measured in corn at concentration of $10^{-2}$ M of Pb-acetate, 24hrs. after the treatment (200% more than in control), and 48hrs. after the treatment in wheat (130% more than in control). Peroxide and katalase activity was decreased 72hrs after the treatment.

Key words: plants, Pb-acetate, enzymes, catalase, peroxidase

INTRODUCTION

Changes which occur in metabolism under the influence of pollutants are actually the inhibitions or modifications of enzyme activity and can be detected very early, before visible damages of plant tissue occur (Pierre Michele, 1985). It is known that under the influence of pollutant, enzyme activity goes into two directions: as an inhibition of some enzymes or increased activity of other enzymes. It is considered that enzyme inhibition is a consequence of blocking of different functional enzyme groups by anthropogenic xenobiotics. However, Stiborova et al. (1986;1988) have found that heavy metals (Pb, Cd, Cu) irretrievably inhibit the activity of enzyme ribulose - 1,5-diphospho-carboxilase which is isolated from barley leaves (Hordeum vulgare L) through the formation of mercaptides with tyol groups of enzymes. In these same plants they found destruction of fourfold enzyme structure as well as enzyme disassociation on subunits of different size, which resulted in decrease intensity of photosynthesis.

Also other research workers (Stiborova and Zeblova, 1985) have noticed that plants which are intoxicated with Pb, have some decreased enzyme activity, in this case in alcohol dehydrogenesis, in which the degree of decreased activity depends on the pH values. The same authors showed that in the presence of NAD and of NAD-ethanol complex enzyme (which probably complex with metals), the inhibiting effects of heavy metals are decreasing, thus increasing the activity of alcohol dehydrogenesis.

On the other hand, heavy metals which are present in plants lead to increased activity of some enzymes (peroxide and katalase), which is probably some form of plant protection from the influence of polluters.

Related to control, Keller (1974) found that in the conditions of air pollution peroxides enzyme activity in fir (Abies alba) increases up to 70%.

Besides these plants, linden (Tilia sap.) and black poplar (Populus nigra L), under the influence of higher concentration of pollutants (SO2 and Pb), and on short exposition, also react through the increase of peroxides and oxidodismutase activity (Jager et al., 1985). According to these authors, tolerant plants develop different capacities including the most efficient defense mechanisms on the influence of pollutants.

On the contrary, low Pb concentrations in peas leaves substantially increase the activity of nitrate reductase, while the activity of this same enzyme at high Pb concentrations is decreasing. This points out that the reaction of this enzyme is of a differential character (Singh et al. 1978).

It is confirmed through various experiments that peroxide activity degree is characteristic for each species (for example, it is higher in pine tree than in (arilish), and it is higher in younger plants than in old ones (Zavialova, 1992).

Based on available literature and on our preliminary results of the research on enzyme activity (katalase and peroxide), under the influence of different Pb-acetate concentrations, we have decided to examine activity of these enzymes in corn and wheat seedlings at different concentrations ($10^{-5}$, $10^{-4}$, $10^{-3}$, $10^{-2}$ and $2 \times 10^{-2}$ M) of toxicants, without the influence of other polluters.
According to our opinion, the obtained results can be used for the benefit of early detection of pollution - the biochemical monitoring.

MATERIAL AND METHODS

We have analyzed wheat (Triticum vulgare L., var. "zitnica") and corn (Zea mays L. var. domestic white) seeds.

The seeds were planted in lab conditions. Young plants were treated with 20ml Pb-acetate solution of different concentration (10^{-5}, 10^{-4}, 10^{-3}, 10^{-2} and 2x10^{-2} M).

Measurements of peroxide and katalase activity were made in different periods of time: in the moment of treatment (zero time) and after 24, 48 and 72hrs. from the treatment. Enzyme activity in control plants was measured at the same time.

Gasometric method was used to measure peroxide and katalase activity (Moseva, 1982). This method is based on determination of oxygen amounts after the addition of plant extract which contains hydrogen peroxide catalysis.

Bajarkina method (Pleskov, 1985) was used to estimate peroxide activity. This method is based on the speed rate of benzidine oxidation under the influence of plant enzyme, until the product of oxidation reaches blue color of specific concentration which is determined by colorimeter.

RESULTS AND DISCUSSION

Peroxides and katalase activity in corn and wheat plantlets was measured in the conditions of experimental intoxication with different Pb-acetate concentrations (10^{-5}, 10^{-4}, 10^{-3}, 10^{-2} and 2x10^{-2} M) and in different periods of time (0h, 24h, 48h and 72h) after treatment. The obtained results show a tempestuous increase in activity of these enzymes, especially at high Pb-acetate concentrations.

![Fig 1. Peroxidase activity in seedlings of corn (Zea mays L., var. domestic white) treated by Pb-acetate under experimental conditions.](image1)

![Fig 2. Catalase activity in seedings of corn (Zea mays L., var. domestic white) treated by Pb-acetate under experimental conditions.](image2)

![Fig 3. Peroxidase activity in seedlings of wheat (Triticum vulgare L.) treated by Pb-acetate under experimental conditions.](image3)

![Fig 4. Catalase activity in seedings of wheat (Triticum vulgare L.) treated by Pb-acetate under experimental conditions.](image4)

Sl. 1. Aktivnost enzima peroksidaze kod mladih biljaka kukuruza (Zea mays L., var. domaći beli), tretirani Pb-acetatom u laboratorijskim uslovima.

Sl. 2. Aktivnost enzima katalaze kod mladih biljaka pšenice (Triticum vulgare L. var. žitnica), tretiranih Pb-acetatom u laboratorijskim uslovima.
Maximum values for peroxides and catalase activity was measured in young corn plants after 24hrs. of treatment (Figures 1, 2). But in young wheat plants, maximum value of peroxides and catalase activity was measured after 48hrs. after the treatment (Figures 3, 4).

Measurement results clearly show that peroxides activity in corn and wheat, at concentration of $10^{-2}$ M of Pb-acetate, is increased for 200% compared to the control. Catalase activity in the same plants at the same Pb-acetate concentration is increased for 130% compared to the control (Figures 2 and 4).

According to the obtained results, peroxide activity is higher in both groups of examined plants than catalase activity.

This research also showed that peroxide and catalase activity decreases after 72hrs. from treatment in both types of plants (corn and wheat). Probably, it is because of the decrease of Pb-acetate concentration due to the watering of plants.

Similar results on the increased activity of these enzymes under the influence of the pollutants can be found in literature as well.

Sarsenbiyev et al. (1983) point to increased peroxide activity in young plants of different types of grains treated with SO$_2$. These authors have found that peroxide activity is increased especially on the spots where SO$_2$ caused injury of plant tissue.

Romanova and Kemrov (1986) proved that peroxide activity is increasing several times more in grains which are watered with contaminated water.

According to Munir et al. (1990), different Pb-acetate concentrations provoke increased peroxide activity in seedlings of winter crop (wheat) in controlled conditions. But in the seedlings of that same wheat which were grown in field condition near to the industrial zones, peroxide activity was not detected.

In the conditions of experimental intoxication of bean seedlings with chrome sulfate, the catalase activity increased several times more comparing to the control (Mukherji and Kumar, 1981).

Jablanovic et al. (1985) pointed out on the increased catalase activity in corn plantlets which were treated with different Pb-acetate concentrations. According to the authors, higher Pb-acetate concentrations provoke increased catalase activity but in the plants which were permanently exposed to the Pb and other heavy metals the catalase activity had not been changed.

Based on some published data and on the results obtained during our research, the increased catalase and peroxide activity represents the process of detoxification through the adaptation of metabolism, which belongs to the qualitative mechanisms of seedlings to acquire the resistance toward the pollution. We assume that the peroxide and the catalase are involved in defense mechanisms for toxic effects of active forms of oxygen and hydrogen peroxide, which are formed due to the mutual activity of toxicant with cell mem-

brane and cell organelles membrane. We think that the increased activity of these enzymes is actually a biochemical indication for higher contamination of the environment.

**CONCLUSION**

The measurements of peroxide and catalase activity in young wheat and corn plants in the conditions of experimental intoxication show an increased activity of these enzymes representing a biochemical indication for higher pollution of the environment. The results of the research show that the activity reactions of these enzymes are very tumultuous, and the response on the presence of pollutants is best in corn, after 24hrs., and in wheat, 48hrs. after the treatment. This is happening because the mechanism of detoxification, which disassembles harmful substances to the products which are not harmful for plants, is activated.

The increased peroxide and catalase activity is the response of plants to pollution before the visible damages occur. That is why we can use these results as biochemical monitoring for the purpose of early diagnosis of the pollution.

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REZIME

AKTIVNOST ENZIMA PEROXSIDAZE I KATALAZE KOD MLADIH BILJAKA KUKURUZA I PŠENICE U USLOVIMA EKSPERIMENTALNE INTOKSIKACIJE Pb-ACETATOM

Filipović Radmila, Jablanović M.

Odsek za biologiju, Prirodno matematički fakultet, Univerzitet u Prištini, 38000 Priština, Jugoslavija

Teški metali a, i drugi zagađivači kod biljaka izazivaju promene enzimskog sistema u metabolizmu, koje se manifestuju kao inhibicije jednih enzima ili aktivacije drugih enzima.

Inhibicije enzima nastaju kao posljedice blokiranja funkcionalnih grupa enzima od strane zagađivača. Sa druge strane aktivacije enzima pod uticajem zagađivača predstavljaju zaštitne reakcije biljaka na delovanje polutanata, koje se mogu upotrebiti u korisne svrhe biohemijskog monitoringa. U vezi sa tim višli smo ispitivanja aktivnosti enzima katalaze i peroksidaze kod mladih biljaka kukuruza (Zea mays L var domaći beli), i pšenice (Triticum vulgare L var žitnica), u uslovima eksperimentalne intoksikacije različitim koncentracijama Pb-acetata (10-5, 10-4, 10-3, 10-2 i 2 x 10-2M), u funkciji vremena (0h, 24h, 48h i 72h od tretmana). Aktivnost katalaze određena je gasometrijskom metodom a peroksidaze reakcijom oksidacije benzidina pod dejstvom enzima. Dobijeni rezultati pokazuju da se aktivnost ovih enzima buno povećava u prisustvu Pb-acetata kod obe grupe biljaka (kukuruza i pšenice), to naročito pri većim koncentracijama, što verovatno predstavlja pokretanje odbrambenog mehanizama reakcije na prisustvo Pb-acetata. Najveća aktivnost peroksidaze (200% više u odnosu na kontrolu) zabeležena je pri koncentraciji od 10-2 M Pb-acetata a katalaze pri istoj koncentraciji (130% više u odnosu na kontrolu.) Pretpostavljamo da je ovo povećanje aktivnosti peroksidaze i katalaze jedan vid detoksikacije na nivou čelije. Kako se ove promene aktivnosti enzima javljaju pre pojave vidljivih oštećenja mišljenja smo da se ovi rezultati mogu koristiti za razumijevanje zagađenja.

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Faunistic-ecological Investigationes of the Oligochaetes (Annelida: Oligochaeta) on the Mouth of the Left Tributary Lepenac at the Upper Part of River Vardar, Macedonia

ŠAPKAREV Jonče
Institute of Biology, Faculty of Natural Sciences and Mathematics, University of Skopje, 91.000 Skopje, Macedonia

ABSTRACT

This paper represents the data obtained from faunistic-ecological investigations of the mouth waters of the river Lepenac. A list of determined species is given. In comprises 8 naidids, 5 tubificids, 2 lumbricids and enchytraeid species undetermined. Two communities from stony and muddy habitats were ecologically studied. Also it was made some observations for pollution influence on the structure of oligochaete's community from the mouth of this left tributary at river Vardar.

Key words: Oligochaeta, Lepenac river, Ecological analysis

INTRODUCTION

The former aquatic oligochaete's researches on running water ecosystems in Macedonia are very obscure. Just in the last time begin the faunistic and ecologic investigations (Šapkarev and Vagner, 1990; Šapkarev, 1991, 1992). This work represents the data obtained from faunistic-ecologic investigations on aquatic oligochaetes of the mouth of Lepenac. This river, as a north tributary of river Vardar, there is the greatest part of its basin in Serbia and annually small part in Macedonia. Its spring is located on the east side of the mountain Šar-planina at 1860 m above sea level and its mouth is at 253 m.a.s near the village Zlokućani. Its lenghts amounts 75 km with a relative fall of 210/00 (Gasevski, 1978, 1979). In regard to the pollution, the river Lepenac is recipient of communal waste waters from tourist settlement Brezovica, and from the settlements of the village Štrpe and town Kačani, this river receives large quantities of agricultural, communal and industrial waste waters. Nevertheless, River Lepenac flowing through the settlement of General Janković where a large cement factory is settled, is polluted by suspended soluble anorganic matters, which are brought at the river mouth near Zlokućani.

RESULTS OF INVESTIGATIONS

The following list presents the composition of the fauna of oligochaetes on the mouth of the examined river:

Fam. NAIDIDAE
Chaetogaster diaphanous (Gruit.) 1828
Opibondais serpentina (Müller) 1773
Dero digitata (Müller) 1773
Nais pardalis Piquet, 1906
Nais communis Piquet, 1906
Nais bretscheri Michaelsen, 1899
Nais sp.
Pristina rosea (Piquet) 1906

Fam. TUBIFICIDAE
Tubifex tubifex (Müller) 1774
Limnodrilus boheinieri Clapareda, 1862
Limnodrilus udheuemianus Clapareda, 1862
Psammorychides albicolor (Michaelsen) 1901
Tubificidae gen. sp. (fuv.)

Fam. ENCHYTRAEIDAE

Fam. LUMBRICIDAE
Eiseniella tetraedra (Savigny) 1826
Aporrectodea rosea (Savigny) 1826

MATERIAL AND METHODS

The qualitative and quantitative material from the mouth of River Lepenac seasonal was collected during 1989. The first one from various habitats (stones, bottom overgrown with algae, sand, mud, on the vegetation or amongst the roots of water plants) was obtained using an usual hydrobiological net. The second one was collected using an Ekman dredge (15 x 15 cm) for softly (mostly muddy) and surber's stream-bottom sampler (33 x 33 cm) for hard (mostly stony) habitats.
From this list it can be seen that 14 species of oligochaetes were determined, and some species of Tubificidae and Enchytraeidae were not determined. Determined species can be classified into 9 genera and 3 families. Total 7 species from 5 genera belong to fam. Naididae, 4 species from 3 genera to fam. Tubificidae and 2 species from 2 genera belong to fam. Lumbricidae. The most dominant genera in examined mouth of river Lepenac were Nais represented with 4 species and Limnodrilus with 2 species and one species to Chaetogaster, Opobdona, Pristina, Dero, Tubifex, Pseumoryctides, Eiseniella and Aporrectodea each.

The analysis of the numerical representation of the oligochaete species populated on stony shows 3 dominant species (Nais pardalis - 23.9%, N. bretscberi - 21.2% and Opobdona serpentina - 8.6%, which everyone together represent 53.7% of the total average number of the sampled oligochaetes during 1989. Far behind were Limnodrilus bohmeisteri, Tubifex tubifex, Nais communis and Pristina rosea took a part altogether with 26.0%. The remaining oligochaetes represent all together cca 20.0%. In the muddy habitats dominant species were tubificids species, on the contrary to stony habitat, were the tubificids Tubifex tubifex, Limnodrilus bohmeisteri and L. udekeniannus, which participate all together more than 80.0% of the total numbers of the sampled oligochaetes.

ECOLOGICAL ANALYSIS

The bottom of the river mouth was stony, sandy, muddy and a few habitats were overgrown with plants. Naidids of Oligochaeta prefer stony habitat or a bottom overgrown with plants while tubificids - a muddy habitat. Qualitative samples were taken of all kind habitats but quantitative ones were taken only from stony and muddy habitats. The communities of oligochaetes of those two last habitats can be seen on tables I and II.

Table 1. Seasonal changes of the population density of oligochaetes inhabiting on a stony habitats at the mouth of Lepenac during one-year period.

Table 2. Seasonal changes of the population density of oligochaetes inhabiting in a muddy habitat at the mouth of Lepenac during one-year period.

<table>
<thead>
<tr>
<th>Species - Vrste</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.69</td>
<td>12.98</td>
<td>3.89</td>
<td>1.45</td>
<td>3.65</td>
</tr>
<tr>
<td>Nais communis</td>
<td>69.2</td>
<td>69.2</td>
<td>69.2</td>
<td>69.2</td>
<td>69.2</td>
</tr>
<tr>
<td>Nais bretscberi</td>
<td>23.9%</td>
<td>23.9%</td>
<td>23.9%</td>
<td>23.9%</td>
<td>23.9%</td>
</tr>
<tr>
<td>Nais pardalis</td>
<td>12.98</td>
<td>12.98</td>
<td>12.98</td>
<td>12.98</td>
<td>12.98</td>
</tr>
<tr>
<td>Nais sp.</td>
<td>3.89</td>
<td>3.89</td>
<td>3.89</td>
<td>3.89</td>
<td>3.89</td>
</tr>
<tr>
<td>Pristina rosea</td>
<td>1.45</td>
<td>1.45</td>
<td>1.45</td>
<td>1.45</td>
<td>1.45</td>
</tr>
<tr>
<td>Opobdona serpentina</td>
<td>3.65</td>
<td>3.65</td>
<td>3.65</td>
<td>3.65</td>
<td>3.65</td>
</tr>
</tbody>
</table>

- Enocust species in the oligochaete's community of the stony habitat were Nais pardalis, Opobdona serpentina, Limnodrilus bohmeisteri and Tubifex tubifex, while in the community of the muddy habitat eucust species were only tubificids, namely Tubifex tubifex, Limnodrilus bohmeisteri and L. udekeniannus. Sporadic species at the community of the stony habitat were Dero digitata and Nais sp. And for the muddy community were naidids (Nais bretscberi, N. pardalis and other naidids) only.

- The dominant species in the community of stony habitat were Nais pardalis with 311.4 ind/m-2 in annual average, respectively 23.9% of the total number of individuals from all species, N. bretscberi (276.8 ind/m-2 or 21.2%) and Opobdona serpentina (112.4 ind/m-2 or 8.6%). That means, these three naidids species represent more than 50% of the whole number of the sampled oligochaetes. On the contrary, the dominant species of the muddy habitat were tubificid species Tubifex tubifex (910.2 ind/m-2 in annual average, resp. 44.1% of the total number of individuals from all species), Limnodrilus bohmeisteri (532.8 ind/m-2, resp. 25.7%) and L. udekeniannus (321.5 ind/m-2, resp. 15.6%) or these three tubificid species represent 85.4% of the total number of the populated oligochaetes in that site.

- It was obviously that the structure of the community and the density of oligochaetes' populations were conditioned by the character and the facies of the bottom from the explored river's mouth. So, in the stony habitat was greater number of species and smaller population density, while in the muddy habitat on the contrary - the number of representatives was smaller but the density of populations was greater. As result of that annual average in the stony habitat was 1303.8 ind/m-2 and 2064.6 ind/m-2 of the whole fauna of oligochaetes in the muddy habitat of river Lepenac mouth.

Analysing frequency, that is the degree of finding of the species according to Parede (1975), they can classify to four groups:

- massive found species (pF>20%): Tubifex tubifex, Limnodrilus bohmeisteri Nais pardalis and N. bretscberi;
- species found usually (pF= 5-20%): Limnodrilus udekenianus, Ophidonais serpentina, Nais communis, Chaetogaster diaphanus;
- rare found species (pF = 1-5%): Psamnomyctides albicola, Pristina rosea, Nais sp., Limnodrilus sp., Dero digitata;
- very rare species (pF<15): Eiseniella tetraedra, Aporrectodea rosea.

The quantitative analysis of the population density of various oligochaetes inhabited on the hard basis-stony and in soft basis-muddy habitats from the mouth of Lepenac river in various seasons during 1989 are given on the tables I and II. The two dominant naidid species, Nais pardalis and N. bretheschi, on the stony habitat show the same dynamics of the population density, namely from spring (March) to autumn (September) their density of populations make smaller but in winter (November) it suddenly increase. The most numerous tubificid Tubifex tubifex in the muddy habitat there was the densest populated in spring and in autumn, and the smallest population density in summer. The other two dominant tubificid species in this habitat, Limnodrilus boffmeisteri and L. udekenianus, were with the greatest population density in autumn, while it was at least in spring. Dynamics of the whole fauna of fresh-water oligochaetes from the stony habitat illustrate the most numerous density in November (2214.4 ind/m-2) and at least - in September (553.6 ind/m-2) during the examined year. In the muddy habitat the dynamics of the population density shows increases from spring (in March 1687.2 ind/m-2) to autumn (in September) when it reaches a maximum of 3636.6 ind/m-2 and a minimum in winter (November only 1642.8 ind/m-2).

POLLUTION AND SAPROBITY LEVEL OF THE MOUTH WATERS

River Lepenac, as many other tributaries of river Vardar, is recipient of waste waters. At first, it recipient of communal waste waters from tourist settlement Brezovica. In addition, downstream, flowing near village Štrpce and local town Kačnik, river Lepenac receives great quantity of agricultural, communal and industrial waste waters. However, flowing through the settlement of General Janković there is a big cement factory, the river is polluted by suspended hardly soluble anorganic materials which are the basic mark to the mouth of the river, which polluted waters empty into the River Vardar. As a conclusion may be said that river Lepenac is intensively polluted and belongs to group of very polluted tributaries in Vardar River system. Dominant species of oligochaetes on the stony habitat of the mouth waters of river Lepenac were the naidids Nais pardalis, N. bretheschi and Ophidonais serpentina, whilst in the muddy habitat were the tubificids Tubifex tubifex, Limnodrilus boffmeisteri and L. udekenianus. It was said that these structures of oligochaete's communities were conditioned by the nature of the bottom of the mouth in the explored tributary. Meanwhile, it is necessary in connection with the pollution and saprobity level of the mouth waters, which are that oligochaetes and do they can serve as bioindicators for the saprobity level of the waters from this part of the river Lepenac. The most dominant species on the explored site was Tubifex tubifex, which in the muddy habitat was populated with 910 ind/m-2 in annual average or 44 per cent of the total number of individuals from all species. According to Kolkwitz and Marsson (1909), Liebmann (1962), Sladáček (1973) and Uzunov (1977) this species represents polysaprobic indicator. It is characteristic for an extremely polluted waters (Stephenson, 1930) and it shows a great resistance to a shortage of oxygen (Aston, 1971). Limnodrilus boffmeisteri is typical species for hypertrophic biotopes and it resistant to an influence of waste waters (Brinkhurst and Kenedy, 1965). It is classified by Sladáček (1973) in group of alphanosesaprobic to polysaprobic indicators. Finally, the third dominant tubificid species, L. udekenianus, is frequently found, together with L. boffmeisteri and T. Tubifex (Wach, 1963; Hawmill and Scott, 1977) in mouths of rivers. Uzunov (1977) is of the opinion this species for alphanosesaprobic indicator. The presence of tubificid species, together with dominant naidids of the stony habitats as bioindicators, it makes possible to classify the mouth's waters of the river Lepenac in beta-mesosesaprobic range of pollution. That is in contrast with floristic and saprobologic investigations on the same river by Krsic et al., 1990 as well as pollution influence on microflora of Lepenac mouth waters by Kungulovski et al., 1992.

CONCLUSIONS

The fauna of oligochaetes was investigated at the mouth of the river Lepenac from point of view species composition, ecological analysis, pollution and saprobity level of the mouth waters. These investigations seasonally were carried out during 1989. The obtained results can be summarized as follows:
- in the whole material collected with qualitative and quantitative samples 15 species (without enchytraeids) were established, belonging to 3 families: Naididae (8), Tubificidae (5) and Lumbricidae (2 species);
- the kind of substrate as an abiotic factor was of primary importance for the species composition in the community of oligochaetes;
- in the stony habitat were populated 12 species and in muddy habitat - 8 species only;
- the naidids prevail in the community of a stony habitat but in muddy habitat prevail tubificids;
- eucenot species in the community of the stony habitat were Nais pardalis, Ophidonais serpentina, Limnodrilus boffmeisteri and Tu-
bifex tubifex, while in muddy habitat - *T. tubifex*, *L. boffi meisteri* and *L. udekel mianius*. Sporadic species in the stony habitat were *Dero digitate* and *Nais* sp. and in muddy habitat were naidids only;

- dominant species on the stony habitat were *Nais pardalis*, *N. bret scheri* and *Opibdonais serpentina* and these 3 naidid species represent more than 50% of the whole number of oligochaetes. In the muddy habitat were tubificid species *Tubifex tubifex*, *Limnodrilus boffi meisteri* and *L. udekel mianius* which altogether represent more than 80%;

- analysing frequency, oligochaetes from the mouth of the river are classify into 4 groups:
  a) massive found species (*T. tubifex*, *L. boffi meisteri*, *N. pardalis* and *N. bret scheri*)
  b) species found usually (*L. udekel mianius*, *O. serpentina*, *N. communis* and *C. diaplanus*)
  c) rare found species (*P. albicola*, *P. rosea*, *Nais sp.*, *Limnodrilus sp.* and *D. digitate*)
  d) very rare species (*E. tieraedra* and *A. rosea*).

- the dominant species from the stony habitat, *Nais pardalis* and *N. bret scheri*, show the same dynamics of the population density, namely from spring to autumn it make smaller population and in winter it suddenly increase. The most numerous *Tubifex tubifex* from the muddy habitat there was the densest population in spring and autumn and the smallest in summer;

- dynamics of the whole fauna from the stony habitat illustrates a maximum of the density in November and minimum in September, but in the muddy habitat shows opposite direction;

- river Lepenac is intensively polluted and belongs to group of very polluted tributaries in Vardar river system;

- the tubificids *Tubifex tubifex* and *Limnodrilus boffi meisteri* are polysaprobiic indicators. These two polysaprobiic indicators are followed by *L. udekel mianius* and all together are very resistant to waste waters.

**LITERATURE CITED**


REZIME

FAUNISTIČKO-EKOLOŠKA ISTRAŽIVANJA OLI-
GOHETA (Amelida: Oligochaeta) UŠĆA REKE
LEPENAC - LEVA PRITOKA GORNJEG DELA VAR-
DARA

ŠAPEKAREV Jonče

Institut za biologiju, Prirodnou-matematičkog fakulteta
Univerziteta u Skopju, 91000 Skopje, Makedonija

Istraživana je fauna oligoheta sa ušća reke
Lepenac u pogledu sastava vrsta, populacione struk-
ture, ekoloških odnosa i indeksa saprobnosti. Sezon-
ska istraživanja su vršena u toku 1989. godine.
Utvrđeni rezultati se mogu predstaviti u sažetoj formi
na sledeći način: priroda rečnog dna, kao abiotički
faktor, predstavlja primarnu važnost za sastav vrsta u
zajednici oligoheta; u kamenitim staništima bilo je
nadjeno 12 vrsta, dok je u muljevitim staništima nar-
jeno svega 8 vrsta; Naididae prevladavaju u zajednici
kamenih staništa, dok su Tubificidae dominantne u
zajednicama muljevitog staništa: Nais pardalis, Ophi-
donais serpentina, Limnodrilus hoffmeisteri i Tubifex
tubifex su u zajednici kamenitog staništa bile eukon-
stantne vrste, dok su u muljevitim staništima takve vrste
 bile: T. tubifex, L. hoffmeisteri i L. udekkemianus. Spo-
radične u kamenitom staništu su Dero digitata i Nais
sp., a u muljevitom staništu su samo Naididae.; domi-
nuntne vrste u zajednici kamenitog staništa su Nais
pardalis, N. bretscheri i Ophidonais serpentina i ove tri
vrste Naididae predstavljaju više od 50% od ukupnog
broja oligoheta. U muljevitom staništu to su bile vrste
Tubifex tubifex, Limnodrilus hoffmeisteri i L.
udekkemianus (Tubificidae), koje sve zajedno čine
iznad 80%; ispitujući frekvencnost oligoheta sa ušća
reka možemo ih klasifikovati u četiri grupe: masovno
nalažene vrste (T. tubifex, L. hoffmeisteri, N. pardalis i
N. bretscheri) obično nalažene vrste (L. udekkemianus,
O. serpentina, N. communis i Ch. diaphanus) retko
nalažene vrste (P. albicola, P. rosea, Nais sp., Limno-
drilus sp. i D. digitata) vrlo retke vrste (E. tetraedra i A.
rosena). dominantne vrste sa kamenitog staništa, Nais
pardalis i N. bretscheri pokazuju istu dinamiku gustine
populacije, naime, od proljeća ka jeseniti gustina postaje
manja i iznenadno se povećava zimi. Najbrojnija vrsta
Tubifex tubifex sa muljevitog staništa pokazuje naj-
veću brojnost populacije uproleće i ujesen, a najreda
je leto; dinamika ukupne faune kamenitog staništa ilu-
struje maksimum gustine u novembru i minimum u
septembru, ali u muljevitom staništu dinamika
pokazuje obrnuti trend; reka Lepenac se intenzivno
zagadjuje i kao takva pripada grupi zagađenih pritoka
Vardarskog rečnog sistema; vrste Tubifex tubifex i
Limnodrilus hoffmeisteri (Tubificidae) su izrazito po-
lisaprobnii indikatori. U pratri ova dva biodinilaktora
je i vrsta Limnodrilus udekkemianus a sve zajedno su
vrlo otporne na zagadnjenja vode.

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Composition of Zooplankton and Macrozoobenthos in Big and Small Djeravica Lake

ŽIVIĆ Nebojša, MIJANOVIĆ Branislav*, LABUS Nenad, JAKŠIĆ Tatjana
University of Priština, Faculty of Sciences, Department of Biology, Vidovdanska bb, Priština
*University of Novi Sad, Faculty of Sciences, Institute for Biology, Dositejeva 2, Novi Sad

ABSTRACT

Investigating the composition of zooplankton and macrozoobenthos in two glacial Djeravica lakes (Big and Small Djeravica lakes) and Lokva in the summer 1996, it is established the few but diverse fauna. Fauna mostly occupies littoral parts of the lake, where the eutrophication process has began by creation of thin layer of send and soil with dense clods of swanum moss. Zooplankton is poor and represented with three kinds of Copepoda and one kind of Cladocera. Beside the Acanthodiaptomus denticornis species, the rest of the species are faunistic rarity for the high mountain lakes of this geographical area. The best qualitative and quantitative composition of macrozoobenthos is represented in the Big Djeravica lake with 18 taxa and 88 individuals, where the representatives of Trichoza group predominate. Twelve taxa and 37 individuals were established in Small Djeravica lake and the representatives of Chironomidae and Trichoza groups predominates. Nine taxa and 21 individuals in total were established in Lokva and Oligochaeta and Chironomidae predominates. Besides the eurytopic species, the occurrence of stenotopic species Lsubaneus is characteristic, adjoined by the speics that belong to Sericostoma sp., Limnephilus sp., Dina sp. and Peloscolex sp. groups, for which it was shown that coincide with certain endemic species, so that their detailed taxonomic treatment and confirmation are necessary. Although these lakes are of the similar genesis and conditions their faunistic similarity is very small so that this diversity, as a consequence of ecological variety, may lead to the development of their fauna in two different evolution directions. Both investigated Djeravica lakes belong to oligotrophic type in which indicator species for oligo and O-b mesosaprobity prevail, while in Lokva the process of eutrophication is obvious.

Key words: Djeravica glacial lakes, Zooplankton, Macrozoobenthos.

INTRODUCTION

Prokletije represents the south-east, final part of Dinarids. They are characteristic for their numerous high mountain lakes, mostly of glacial origin. Basins of these lakes are represented by circular and wave-shaped relief, where the glacial-erosive, and in thermal basins the glacial-accumulative lakes are formed. Most of these lakes are concentrated at the highest top of the mountain, not far away from Djeravica, the highest top of Prokletije, which is one of the center of Pleistocene glaciation. The lakes mostly represents the isolated aquatic biotops with the specific ecological conditions. Such biotops, besides the generally spread palearctic types and types with the regionally spread are characterized by endemic species and subspecies. The establishing of these species contributes to the knowledge and connecting the periods in the historic settlement of fresh waters of certain areas. Investigating the mountain massifs of the western part of Balkan, an Dinarids among them, Apflbeck (1896) had observed the typicalness ad richness of endemic species and subspecies of invertebrate fauna, and aquatic forms among them. It is believed that fauna of Dinarids, that fauna of Prokletije belongs to, is one of the most interesting in Europe (Komarek, 1953, Mučibabić, 1979). Faunistic investigations of the fresh waters in SR Jugoslavija areas date back to the end of the last century and the beginning of this century (Apflbeck, 1896, Mrazek, 1903, 1904) and mostly have comprised the depression flow and still waters. The investigations of the high mountain waters, because of the inaccessibility, started much later. It specially refers to investigation of fauna of Prokletije glacial lakes. The first contribution to better knowledge about fauna of Prokletije high mountain lakes can be found in the works of Radovanović (1957), who established the characteristic species from the Trichoza group in Ridsko lake. In 1968, Ivanović and associates gave short preliminary data for the fauna of several high mountain lakes on Durmitor, Bjelasica and Prokletije (Vizitorko lake). Žunjić (1970) has also treated bentolos of some Durmitor lakes. The more detailed studies with the ecological analysis of the lake bottom fauna can be found in the work of Nedić (1975), who comprised Biogradsko and Plavsko lake. In his faunistic researches of certain groups of
plankton organisms, Petković (1970) has treated two lakes on Prokletije, Ridsko and Visitorsko lakes. Biological investigations of the high mountain lakes of Kosovo and Metohija has started much later. The first complex and systematic investigations had started by Urošović, V. (1979), who worked on algalogical study of numerous lakes of Šar mountain, but the fauna investigations had not been performed. Since the already mentioned specific ecological conditions that give the basis for development of the special biocenosis, we started to investigate the composition of fauna of Kosovo and Metohija high mountain lakes. For the beginning, we determined ourselves for two glacial Djeravica lakes, Small and Big lakes and Lokva, which outflow rivers represents one of the source branches of Ereniku river, that belongs to the river basin of Beli Drim.

MATERIAL AND METHOD

The collection of the faunistic material in Djeravica lake, had been announced in the summer season (30.7 - 04.8), 1996. Zooplankton has been collected by standard plankton net, fixed and later on treated with the standard methods. The relative number of the established species has been determined on the basis of to the estimation five stage scale according to Pantele-Buck (1955). Because of the non-homogeneity and hardness of the substrate, fauna of the lake bottom has been collected in different ways, according to the abilities and needs, but mostly using the Schworbels's net, passing the sand through the sieve, hand sorting by turning the underwater stones and rocks etc. That is the reason why the number of the lake bottom fauna is not expressed on the unit surface, but it is presented by the total number of the selected individuals. During the sampling procedure we tried to take the samples from the different places in each lake in the littoral zone, and also from the pelagic and deep parts of the lakes. Simultaneously with the faunistic tests, the water temperature on the surface, i.e. in small depths was measured, as well as the pH-reaction of the water. We are especially grateful to Prof. Dr Vlasta Pujin, who determined and treated the zooplankton material.

FEATURES OF INVESTIGATED BIOTOPS

The investigated lakes are characterized by high altitude and they are difficult to access. They are situated in the vicinity of Djeravica (south-west), the highest peak of Prokletije (2,656 m above the sea level), Fig.1. As the result of glacier activity they represent the glacial lakes created by the water accumulation in circular areas. They are fed by rain water and melted snow, as well as by waters of poor and periodical wells. The lakes loose water by vaporizing and small outflows, that downstream build the source branch of Ereniku. The surrounding of Djeravica lakes is bare, without trees and bushes, markedly rocky, with mosaic areas of thin layer of grass land. Small Deravica lake - is situated on 2,360 m above the sea level and represents the highest lake in Balkan. The lake is of circular shape with the surface and depth that vary depending on the rapid melting of snow and frequency of rainfalls. In the time of our investigation the lake was 50 m long, 40 m wide and up to 90 cm deep. The bank zones are stony, accessible and with the mild slopes towards the shallow trough. The lake bottom is leveled with gray-brownish stone blocks, and only on separated parts of the littoral zone is covered with the thin soil slime layers, eroded stone parts and sand, as well as with dense moss vegetation. The lake water is olive green and transparent to the bottom. Big Djeravica lake - is situated on a little bit lower altitude (2,309 m) and on the distance of about 500 m from the Small Djeravica lake. These two lakes are separated by the long, high reef. The surface of this lake is much bigger from the Small lake, 260 m long, 150 m wide and 6-8 m deep. The lake has deep trough, with the steep banks. The littoral zones are also steep, so that the accessibility of the lake is limited only on some parts. The water is transparent, of the blue to brown color, that comes from the black stone blocks dispersed on the bottom. On certain shallow parts of the littoral there is a thin layer of sandy and slimy substrate. The outflow stream and bottom of the lake around it are covered with moss. Downwards on 2,270 m altitude this outflow stream enters the enlarged part, so called Lokva, that can be the product of the glacier activity. On the basis of morphometric parameters and structure of the bottom, Lokva differs a lot from the investigated Djeravica lakes. It is 30 m long, 16 m wide and 20 -30 cm deep. The bottom of shallow Lokva on its bigger portion is markedly slimy, covered with the dense moss bushes. By its appearance, such and similar puddles represents the transitional form between lake and swamp (Petković, Sm., Petković, S., 1981).

INVESTIGATION RESULTS

The high mountain lakes are characterized by very low water temperature during the whole year. In the warmest month of August the highest water temperature of 17°C is measured in Lokva, that is, most probably, the consequence of small depth, slimy substrate and intense biological activity. The water of Lokva is characterized by a mild alkaline reaction, pH-8.1. The water of Small Djeravica lake was one degree colder, 16°C, while its pH value was 7.3, i.e. in the range of neutral reaction. The water of Big Djeravica lake was also in those limits, but with significantly lower temperature of only 10°C. The huge water mass of this lake slowly heats up, that enables the creation of thermal stratification with the differentiated thermal layers and significant thermal differences be-
Table 1. Qualitative and quantitative composition of fauna of Small (I) and Big (II) Djeravica lakes and Lokva (III)

<table>
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<th>I</th>
<th>II</th>
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<tr>
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<td>1</td>
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<tr>
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<td>1</td>
<td>1</td>
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<tr>
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<td>1</td>
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<tr>
<td>TOTAL NUMBER</td>
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<tr>
<td>CHIRONOMIDAE</td>
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<tr>
<td>Chironomus sp.</td>
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<td>Tanytarsus sp.</td>
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<td>/</td>
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<tr>
<td>Ablabesmyia sp.</td>
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<td>3</td>
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<tr>
<td>Orthocladiinae</td>
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<td>MEGALOPTERA</td>
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<td>Sialis lustris LINNAEUS</td>
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<tr>
<td>COLEOPTERA</td>
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<tr>
<td>Coelambus impressopunctatus SCHALER</td>
<td>8</td>
<td>2</td>
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<tr>
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<td>/</td>
<td>18</td>
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<td>Polycentropus flavomaculatus PICTET</td>
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<tr>
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<tr>
<td>Dina sp.</td>
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<td>OLIGOCHAETA</td>
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<td>Peloscolex sp.</td>
<td>/</td>
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<td>Peloscolex swireniewci JAROSCHENKO</td>
<td>/</td>
<td>5</td>
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<td>Potamonothrix hammoniensis MICHAELSON</td>
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<td>/</td>
<td></td>
<td>a</td>
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<td>/</td>
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<td>Naia christina KASP.</td>
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<tr>
<td>Lumbricillus sp.</td>
<td>/</td>
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<tr>
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<tr>
<td>Pisidium sp.</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>O</td>
</tr>
<tr>
<td>NUMBER OF TACSONS</td>
<td>12</td>
<td>18</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>TOTAL NUMBER OF INDIVIDUALS</td>
<td>37</td>
<td>88</td>
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tween surface and deeper layers. This explains the fact that fauna of zooplankton and zoobenthos was mostly found in the warmer littoral portion, where the thin layer of slime and sand is and where probably exist the increased mineralization.

The community of Djeravica lakes zooplankton is very poor. There were established only four species, one from Cladocera group, and three species are representatives of the Copepoda group (Tab.1). The impression of uniformity is increased by the mass development of E. lamellatus population in both Djeravica lakes in the small littoral bays, while the population of the Copepoda group is minimal. The established species are good indicators for oligosaprocity. The Acanthodiaptomus denticornis species is eutrophic and well known widely spread in the fauna of mountain lakes of this geographical area (Ivanovic and ass., 1968; Petkovic, 1970; Petkovic, Sm., Petkovic, S., 1971, 1981). Other species represents a significant faunistic occurrence with stenotopic features. In Lokva the complex of zooplankton was not established, probably as a consequence of inadequate conserving and separation. Faunistic poverty of the investigated lakes is reflected in the qualitative and quantitative composition of microfauna of the bottom. Macrozoobenthos of Small Djeravica lakes is presented with 12 taxaons (Tab.1). Because of low water level, fauna of the bottom is spatially uniformly distributed. The most significant components of this fauna were Insecta groups, Gironomidae with 4 and Trichoptera with 3 taxaons. For the Trichoptera group this site is the highest altitude in Balkan where it can be found. The most numerous were larva of Coleoptera species, C. impressopunctatus - 8 individuals, while the number of other taxaons was minimal. The most of the established taxaons involves eurytopic species, indicators of
oligosaprobity and oligo-beta mezosaprobity waters. Big Djeravica lake is inhabited by qualitatively and quantitatively more numerous fauna of the bottom than the previous one and it is represented with 18 taxa and 88 individuals in total. Spatially, fauna has been found mostly in the littoral portion of the lake, where the convenient ecological conditions exist. The Trichoptera group is represented with 7 taxa and its representatives were also the most numerous. Then the Oligochaeta, Chironomidae and Coleoptera groups follow (Tab.1). The most numerous was population of A. nervosa with 18, then Peloscolex sp. with 17 and Pisidium with 10 individuals. Most of the taxa involves the species, indicators for the oligosaprobity of waters. Diversity of the macrozoobenthos groups is conditioned by existence of different ecological conditions in this lake. The species I. Subaneus, P. flavomaculatus are characterized by stenotopic character, so that their populations were found in deeper, cold zones on stony substrate. The representatives of Sericostoma sp., Dina. sp., Peloscolex sp., taxa are characterized by the series of specific characteristics, so that it can be shown, by the detailed analysis and taxonomic check, that this is a case of endemic forms or at least their varieties which express the deviations in certain elements of typical morphological structure. Comparing the qualitative composition of the macro fauna of the lake bottom it may be stated that a small number of taxa, only 6, is common for both investigated lakes. Macrozoobenthos of Lokva is presented with 9 taxa and 21 individuals. Because of the slimy bottom in Lokva Chironomidae and Oligochaeta groups prevails. The most numerous are taxaions of Lumbriculus sp. and Pisidium sp. groups with five individuals each. Faunistic similarity of Lokva and Djeravica lakes is minimal. Only four common taxaions with Big and five with Small Djeravica lakes. Most of the established taxaions of Djeravica lakes are characteristic for smaller stagnant waters that are widely spread, ecologically very diverse and smaller number is selective according to the altitude.

DISCUSSION AND CONCLUSIONS

Investigations of many glacier lakes of Balkan, Alps, Pirineas and so on (Borer, 1921; Rylov, 1931, 1935; Pljakić, 1966; Ivanović et al., 1968; Žunić, 1970; Petković, 1970; Stanković, 1975; Nedić, 1975; Petković, Sm., Petković, 1981) showed that they possess a series of similarities created under the influence of historical and geological factors. However, in the longer period of time they underwent the changes and development of specific ecological conditions that influenced the diversity in composition and structure of their biocenosis. Although the investigated Djeravica lakes are glacial lakes of the same origin, geological age and substrates, and they exist in similar climatic conditions and are relatively close to each other, they show significant faunistic diversity. It is, first of all, related to the qualitative and quantitative composition of macrozoobenthos. The qualitative and quantitative differences in algae flora of these lakes is also established (Urošević, 1997). The established differences, spatially close biotops are reflection of different ecological conditions that exist in them. Undoubtedly, the long and high reef that separates these two lakes had a contribution to the divergent development of the mentioned conditions. It may be said that fauna of Djeravica lakes is not numerous, but it is diverse in regard to their dimensions and ecological conditions that exist in them. These conditions are obviously most appropriate in the summer when the best qualitative and quantitative composition occur in them. Besides the eutrophic organisms, that are widely spread in different types of fresh water biotops, taxaions which species are selective toward the elevation spread are established in fauna of Djeravica lakes. They can be found mostly on higher elevation in pure well or stagnant waters. It is specially valid for the representatives from the Trichoptera group (Radovanović, 1957; Kumanski, 1971; Gospodnetić-Marinković, 1978, 1979.). According our investigations, and on the basis of other data (Ivanović et al., 1968; Petković, Sm., Petković, 1971, 1981) it may be stated that the investigated Djeravica lakes belong to oligotrophic lakes and contain little nutritional materials and this is reflected on relatively small population of fauna. However, washing out of the banks and decaying of the plant materials in littoral portions create a small slime and sand layers covered with the dense moss that represents the beginning of eutrophication. The convenient conditions for the development of fauna are created in those parts, where fauna is also the most abundant. It is especially evident on some parts of Small Djeravica lake and in Lokva where Oligochaeta and Chironomidae prevail. On the basis of our investigation of qualitative and quantitative composition of fauna in high mountain Prokletije lakes, Small (2,360 m a.s.l.) and Big (2,309 m a.s.l.) Djeravica lakes, as well as Lokva (2,270 m a.s.l.) during the summer in 1996. We may conclude: Small Djeravica lake and Lokva are characterized by relatively increased water temperature of 16°C and 17°C, respectively, as the consequence of low water level. Water temperature of Big Djeravica lake is low (10°C), typical for the mountain lakes as wells. Water pH reaction in Big and Small Djeravica lakes is in the limits of neutral reaction (pH 7.3-7.7), while the water in Lokva is mildly basic (pH 8.1). Zooplankton in both lakes are made of population of four species, where E. lamellatus has a mark occurrence. Besides A. denticornis, other species are not established in high mountain lakes of Prokletije and neighboring mountains. Qualitative and quantitative compositions of macrozoobenthos in the investigated lakes are small. The biggest diversity of macro fauna of the lake bottom and the biggest number of the individuals was established.
in Big Djeravica lake, 18 taxaons and 88 individuals in
total, with the marked prevalence of Trichoptera
group. The populations of A. nervosa with 18, and
Peloscolex sp. with 17 individuals are the most nu-
merous. Twelve taxaons were determined in Small
Djeravica lake, mostly from the Clitoniomidae and
Oligochaeta groups, and the most numerous is popu-
lation of the C. impresspunctatus species from the
Coleoptera group. Fauna of the Lokva bottom is re-
presented with 9 taxaons, with the prevalence of Ciro-
nomidae and Oligochaeta. Four macrozoobenthos
taxaons are common for all three investigated biotops.
Big Djeravica lake has 6 common taxaons with Small
Djeravica lake, and 4 with Lokva. Only 5 taxaons are
common for Small Djeravica lake and Lokva. It can be
generally concluded that Small and Big Djeravica lakes
represent oligotrophic lakes with increased mineral-
ization on certain portions of the littoral. The process
of eutrophication, which takes place over a transient
mezo trophic state, is intense in Lokva. The species
indicators for oIigo and 0-b saprobity prevail in
Djeravica lakes, while in Lokva indicators for 0-b me-
zosaprobity prevail. On the basis of the presented
results of one season aspect we may state that the
investigated biotops of Small and Big Djeravica lakes,
as well as of Lokva, even with the common genesis, by
their ecological features influence the fauna compo-
sition to develop in various evolution directions.

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REZIME

SASTAV ZOOPLANKTONA I MAKROZOOOBENTOSA VELIKOG I MALOG DERAVIĆKOG JEZERA

Živić Nebojša, Miljanović Branislav*, Labus Nenad i Jakšić Tatjana

Univerzitet u Prištini, PMF, Odsek za biologiju, Viševoddačka bb, Priština; *Univerzitet u Novom Sadu, PMF, Odsek za biologiju, Dositejeva 2, Novi Sad


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New discovery of the species *Salamandra atra* (Laurenti 1768; Salamandridae: Caudata) in the area of Prokletije

KRIZMANIC Imre
The Institute for Protection of Nature of Serbia

**ABSTRACT**

Alpine-Dinaride glacial relict species *Salamandra atra* has been found so far in two locations in the area of Prokletije: Raski do (UTM DN 22), (RADOVANOVIC 1964) and Bogicevic (UTM DN 21), (PASULJEVIC 1968; DZUKIC 1993). This new discovery in the area of Lumbards mountains (UTM DN 32) pushed farther the eastern border of the habitat area of this species. This particular specimen was registered at altitude of 1980 meters, above the zone of upper forest limit, in the area of mountain pine (*Pinus mugo*). Captured specimen is a female with two incompletely metamorphosed larvae. The form and position of the vomero-palatine teeth have been analyzed and compared to published data on other specimens found in other parts of the area and other specimens of Prokletije population. The specimen from the newly discovered location is obviously different from the specimens in proximal area which have been described so far. Variations of this type are known within the isolated population of Prokletije, to which belongs the specimen from Lumbards mountains.

**Key words:** *Salamandra atra*, Prokletije

**INTRODUCTION**

Glacial relict species, *Salamandra atra*, as Alpine-Dinaride species is inhabiting disjunct, island-type area. The area of habitation stretches from northern parts of the French Alps and Jurassic, through most parts of Switzerland, Bavarian Alps and Wurttemberg in Germany, Austrian Alps, Koraska to Italian Alps. In the south-western part of the area are Dinaride, namely, from the western parts of the Balkan Peninsula, through certain sections of the Dinaride system, to Prokletije massif in the far south-east (Dzukic 1993).

This species inhabits high mountain areas above the forest zone, mostly above the altitude of 1000 meters, although it has been registered at the altitude level of 900 meters in the zone of beech forest (Kletcko 1990). Alpine salamander, as one of the most rare examples of amphibious fauna in Serbia, was discovered in 1964 in Prokletije, at the location Raski Do (UTM DN 22) (Radovanovic 1964). Known habitats in our country are limited to the area of Prokletije massif (Raski Do) and Bogicevica mountains, namely between Maja Rops and Pasji vrh at altitude between 2100 and 2200 meters (UTM DN 21), (Pasuljevic 1968; Dzukic 1993). According to Dzukic (1993) there are indications that this species is present in Sar planina, at the location Piribeg (UTM EM 06 and DM 96).

**RESULTS**

![Distribution map of *S. atra* in the area of Prokletije.](image)

Fully grown specimen of the alpine salamander was registered on 07.07.1995 in the area of eastern part of Lumbards (Ljumbardska) mountains, (UTM DN 32) at altitude of 1980 meters, above the forest area, in the zone of mountain pine (*Pinus mugo*).

Weather conditions at the time when the specimen was caught (low clouds with maximal temperature of 12 °C and drizzling rain) characterize good accommodation of this animal to the conditions of high humidity and relatively low temperature. Thanks to these meteorological conditions the specimen was caught on ground surface at 1:00 p.m., in spite of the
presence of larvae which could be discerned laterally on both sides; color is monochrome black with no dorsal or ventral blurs or spots. Tail is characteristically shorter than the length of the body and tail taken together, oval at the cross-section with no groove on ventral side.

MORPHOMETRIC CHARACTERISTICS (Adx)

<table>
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<th></th>
<th>L</th>
<th>Ac</th>
<th>Spp</th>
<th>Lsd</th>
<th>D</th>
<th>Lsv</th>
<th>L-std</th>
<th>L-Lsd</th>
<th>Le</th>
<th>Dn</th>
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<td>115.05</td>
<td>8.5</td>
<td>4.8</td>
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<td>38.7</td>
<td>9.1</td>
<td>9.15d/9.81</td>
<td>44.35</td>
<td>21.35d/22.11</td>
<td>16.30</td>
<td>4.9</td>
<td>12.50</td>
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</table>

L - total length  
Lsd - standard length  
Lsv - Snout-vent length  
L-Lsd - tail length  
Le - head length  
Itc - head width

Ac - maximal head height  
D - limb distance  
Lpa - forelimb length  
P - hindlimb length  
Dn - nostril width  
Do - eyelid length  
Spp - minimal orbit distance  
Lpr - parotid gland length  
A - palm length  
P - foot length  
Lm - jaw length

(measures given in mm)

The form and position of vomero-palatine teeth have been used as determinative characteristic in differentiation of intraspecific relations so far, because of lack of other proofs. This characteristic was used in determination of the sub-species *Salamandra atra* prenijensi (Miksic 1969). Known forms of vomero-palatine teeth (according to Bolkay 1928, Miksic 1969, Dzukic 1993) are shown in Figure 2 (taken from Dzukic 1993), and the form of vomero-palatine teeth in newly discovered specimen is shown in Figure 3. Fig.2 Shape and position of vomero-palatine teeth of the alpine salamander (taken from Dzukic 1993) (A.-S. atra) (according to Bolkay 1928); *S. atra prenijensi* (according to MIKSIc 1969) C. - a specimen from Prokletije Fig.3 Shape and position of vomero-palatine teeth of the alpine salamander from Lumbards mountain. The specimen from the newly discovered location (Figure 3) shows evident difference from the known shape (Figure 2) both in distal and proximal section. In the distal section outside curve of the arches, as well as the central narrowing, are closer to the shape found in specimens from Prenij (A) and other, previously described specimens from Prokletije (C), where as the proximal end shows more resemblance to the shape of vomero-palatal teeth described by (Bolkay 1928) for nominative sub-species. Relation between the appearance of the proximal part of the vomero-palatal teeth in our specimens (Figure 3) and the specimen from Prokletije (Figure 2 C), which is characteristic for extreme joining of the ends of both arches, indicates that there are variations of this character present among the specimens of isolated population of Prokletije. Both juvenile specimens that have been analyzed were in the final phases of metamorphosis with significantly reduced outer gills and open hones.

![Figure 2](image)

![Figure 3](image)
This newly discovered habitat in the area of Lumbards mountains is in congruence with the assumption of Dzukić (1993) that new findings pertaining to distribution of the species *S.atra* in Prokletije could be expected.

**REFERENCES**


**REZIME**

NOVI NALAZ VRSTE *SALAMANDRA ATRA* (Laurenti 1768; *Salamandridae*: Caudata) NA PROSTORU PROKLETIJA

Krizmanić Imre

Zavod za zaštitu prirode Srbije, odeljenje u Novom Sadu

Alpsko-Dinarska glacialna i reliktna vrsta *Salamandra atra* je do sada bila poznata na dva lokaliteta na Prokletijama: Raški do (UTM DN 22) (Radovanović 1994) i Bogićevići (UTM DN 21), (Pasuljević; 1968 Džukić 1993).

Novi nalaz na području Ljumbardskih planina (UTM DN 32) dalje je pomerio istočnu granicu areala ove vrste. Ova specifična vrsta registrovana je na nadmorskoj visini od 1980 metara, iznad zone gornje granice šuma na prostoru gdje vegetira bor krivulj (*Pinus mugo*).

Nađeni primerak je ženka sa dve nekompletno metamorfozirane larve u abdometru. Oblik i položaj vomeropalatinskih zuba je analiziran i uporeden sa objavljenim podacima za druge primerke nađenih na ovim prostorima. Primerak sa novo otkrivene lokacije se očigledno razlikuje od primeraka sa drugih lokacija koje su do sada opisane. Varijante ove vrste poznate su u okviru izolovanih populacija na Prokletijama koje pripada primerak sa Ljumbardskih planina.

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The Mosor Lizard Occurs also in the Prokletije Mountain Massif

DŽUKIĆ G.*, DJOROVIC A. **, KALEZIĆ M. **, ALEKSIC I. *, CRNOBIRJA-ISAIOVIĆ J. *
* Institute for biological research "S. Stanković", Belgrade, Yugoslavia
** Institute for zoology, Faculty of Biology, Belgrade, Yugoslavia

ABSTRACT

It is discussed the question of distribution the Mosor lizard. Field investigations proved its presence on Prokletije Mountain.

Key words: The Mosor lizard, Prokletije Mts.

INTRODUCTION

As early as at the time of the initial dilemma on taxonomic relations of then newly described species of Lacerta mosorensis Kolombatović, 1886 and Lacerta koritana Tomasi, 1889, the idea has been perceived on the possibility for Mosor Mt. which is terra typica for this lizard, to be situated at the northwest edge of this species range of distribution. However, the anticipation on the southeast boundary of the distribution range is quite different. For almost a century, it has been believed that the range of distribution of the Mosor Rock lizard in this direction is limited approximately by a line connecting Crvena Gora in Herzegovina with part of Orjen Mt. in Montenegro. The finds that have followed (Radovanović 1953, Bischoff 1984, Džukić 1987, 1989, De Luca unpublished, Capula & Lapini 1991, Crnobirja-Iasovici & Džukić in press) led to the shift of the range of distribution boundary to the Southeast with a simultaneous argument-supported denial on the existence of the Neretva disjunction of the range of distribution.

It has been demonstrated that the last successes in discovery of the new Lacerta mosorensis habitats are primarily related to a progress in identification of their specificities. A sign-post in this direction was indicated by Karaman (1939) who connected this species with the mountains of the Adriatic Mediterranean. After that, Matvejev (1961, 1973) determined the Mosor Rock lizard as a characteristic inhabitant of Mediterranean mountains on rocky grounds of the "ancient Mediterranean mountains". Later on, based on phytocoenological and florogenetic data, botanists have included this zone in oocaribbean region (Trinajstić 1985) what was accepted by biogeographers (Matvejev & Puncer 1989), as well. Heldreich's pine (Pinus heldreichii) represents an easily identified tree species on mountains exposed to the influence of Mediterranean climate.

Investigations of plant communities formed by Heldreich's pine, which is an endemic and a tertiary relict of the Balkan Peninsula, were performed with the hope that due to a syngenetic link, Lacerta mosorensis, also an endemic and a tertiary relict of the Balkan Peninsula could be found here. After successful finds of this lizard at Lovćen, Maganik and Prenj Mts. (Bischoff 1984, Džukić 1987, 1989, Capula & Lapini 1991) our studies were focused on the community Pinetum heldreichii bertscicum Bleč 1959 at the complex Prokletije massif. The second stimulus to search for Lacerta mosorensis at this massif was a rather old and courageous hypothesis of the distinguished European herpetologist Schreiber (1912) suggesting that Mosor Rock lizard could inhabit the Albanian mountains, as well. This possibility has been rejected neither by Bischoff (1984) nor by Džukić (1987, 1989, 1991).

During long lasting investigations of the neoteny phenomenon in the Kuč region related to mountain lakes occurring there, we attempted several times to find L. mosorensis species in the immediate surrounding of Bukumir and Rikavac Lakes. Finally on May 31, 1995, at debris fans of the Bukumir circle at 1600 m a.s.l. under southwest cliffs of the Djebeza Mts., a subadult Mosor Rock lizard female was found. So, our multidecade expectations on the possibility of this lizard occurrence at the Prokletije massif were confirmed. During the next two expeditions (June 1, 1996 and August 24, 1996) the northeast slopes of Djebeza Mt. towards the Mokrog circle were investigated. It has been found that the cliffs and blocks of rocks above 1500 m a.s.l. were inhabited by a dense population of the L. mosorensis species. Djebeza Mt. itself represents a terminal mountain with a sharp intercircle reef beginning with Toračišćko and dividing from that point a simple circle into two parts (Cvijić 1913). At the same time, this reef represents a watershed of the Danubian and Black Sea confluences. The Djebeza, a 1755 m high mountain, consists of heterogeneous geological substrate with Triassic limestones and Cretaceous period sandstones as dominant rocks. At altitudes above 1600 m a forest of Heldreich's pine is developed. Prof. V. Stevanović and D. Laktišić, M. Sci. of The Institute for Botany and Botanical Garden "Jevremovac", Belgrade, found that in the plant community Pinetum
heldreichii bertischum, the plants belonging to the Mediterranean floristic or florogenetic element (e.g. Campanula pyramidalis, Stachys recta, Anthyllis aurea, Thymus acicularis, Potentilla appenina, P. spicosa, Satureja montana, Minuartia clandestina, Saxifraga marginata, Scabiosa fumaroides, Bupleurum larii, etc.) represent dominant species.

It is important to underline that up to the altitude of about 1600 m, the Mosor Rock lizard shares the habitat with the wall lizard Podarcis muralis. It is also worth mentioning that some females were gravid as early as on June 1, indicating that the mating could start already in May, i.e. earlier than reported in the available literature (Langerwerf 1983).

Taking into consideration the fact that Helderich's pine forests are fragmentarily scattered throughout the Prokletije and neighbouring mountains (Komovi Mt.), and even throughout somewhat more remote mountains (Paštik, Koritnik, Ošljak Mt.) it is quite to be expected that new finds of L. mosorenisi will be discovered what would lead to shifting of its range of distribution both in the South and East directions.

REFERENCES


REZIME

MOSORSKI GUSTER PREBIVA I U MASIVU PROKLETIJA


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The Presence of Homozygotic Recessive Traits in Deaf-mute Children and in Controlled Sample

BRANKOVIĆ Slavko and SAVIĆ Gojko
Department of Biology, Faculty of Science, University of Priština, 38000 Priština, Yugoslavia

ABSTRACT

Population - genetic research on 25 chosen genetic controlled morphophysiological traits was performed in the sample of 103 deaf-mute school children, as well as in the sample of 103 healthy children of the same age. The results of this research (HRCs-test) indicated significant difference between the average presence of these traits in sample of deaf-mute children and in control sample. Significant difference in the type of frequency distribution for 1/5 analyzed traits was also observed. This indicates that differences in the phenotype level may have genetic base. Increased genetic load present in deaf children, together with other environmental negative factors, disturbs genetic and physiologic homeostasis and has influence on expressiveness of specific genes.

Key words: genetic load, homozygously-recessive traits, deaf-mutism

INTRODUCTION

As a result of significant efforts in the area of human population genetics, performed by certain authors and teams in last 30 years, there are many papers which deal with the analysis of genetic structure of local and special samples of human population (Berberovic et al. 1972; Blagojevic et al. 1987; Bozic et al. 1973; Bozic -Krstic, 1990; Hadziselimovic, 1971; Hadziselimovic et al. 1982; Hadziselimovic et al. 1984; Hadziselimovic et al. 1987; Knezevic, 1984; Marinkovic, 1989; Marinkovic et al. 1990; Cukuranovic et al. 1989; Novosel, 1985; Ristic, 1990; Balog, 1992; Savic, 1993; Tomic et al. 1994; Cvetcanin, 1994; Jovanovic et al. 1995). Phenotype (morphophysiological) approach is used frequently in the population-genetic research, because the series of morphophysiological traits appear as qualitative mono or oligogenical determined traits (Winchester, 1968; 1973; McQuisic, 1968; Fristom and Cleg, 1987; 1991).

When the presence and distribution frequency of these traits in homozygotic recessive form is established, it can be used as a base to estimate the size and the type of genetic predisposition for the appearance of certain diseases, medical and biological phenomena, and homozygotic degree of different chromosomes.

Based on the results of these investigations we have assumed the presence of certain differences with regard to homozygotic recessive features in deaf-mute children and in the sample of control group. The aim of our work was to establish the degree of genetic homozygosity in deaf-mute children and in the control sample of school children in Belgrade.

MATERIAL AND METHODS

Research was performed in Belgrade and it included 206 school children. That is 103 children with damaged hearing and in 103 children used and the control group.

Alternative morphophysiological characters were used as genetic markers, since they are clearly distinct as dominant or homozygously recessive. We have examined the presence of 25 homozygotic recessive traits (HRC - test, Marinkovic et al. 1990). Obtained data were used to establish the difference in degree of genetic homozygosity between analyzed groups. Relative frequency of recessive allele (q) was calculated according to formula q = √a/n; n = the size of sample. Statistically significant difference in frequency of recessive phenotype between analyzed groups was tested by using t - test. Importance of differences in the obtained degree of homozygosity between deaf-mute children and the control group was found through X² test for each trait and through total cumulative X² test for 25 examined homozygotic morphophysiological traits. Variability in the control group and in the sample of deaf-mute children was found by the variance analysis and using the F-test.

RESULTS AND DISCUSSION

Numerical presence and relative frequency of recessive allele (q) for 25 analyzed traits is shown in Table 1.

Average homozygosity in A sample is 7.44 ± 0.19, and in B sample ± 0.21. This is the significant difference in average presence in 25 observed HRC- s between these two analyzed samples.
### Table 1. The presence of 25 homozygously recessive traits in two samples of school children in Belgrade

**A - sample of children from a special school – uzorak dece iz specijalne škole**

**B - sample of children from regular elementary school – uzorak dece iz regularne osnovne škole**

<table>
<thead>
<tr>
<th>Home-recessive traits</th>
<th>A (a%)</th>
<th>q</th>
<th>B (a%)</th>
<th>q</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight hair</td>
<td>72,81</td>
<td>0,85</td>
<td>66,99</td>
<td>0,81</td>
<td>0,52</td>
</tr>
<tr>
<td>Pravna kosa</td>
<td>77,66</td>
<td>0,88</td>
<td>63,1</td>
<td>0,79</td>
<td>35,76***</td>
</tr>
<tr>
<td>Flat scalp</td>
<td>22,33</td>
<td>0,47</td>
<td>20,38</td>
<td>0,45</td>
<td>0,19</td>
</tr>
<tr>
<td>Ravan skulp</td>
<td>23,3</td>
<td>0,48</td>
<td>16,5</td>
<td>0,40</td>
<td>2,88</td>
</tr>
<tr>
<td>Blu eyes</td>
<td>31,06</td>
<td>0,55</td>
<td>31,06</td>
<td>0,55</td>
<td>0,0</td>
</tr>
<tr>
<td>Vezan usni režanj</td>
<td>66,99</td>
<td>0,81</td>
<td>37,86</td>
<td>0,61</td>
<td>18,28***</td>
</tr>
<tr>
<td>Ear without Darvinian knot</td>
<td>29,12</td>
<td>0,53</td>
<td>13,59</td>
<td>0,36</td>
<td>36,10***</td>
</tr>
<tr>
<td>Narrow nostrils</td>
<td>28,15</td>
<td>0,53</td>
<td>9,7</td>
<td>0,31</td>
<td>0,0</td>
</tr>
<tr>
<td>Thin lips</td>
<td>0,97</td>
<td>0,09</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
</tr>
<tr>
<td>Tanko usne</td>
<td>66,01</td>
<td>0,80</td>
<td>42,71</td>
<td>0,65</td>
<td>13,09***</td>
</tr>
<tr>
<td>Small and ingrate chin</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
</tr>
<tr>
<td>Face asymmetry</td>
<td>9,7</td>
<td>0,31</td>
<td>16,5</td>
<td>0,40</td>
<td>2,88</td>
</tr>
<tr>
<td>Asimetrično lice</td>
<td>33,98</td>
<td>0,58</td>
<td>27,18</td>
<td>0,52</td>
<td>1,75</td>
</tr>
<tr>
<td>Inability to roll tongue</td>
<td>80,58</td>
<td>0,89</td>
<td>67,96</td>
<td>0,82</td>
<td>2,42</td>
</tr>
<tr>
<td>Nenugod. uždrž. savijanja jezika</td>
<td>3,88</td>
<td>0,19</td>
<td>3,88</td>
<td>0,19</td>
<td>0,0</td>
</tr>
<tr>
<td>Right thumb over laping</td>
<td>23,3</td>
<td>0,48</td>
<td>26,21</td>
<td>0,51</td>
<td>0,33</td>
</tr>
<tr>
<td>Dvokrak palce preko levo</td>
<td>8,73</td>
<td>0,29</td>
<td>2,91</td>
<td>0,17</td>
<td>12,00***</td>
</tr>
<tr>
<td>Three streaks in hand bone</td>
<td>16,5</td>
<td>0,40</td>
<td>15,53</td>
<td>0,39</td>
<td>0,06</td>
</tr>
<tr>
<td>Oskrnut cvet u kosu</td>
<td>50,48</td>
<td>0,71</td>
<td>46,6</td>
<td>0,68</td>
<td>0,33</td>
</tr>
<tr>
<td>Nepravilenost malog gretsa</td>
<td>17,47</td>
<td>0,41</td>
<td>17,47</td>
<td>0,41</td>
<td>0,0</td>
</tr>
<tr>
<td>Digital indel 4th to 2nd &gt; 1</td>
<td>62,13</td>
<td>0,78</td>
<td>60,19</td>
<td>0,77</td>
<td>0,06</td>
</tr>
<tr>
<td>Jupci u bradi</td>
<td>9,7</td>
<td>0,31</td>
<td>10,67</td>
<td>0,32</td>
<td>0,09</td>
</tr>
<tr>
<td>Svetla plava oči</td>
<td>0,0</td>
<td>0,00</td>
<td>0,0</td>
<td>0,0</td>
<td>0,0</td>
</tr>
</tbody>
</table>

\[ \Sigma X^2 = 128,98 \]

**p > 0,05**  
**p > 0,01**  
**p > 0,001**  

a% - Percentual frequency of the recessive phenotype  
q - Relative frequency of the recessive allele  

The total cumulative chi-square difference for 25 observed HRCs amount $X^2 = 128,98$ (d.f. = 23; p 0,001). This indicates that the frequency distribution of HRCs in the sample of children with damaged hearing (deaf-mute) and in the sample of healthy children (control sample) are statistically significantly different. The results of individual variability in the presence for each of 25 analyzed homozygotic recessive traits are shown in Fig. 1.

Curves of distribution differ which point to the presence of important distinctions in the type and scope of variability. Between the sample of children with damaged hearing and control sample there was a difference in the type and distribution for one lift of analyzed traits. The obtained results are the indicators for the differences on the phenotype level; between the control sample and the sample of children with damaged hearing. The presence of differences between examined children is the results of the genotype level, although we cannot exclude the effects of some negative factors such as infective diseases, drugs, (antibiotics), physical and chemical factors, high temper-ature, mechanical injuries, noise, vibrations, incompatibility of parents Rh factors, etc., which can
Fig. 1. - Distribution of HRCs in two samples of school children in Belgrade
A - from a special school
B - from a regular elementary school

Slika 1. - Distribucija HRK kod dva uzorka školske dece u Beogradu
A - iz specijalne škole
B - iz regularne osnovne škole

also affect the appropriate genes. Differences established in regard with the average presence and distribution of HRCs indicate the different degree of genetic homozygosity of analyzed groups. Proportional increase in homozygotic locus disturbs genetic - physiological homeostasis and altogether with pleiotropic action of present genes, decreases the resistance to their action of specific environmental factors and increases predisposition for disease genesis. The analysis of obtained results indicates the following: There exists a population - genetic difference between observed groups, as well as large individual variability. Increased genetic load is not a direct cause for diseases genesis. But, together with the effect of inheritance factors and specific environmental factors, it can increase the predisposition for genesis of damaged hearing.

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REZIME

ZASTUPLJENOST HOMOZIGOTNO RECESIVNIH OSOBINA KOD GLUVONEME DECE I KONTROLNOG UZORKA
BRANKOVIĆ Slavko i SAVIĆ Gojko

Odsek za biologiju, Prirodno matematički fakultet Univerzitet u Prištini, 88000 Priština, Jugoslovia

Population genetička analiza odabranih 25 genetički kontrolisanih morfofizioloških osobina obavljena je u uzorku od 103 učenika specijalne škole za deca sa oštećenim sluhotom, kao i u kontrolnom uzorku od 103 učenika redovne osnovne škole. Utvrđivanjem zastupljenosti homozigotno recessivnih osobina (HRO test) ustanovljena je značajna razlika u prosečnom prisustvu ovakvih odluka između uzorka dece sa oštećenim sluhotom i kontrolnog uzorka. Utvrđena je i značajna razlika u tipu distribucije učestalosti za jednu petinu analiziranih karakteristika. Ovo nam, sugerise da razlike na fenotipskom nivou mogu imati genetičku osnovu. Uvećana genetička op terećenja uočena kod dece sa oštećenim sluhotom, zajedno sa drugim faktorima spoljašnje sredine remete gensko - fiziološku homeostazu i utiču na izražajnost odgovarajućih gena.

Translated by Nikoleta Bašić

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Water-bearing Capacity of Cracked Rocks and Hydrogeological Characteristics of Fracture Aquifers in the Spring Area of Erenik-Djeravica

Mijošić Dušan
The Institute for Protection of Nature of Serbia, Belgrade

ABSTRACT

As a part of the project of evaluation of natural resources in the spring area of Erenik-Djeravica hydrogeological characteristics and water-bearing capacity of fracture aquifer of gabbros and diabases have been examined by means of hydrogeological methods and laboratory analyses. Slightly mineralized waters of this aquifer are mostly formed through inflow of waters from deep cracks stretching along NNW - SSE axis, which direction is generally assumed to be the direction of movement of underground waters in the area. Average value of the fracture porosity coefficient is 2%, and complexity of the rupture block resulted in utter anisotropy of water-bearing capacity of metamorphites.

Key Words: Hydrogeology, fracture aquifer, water-bearing, water permeability, Djeravica.

INTRODUCTION

The objective of quantitative determination of water bearing capacity of the spring area of Erenik Djeravica is regarded as the most important part of the hydrogeological research program carried out as a part of the field research project aiming at evaluation and protection of this particular area, mostly because of its highly specific geologic structure and required interdisciplinary approach.

However, the general objective of the research project is determination of hydrogeological characteristics of isolated lithologic environments, namely, determination of quantitative and qualitative characteristics of underground waters, as well as assessment of the level of danger for the water-bearing structure. Besides, as a part of this project, protective measures for underground waters and the spring area in general have been defined and future potentials of this area have been determined.

Research of the area under examination has not been very detailed and the results that have been procured are generalized and mostly inferred by interpolation and comparison with the areas at lower altitude. Earlier petrological research was carried out by S. Mojsilovic, V. Avramovic (1962) and D. Rajcevic (1968), and the basic geologic mapping was done by R. Antonijevic and his associates (1978). There were no available hydrogeological data pertaining to this area, and some hydrogeological research was done by R. Ilie (1989).

RESEARCH METHODOLOGY

High level of fracture porosity inside the solid rock masses found in this area, i.e. gabbros and diabases, resulted in development of fracture hydrogeological system the structure of which is continually changing, mostly because of development of rupture, as well as other factors. Hydrogeological research project designed on the basis of the general concept of the research project in the spring area of Erenik Djeravica comprised both cabinet and field work, carried out in accordance with the following dynamics scheme:

- collection and analysis of geological, hydrogeological, results of previous research work in broader region of the spring area of Erenik. This analytical approach facilitated determination of lithologic areas, spatial disposition of geologic structures and most interesting points within the research area;
- realization of the hydrogeological mapping of the area under research, with special emphasis on fracture systems developed over outcrops of metamorphites for the purpose of collecting data necessary for definition of water-bearing capacity. Structural elements have been determined (measured) by means of geological compass;
- mapping of hydrogeological phenomena was carried out by means of electronic thermometer and pH-meter, and determination of carbon-dioxide was carried out by means of titration of sampled water by Na₂CO₃. Water samples were prepared for laboratory analysis for oxygen by means of fixing by NaOH and MnCl₂. Waters also have been sampled for laboratory determination of biochemical consumption of oxygen. Waters found in representative hydrogeological phenomena also have been sampled for the basic chemical analysis;
- statistical processing of collected elements of the structure and application of empirical-graphical
analysis methods resulted in determination of water-bearing capacity and coefficient of water permeability of the aquifers under examination;
- interpretation of results of chemical analyses of sampled waters relative to the effective drinking water regulations for the purpose of establishing qualitative characteristics of examined aquifers;
- synthesis of the obtained research results.

RESULTS

The spring area of Erenik consists of gabbros, where as the western-summit parts of Djeravica slopes, as well as those in the north and east, consist of diabases. Gabbros and diabases generally belong to the group of basic magmatic rocks, however, due to in situ granitization of rocks of Junika, in this particular case they belong to the group of metamorphic rocks. The following rock types have been observed as dominant in the broader area of the research zone: epidot-actinolite shale and rocks. There are also wide spread glacial material and coarse alluvial sediments, as well as large blocks which form so called sea of stone.

Research area belongs to outside Dinarides, i.e. eastern-Bosnian-Durmitor block which is a part of the geotectonic system of Dinarides (M.Dimitrijević, 1995).

Highly developed hydrogeological relations inside the gabbros and diabases, as well as in the surrounding terrain, conditioned by hydrodynamic conditions within widely spread lithologic elements, resulted in formation of fracture type aquifers as the dominant type. Although it has been formed in midst of glacial material, alluvial deposits and the compact type aquifer is practically insignificant for the underground waters of the fracture hydrogeological system. 

Spreading of isolated lithologic environments with corresponding type of aquifers within the research area is shown in Figure 1.

Analysis of the developed fracture type aquifer revealed difference between that part of the aquifer which is situated within the fracture system in the zone of regional fracturing, and that part which is situated in the fault zone, i.e. above the local erosion basis and below the local erosion basis. Formation of the local erosion basis occurred after impression of magmatite. Due to impact of endogenic and exogenous forces it is still descending.

Geostuctural analysis and hydrogeological interpretation of the data obtained revealed that complexity of rupture structure of the block resulted in utter anisotropy of water-bearing capacity of metamorphites. Maximal effective porosity of metamorphites (emax) composed of the dominant family of hydrogeologically active fractures (Fig.2) is about 2%.

Completed research work has not determined the character of changes in effective porosity of metamorphites which vary depending on depth. Isolated fracture families are distinguished by variety of filtration characteristics.

Minimal coefficient of water porosity for certain families of fractures is around Kmin= 4.5 x 10⁻⁶ cm/s, and maximal coefficient of water porosity does not exceed Kmax= 1.26 x 10⁻³ cm/s. On the basis of these values this water-bearing structure is placed in the category of structures with low water-bearing capacity. Coefficients of water porosity are shown in the polar diagram (Fig.2).
As regards filtration quality - in spite of the fact that the diagram of water porosity indicates that the whole area has relatively poor filtration quality - the most distinguished direction is the one with approximate orientation NNW - SSE.

This family of fractures significantly influences the conditions of formation, movement and flow of water through fracture aquifers developed in metamorphites of the spring area of Erenik. On the basis of completed analysis, it has been established that its dip elements (DE) are 110/80, and average value of the coefficient of water porosity of this system for fractures is $K_1 = 1.26 \times 10^{-5}$ cm/s. Other families of fractures have far less impact on filtration quality of gabbros and diabases.

According to physical properties, analyzed waters are mostly clean and pure, with no color, smell or taste. Temperature of aquifer waters is usually between 2.3 and 7.3 °C. Concentration of hydrogen ions (pH) of analyzed waters varied between 5.3 and 5.5, which means that these waters may be described as slightly acidic.

Overall hardness of water of the fracture aquifer is between 0.5 and 0.8 dH, which means that according to Klut classification this water is categorized as soft.

Electrochemical conductivity varies between 10 and 18 $\mu$S/cm, which fact indicates formation under reduction conditions.

According to O. A. Alekin classification, all examined waters from fracture type aquifer belong to the hydrocarbonate water class, calcium group of the first type.

Representative elements of the chemical composition of underground waters, from the point of view of usability for water supply purposes, are presented in Figure 3.

**DISCUSSION AND CONCLUSION**

On the basis of the results of completed hydrogeologic and other research work and complex analysis and synthesis there of, the following facts have been established:

- formation of the fracture hydrogeological system has been conditioned by mechanical and other characteristics of the rock mass of gabbros and diabases, which, regardless of their genetic origin, display clearly defined elements, structure and borderline conditions;

- according to the hydrogeological structure, rock masses of the area under examination belong to the semi-closed type;

- formation of aquifer waters takes place in the fracture hydrogeological system of metamorphic gabbros and diabases, where the main additive source is inflow from other aquifers (peripheral epidot-actinolite shale, limestone and dolomite in south-east) especially along the deep cracks. Paths of the deep cracks on which the structures with divergent movement are located (B. Marković, 1980) are parallel with spreading of lithologic units in the researched area, namely NNW - SSE, and, taking into consideration that terrain in this area is rising at rate of 6 to 8 mm a year, we should expect that circulation of underground waters in the future shall be most intensive along these privileged paths;

- drainage of aquifer waters is taking place through "exsurgence" Erenik and other, less abundant springs which belong to the ascending type;

- fracture porosity coefficient values for isolated families of fractures are between 1.5 and 2.5% and they fit well into statistical data published by foreign authors;
- on the basis of completed research work and obtained results, it is clear that the spring basin of Erenik has exceptional natural potentials which need to be protected and presented for the purpose of preservation and protection from any technogenic factors. In order to achieve this, it is necessary to determine the basin surface of Erenik through further research projects, establish directions and routes of movement of underground waters, carry out hydrodynamic research and produce mathematical models.

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REZIME

VODONOSNOST ISPUCALIH STENA I HIDRO-GEOLŠKA SVOJSTVA PUKOTINSKIH IZDANI U IZ- VORIŠNOM DELU ERENIKA-DERAVICA

Mijović Dušan

Kao deo projekta ocene prirodnih resursa u izvorisnom delu Erenika-Deravica hidrogeološke karakteristike i vodonosnost pukotinskih izdani gabra i dijabaza, ispitivane su uz pomoć hidrogeoloških metoda i laboratorijskih analiza na uzorcima. Bлага mineralizovane vode ovih izdani se uglavnom formiraju kroz dotok vode iz dubokih pukotina koje se pružaju po pravcu sever, severozapad-jug, jugoistok, za koji se smatra da je pravac kretanja podzemnih voda na tom prostoru. Prosečna vrednost koeficijenata poroznosti nepselina je dva prosenca, a kompleksnost pukotina se odražava u potpunoj anizotropiji vodonosnog kapaciteta metamorfta.

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The Grlja Canyon Natural and Tourist Resource

Knezevic Marko and Kicovic Dragomir
Geography Department of the Faculty of Mathematics and Natural Sciences, The University of Pristina, 38000 Pristina, Yugoslavia

ABSTRACT

The paper, from the tourist-geographic aspect, dealt with the tourist (geomorphologic and hydrographic) resource of the Grlja Canyon within the Ropojsansko-Vrujski glacial valley in the Gusinje part of Prokletije. The canyon is significantly interesting with its numerous waterfalls and gigantic water basins, meanders, natural bridges and lakes. It attracts numerous visitors as a unique geomorphologic-hydrographic natural monument. However, due to its peripheral position, incomplete tourism material base and organizations needed for tourist visits, its tourist value is small and inadequate compared to its natural resource.

Key words: Grlja canyon, Ropojsansko-Vrujski glacial valley, water falls, springs, natural resource, tourist value.

INTRODUCTION

Glacial erosion and accumulation forms dominate in the geomorphologic structure of the Plav-Gusinje part of Prokletije due to an intensive Pleistocene glaciation. Valleys are the most interesting among them. Ropojsansko-Vrujski, Grncarsko-Ljucka and Babinopoljska glacial valleys are the most significant according to their area, recreation, esthetic and curiosity characteristics. The Ropojsansko-Vrujski glacial valley is of the highest tourist value with the most favorable conditions for tourist activities. Interesting geomorphologic and hydrographic objects, as well as, rear plant and animal species are listed and combined in the valley, 10 km in length. The Grlja canyon with waterfalls and gigantic basins, tall and sharp peaks of Maja Scokista and Karanfil, moraine blocks in Ropojsan, the hole Suplja Vrata in on of the Karanfil rocks, Vrusila and Savino karst springs with Vrusa river and Jezercze lake created around, attract a special attention with its natural tourist characteristics. The paper analyses the most important natural elements of the canyon and the valley tourist value (geomorphologic, hydrographic and floral), indicating the need for tourist organization and making the canyon an active one.

The Grlja Canyon Position and its Discovery

From the point of local, regional and wider contractive zone, the Ropojsansko-Vrujski glacial valley with the Grlja Canyon is characterized by a peripheral and nonfunctional tourist-geographic position. There are no larger town settlements, within the local and regional zone, that could be the emissive centers for the excursion and stationary tourism in the valley within the frame of Prokletije. An unfavorable position of the valley, Gusinje settlement, respectively, toward the main tourist places, as the sources of tourist demand, and bad traffic connections indicate an undeveloped tourism. The Ropojsansko-Vrujski glacial valley extends south of Gusinje, up to the state border toward Albania, between the mountains of Karanfil and Vezirova Brada, in the west, and Maja Scokista, Bjelica and Bor, in the east. The Ropojsansko-Vrujski glacier, as one of the largest Plavski glacier spring branches, moved down the valley. It started from the circues, located among the Bjelica (Maja Rosit, 2,523 m), Maja Jezercesa (2,694 m) and Maja Snikuta (2,554 m). Pec-Gusinje-Skadar (Pecki road) caravan road used to pass along the valley bottom, up to the moment of the border division with Albania in 1912. It climbed down into the Valbona valley in Albania through the Cafo Pejs (1,690 m). The custom-office building ruins can be found in the spring part of Ropojsan, indicating the significance of the road. Nowadays, a village cart road, connecting Vusanje and Gusinje, leads along the valley bottom and by the Grlja Canyon. It reaches the Savino Oko spring and Jezerce in Ropojsan.

The attempts of invading, discovering and researching the canyon are recent, and are connected to the Savino Oko spring and Skakavica river dry period, when there is the smallest water quantity, making the only possible passage of the canyon. In October 1982, the Plav visitor, mountain club, team members (H. Sahmanovic and A. Bakovic) succeeded in intruding the canyon interior by boat, from the downstream direction, some 100 meters upstream. Then, they discovered a new water fall in the canyon, some 25 m high. The same team, October 10, 1983, succeeded in climbing down the canyon, starting from the entrance, and reaching some 200 m downstream. Three more waterfalls were discovered then. A very strong karst spring was found just bellow the Skakavica entering waterfall gigantic water basin. Thanks to the spring, Grlja, as a difference to Skakavica, does not get dry even in the driest period. But, the Belgrade Mountain Association - Rescue Service - Kopaonik Station team
was awarded the honor of the first invaders of the whole canyon, headed by the engineer M. Rudakovic (1987). The team was joined by the Plav Mountain Club member H. Sahmanovic. From October 18-19, 1987, the team was the first to pass the whole canyon using the alpine and speleological equipment. According to the team member impressions, narrow cuts (1-2 m) are exchanged with vertical water fall cut sections and gigantic water basins. There are two natural bridges in the canyon, one of which represents built-in natural bridge, while the other one was created by the accumulation of falling rocky blocks. According to the opinion of mentioned team members, the Grilja Canyon with its meanders, water falls, gigantic water basins, filled with water, and the lakes, is no less impressive than the Komarnica Canyon, named "Nevidio".

RESULTS

The Canyon Natural Characteristics

The Ropojaško-Vršijski glacier, in its longitudinal profile, has continually deepened its valley, along a significant length, and has created five dams, made of limestone, by a selective erosion, due to various surface resistance (limestone, schist, erosive limestone). Continual depths and dams are alternately replaced by one after another. When the valley was inherited by the Vruja river after the ice melted, it cut and destroyed two lowest dams with its erosion. The fragments of the dams mentioned are the Cekica Krs near Gusinje and Cosovica Krs in the lower part of the Vusanje village. The three other dams are complete, still damming the valley. The first of them upstream, named Suka, is located in Vusanje. The dam absolute height accounts to 1,063 m, relative one to 65 m, respectively. The dam is 1,000 m in length, and 500 m in width. It is made of the upper-Cretaceous soft limestone that, in the upper part of the Djonbalicj settlement, joins with the upper Cretaceous erosive limestone of the southwestern slopes of Bor mountain (Zivaljevic, 1959). "Suka" is karstified on the surface. It consists of moraine blocks, looking like the tombstone monuments from another time (Cvijic, 1933). Surmounting the "Suka", the Vruja river, that, in its spring flow, from the Savino Oko spring to the dam, some 1.5 km in length, is called Skakavica, and downstream of the dam Vruja, has cut through an unusual canyon named Grilja, some 40-50 m deep, with an average width some 2-5 m, in the upper part, and 500 m long. Although being of small dimensions, the canyon represents a unique geomorphologic natural monument, its attraction being filled with waterfalls, gigantic water basins and lakes.

The Grilja Canyon is of an erosive origin and belongs to the fluvial-karst forms of relief. At the beginning, it was the lost riverbed, created by the erosion of a sub-glacial creek. The canyon polished sides above the gigantic water basins are the witnesses of the above. The canyon is identical to the form of Pont des Que Urs on Rhone river bellow the Geneva lake (Cvijic, 1933). The two natural bridges are the witnesses that the Grilja Canyon is the result of the erosion, of the same named river ground water-flow. The canyon cross-section profiles, marked with No. 1, 2, 3, 5 in Figure 1, also confirm the above. The profiles indicate that the canyon is widened at the bottom, narrower in the upper part close to its edges. The canyon width, at the level of the gigantic water basins and the lakes, amounts to 15 m, while, above the respective, at the topography surface, it partially amounts to 2-3 m.

The altitude difference, from the point of Skakavica entering the canyon (1,005 m/a/s/l) to the Grilja point of leaving the canyon (940 m/a/s/l), is 65 m in length. The Grilja riverbed total drop is of the same length too. The river drop mainly consists of the vertical rocky cuts with waterfalls, bellow which, are the deep gigantic water basins. In the southwestern part Suka is cut by an additional gorge, that, as a difference to Grilja, is dry and is named Griljic. The later is also considered to be of an erosive origin. The two gorges were not created by the same river. Namely, Grilja was deepened by Skakavica (Grilja), and Griljic was the result of the Soccica, the sub-glacial creek erosion during the glaciation, respectively (Milojevic, B., 1957). Savino Oko is strong karst spring, breaking out from the hollow in the bottom of the Ropojaško glacial valley, at 1,050 m above sea level. Its maximum capacity is 10 m³/s (Stankovic, S., 1972). Minimum depth of the spring lake-surface, when losing the arm of the river, is 6m (measured Oct. 13, 2018), and maximum 12 m, when Skakavica river flows out with the largest flow capacity. At the canyon entrance, Skakavica falls down, through vertical karst cut, into the gigantic water basin and makes a waterfall (A) some 15 m high. The waterfall noise, especially during the period of high water level and the river flow, could be heard far away around. The gigantic water basin - cauldron, whose depth is not measured yet, and according to some estimates, during the river mid water level, is some 5 m. Its width is some 10 m. The next waterfall (B) is some 5 m high. From the waterfall left side, there is a spring breaking out with the maximum capacity of 10 liter per second. The waterfalls marked C (Figure 2) are 2-3 m high. Downstream the waterfall, in the Grilja riverbed, there is a rock of the waterfall height, and further bellow there is a smaller rock too. The Grilja river greatest deep, over 13 m, is in the lowest erosion expansion, at the canyon exit, with a huge rock in the riverbed (Milkovic, Petrovic, 1989).
Longitudinal Section of the Grilja Canyon
Figures 1, 2, 3, 4, and 5 mark sketches of cross sections of the Canyon.

Y = Cliff,
A, B, C, D, E = Waterfalls

According to M. Rudakovic

Ropojane valley (Original drawing)
Ropojanskoj valov (Originalni crtež)
The Ropojansko-Vrujski glacial valley, as a complex and polyvalent valley, has got favorable natural predisposition for the development of many types of tourism (fishing, hunting, weekend-exursion, excursion, mountaineering, Alpinism. Kicovic, 1995). The tourist value of the Grilja Canyon and its glacial valleys is, mainly, based on its characteristics and the utilization elements, its rarity and diversity. The utilization possibility results from the valley and closer surrounding characteristics and possibilities in satisfying the tourist movement needs, such are: recreation, education, esthetics, etc. Recreational and psycho-physical needs could be satisfied here through walking, fishing, hunting, mountaineering, natural attraction visits, medicinal herb collecting, etc. The Ropojansko-Vrujski glacial valley, and its closer surrounding, represents a real didactic polygon and science laboratory for the field lecture and research, under the open sky. Therefore, it is often visited by pupils and students, numerous scientists, especially geo-morphologists, hydrologists, geographers, botanists and geologists. Typical forms of glacial erosion and accumulations could be found here in a relatively small area. Among these, the marking ones are the glacial valleys and cirques, sharp and toothed crests, moraines and peaks. The karst forms of relief - the canyons, hollows, caves, pits, windows, etc. These are often combined with the glacial relief, giving the glacial valley a specific characteristics. The geologist attention is attracted by the layer profiles at the eastern side of Karanfili, Vrujski saddle, by the rock and mineral formations, as well as, by the polynetal sulfide phenomena (copper, lead, zinc, etc.) in direct surrounding. The Gusinje part of Prokletije is characterized by a great number of endemic and relict floral species. Recently, a new discovered species of the family Cruciferae, Draba bertiscea - the Prokletije portulaca, with Maglic being the unique one and the only known area, attracted the botanist and the scientific public attention. However, Prokletije, with its 150 floral species at 2,500 m², represents the major center of florist diversity in the FR of Yugoslavia (Stevanovic V. et al., 1995). The original, landscape, especially geo-morphological, hydrographic and phyte-geographic diversity, make the Ropojansko-Vrujski glacial valley to be the one of the most beautiful and the most attractive valley in the FR of Yugoslavia. Such resource of diverse esthetic space elements, composed into the landscape, could be rarely found elsewhere, but here. The slogan "diversity is beauty" in the valley has its full and real meaning. The miraculous relief forms, as are the sharp peaks like the Maja Scokiste and Karanfili, windows, vertical cuts in cirques, canyon cuts in the dams, cave holes, then, the rivers with waterfalls, strong karst springs and direct touches of bare rocks and greenery, give the Ropojansko-Vrujski glacial valley and the Gusinje part of Prokletije, a magic visual impression and evoke emotive and mystic experience of high degree. This part of Prokletije originality, diver-

Figure 3. The Nakavica Waterfall on the entrance of the Grilja Canyon

Figure 4. The Vruja River (Grilja) on the exit of the Canyon
sity, rarity and fame of the natural resources and specific, are the inexhaustible inspiration and challenge for many writers, painters and photographers. Despite the resources and the potential indications, nothing has been done so far, regarding the tourist organization of the Ropojansko-Vrujski glacial valley and the Grilja Canyon. There is no organized sight spot along the canyon, from where, the interior of the geomorphologic area with waterfalls, gigantic water basins and lakes could be seen. The canyon, however, is invisible, unless its high, vertical and, largely, inverse leaned side, is directly reached. The canyon bottom could be seen from two, or three spots, only. As there is the shortage of the sight spots and of the fans, the watching of the canyon is a risky one. It evokes fear and dizziness in certain visitors. There were tragic outcomes too. The Project preparation is needed for the tourist organization of the canyon, that would project the construction of the suspension bridges along the canyon, with several cross bridges, that would also serve as the sight spots. Technical organization also supposes the lighting up of the canyon, the construction of access paths an (waterfalls with the gigantic water basins, rocks, meanders, etc.). An adequate tourist organization of the canyon would enable the visitors to do the sightseeing, to get acquainted with, and to experience the most unusual morpho-structural and morpho-sculptural forms and hydro-geographic curiosities that can be found in the canyon. The later would enable the tourist longer staying and greater consumption, and consequently, the economic feasibility of the canyon tourist exploitation. Thus, the canyon, as an exceptional geomorphologic rarity and natural resource, would become the tourist value that makes profit. An adequate advertising activity, as well as, a well organization of tourism in the area considered, would be of great significance for the tourist animation of the canyon. It should be mentioned, that, technical organization should not disturb, or degrade the natural appearance of the canyon.

**DISCUSSION AND CONCLUSION**

Based on the above, the Ropojansko-Vrujski glacial valley with the Grilja Canyon is characterized with exceptional natural resources, especially geo-morphological, hydrographic and floral ones. The values, according to their quality and significance, no doubt, exceed local and regional character and are of greater significance. There are here, not only, the Balkan's, but also the European and, even, the World's natural rarities. Therefore, the valley was declared to be the reservation of the natural region that should be activated from the point of tourism. It should be expected that it is going to be included in the zone of strict protection of the future National Park of Prokletije.

Whether the natural values of the valley and the canyon considered, include the tourist value too, the answer is affirmative, although, there are opposite opinions too. The Ropojansko-Vrujski glacial valley and the Grilja Canyon are the integral part of the Plav receptive tourist zone, the Plavsko lake respectively, and the Gusinje locality zone too. It is an area of primary tourist exploitation of the Plavsko-Gusinski part of Prokletije. The Grilja Canyon is 17 km far from Plav by road, 6km from Gusinje respectively. Its most frequent visitors are the guests of "The Plavsko Lake" hotel in Plav, excursionists from Andrijevica and Berane and the excursionists and mountainers from various parts of our country. Its natural values (the relief, water, air, flora and fauna) represent primary attractive factors of the area tourist offer. Its essential attractive attributes are: originality, rarity, diversity, specificity and representativeness, as well as, the esthetic and curiosity characteristics. Thanks to the ski grounds in the near by Bor, there are favorable conditions for winter-sport tourism too. In order to enable the canyon and the glacial valley obtain higher tourist value, i.e., the respective are more successfully evaluated, the Phase one would, apart from the canyon organization, require the construction of a high quality road along the glacial valley and a motel, or a hotel in the glacial valley itself.

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REZIME

KANJON GRIJE KAO PRIRODNA I TURISTIČKA VREDNOST
Knežević Marko, Kćović Dragomir

Južno od Gusinja, u ropojansko-vrujskom valovu, kojim se u pleistocenu kretao najduži prokletijski ledenik, usećen je kanjon Grije. Dubok je 40-50 m a prosečno širok 2-5 m. Predstavlja jedinstven prirodnog kompleks sa džinovskim loncima dubokim do 5 m, prirodnim mostovima, kraškim vrelima (Savsko oko s maksimalnom izdašnosti od 10 m³/s i tri vodopada (najduži oko 15 m a najkraći 2-3 m). Levo i desno od kanjona izdižu se šiljati vrhovi Maja Šćokišta i Karanfila, džinovski prozorci u stenama, vertikalno usećeni čirkovi, kanjonski odseci sa prečagama i pečinski otvori. Ove osobine kanjona Grije mogu se koristiti u lovnom, ribolovnom, izletničkom i ekskurzivnom turizmu, a pogodne su i za nastavu u prirodi. Ropojansko-vrujski valov sa kanjonom Grije može se pretvoriti i u prav način-istraživački poligon.

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The Elements of the Pristina Bio-climatic Characteristics

PECELJ R. Milovan1, JOVIC S. Goran1, STEVANOVIC Vladica2
1Geography Dept., NSF, Pristina
2The Institute for protection of nature if Serbia, Pristina

ABSTRACT

Bio-climatic analysis of Pristina was made on the basis of equivalent temperatures (Et) and Charles's method (the sultriness clime-gram), and the Kruger's anthropo-climatic classification, amended and adjusted, served for the determination of bio-climatic characteristic. The equivalent temperatures were calculated for the Pristina meteorological station (1950-1985 period), classified in five bio-climatic classes and two weather types. Cold (5 °C < Et < 22 °C) and pleasant (22 °C < Et < 50 °C) weather types were present with the classes: cold, quite chilly, cool, pleasant and warm.

Key words: Equivalent temperatures, the sultriness clime-gram, bio-climatology, anthropo-climatic classification, weather types and classes.

INTRODUCTION

Bio-climatology, with its disciplines (climate-therapy, climate-pathology, climate-physiology), studies various relations between the organisms and the perennial atmosphere condition, as well as, multiple interaction with the dominating influence of physical environment in relation to human retroactive reaction. The bio-climatic influence in perceived by the introduction of various complex climatic values, obtained by the combination of certain climatic elements (equivalent temperatures, cold-weather index, air enthalpy, air-cooling ability, radiation-equivalent-effective temperature etc.), being of special significance to the selection of sanitarium location, or recreation destination from the aspect of medicine and multiple climate influence on health (Pecelj, et al., 1996).

METHOD

The bio-climatic analysis is based on the combination of temperature and water vapor pressure (Et = t+2e), being the basis for the determination of the heat physiological sensation and the weather types in accordance with the Kruger's anthropo-climatic classification, amended and divided in three weather types and nine heat physiological sensations (Table 1). Such combination, in addition to the temperature and the water steam pressure, also considers the air stream and the air pressure, and is known as the equivalent temperature (Et), (Milosavljevic, 1985). The significance of the equivalent temperatures in bio-climatology is that, the respective could evoke various heat sensations in healthy and sick people; that could be used as basis for weather classification regarding the recreation and tourism, especially from the medicine point. Pristina (590 m a/s/l) is an urban, economy, management and administration center of Kosovo and Metohija with significant historic-tourist locations and certain natural resources in its vicinity, that could be complementarily evaluated. Thus, one of such bio-climatic analysis could be of great use.

Apart from the equivalent temperatures for the completion of bio-climatic characteristics, the sultriness clime-gram (Charles's s method) is also used and it combines the temperature and relative air humidity. The essence of this method is that the heat is easily transferred if the weather is dry and windy, and more difficult, if its humid and windless. Such unbearable heats are known in climatology as the sultriness. Thus, in cases of the same temperature, a person has various sensations of the heat, depending on the air the humidity and air pressure values (Dušic, 1981).

The equivalent air temperature, practically, represents a supposed dry air temperature that would exist if, the whole water vapor had condensed in a humid air, thus, releasing all the heat that had been previously consumed within the processes implementing the

| Table 1. The Classification of Physiological Heat Sensations and the Weather Types |
|---|---|---|---|---|---|---|---|---|
| Et in °C | < 5° | 5 - 18° | 18 - 22° | 22 - 30° | 30 - 40° | 40 - 50° | 50 - 58° | 58 - 70° | > 70° |
| Physiological Heat sensation | Quite cold | cold | Quite chilly | Fresh | Pleasant | Warm | Slightly sultry | Sultry | Quite sultry |
| Weather type | Cold | Pleasant | High Heat |
water vapor inflow in the atmosphere. The respective acknowledges the latent heat expected within the condensation-sublimation processes. The water transfer from one to the other aggregate condition is followed by the release or the consumption of energy, that creates grandiose processes in the geographic cover. An energy of 2.533 x 10^3 J is required for 1 gram of water be transferred into vapor condition (Milosavljevic, 1985).

**RESULTS AND DISCUSSION**

The respective bio-climatic analysis was based on the meteorological data for the Pristina station within the period 1950-1985. By applying the temperature, the water vapor and the relative air humidity correlation mentioned, the weather types, the physiological heat sensations (equivalent temperatures) and the sultriness clime-gram (Table 1 & 2, Supplement 1 & 2) were selected.

The two weather types (cold and pleasant) and five physiological heat sensations (from the sense of cold to the sense of warm) were selected within the equivalent temperatures.

The Cold Water Type (5 °C < Et < 22 °C) is presented within the period of November -- March. The physiological heat sensations Cold (Et = 5-18 °C) dominates during the three winter months (December, January and February). The physiological sensations Very chilly (Et = 18-22° C) during March is (Et = 16.8 °C), with the November of (Et = 20.4 °C). The class of Quite cold (Et = 5° C) is not presented, but in January its values are partly close (Et = 9.7 °C). Winter is the season with the least accumulated heat during the year. As well as the major part of the winter, January is also characteristic regarding the dominating influence of Mid-European anti-cyclone bringing dry and gloomy weather. That is the period of inverse manifestations, primarily of a radiation type, being the consequence of the relief composition and local conditions.

Pleasant Weather Type (22° C < Et < 50° C) characterizes the whole Summer (June-August) and most of the Spring (April, May) and Fall (September, October). All the classes of the weather type are presented too. The class Cool (Et = 22-30° C) is presented during the start and the end months (April Et = 25.2° C and October Et = 22-30° C). The class Pleasant (Et = 30-40° C) is presented in May (Et = 36.3° C) and September (Et = 40° C). Finally, the class Warm (Et = 22-3 0 °C) is presented during summer months, from June to September. The above mentioned is the period of anti-cyclone activities, but favorable bio-climatic
characteristics too. Then, there is the most of accumulated latent heat, being the consequence of thermal characteristics whose annual trend finally follows the water vapor pressure.

Overbeated Weather Type (50 °C < Et < 70 °C) is not presented during the whole year round. The sultriness climate-graph (Supplement 2) does not state the presence of any form of sultriness, that, again confirms the absence of the weather type.

CONCLUSIONS

Pleasant Weather Type dominates and lasts for seven months. All of its classes are presented. The type covers the whole vegetation period and extends to October. The class warm dominates during the summer, partly covering September (Et = 40.1°C). The cold Weather Type lasts for five months and the classes cold and quite chilly are presented. None of the classes specified as sultry is presented, thus, the presence of the overbeated weather type is excluded.

Using the Charl's method of the sultriness determination, through the combination of the relative air humidity and the temperature, at the sultriness climate-graph a closed form of the curve is observed, being quite distant from division lines of the sultry zone and the comfortzone (pleasant sensation). Therefore, the sultriness in classic form is absent even in the case of high summer temperatures. The respective resulted in a low relative air humidity during summer months. Naturally, certain sultry days can not be excluded on the basis of monthly averages (that again relatively applies within the framework of the procedure itself, the method respectively).

In addition to the enclosure of the equivalent temperature diagram with the weather types, classes and the sultriness climate-graph for Pristina (Supplement 1 & 2), it should be also mentioned that, quality weather and climate monitoring is of an essential significance for the bio-forecasts. Pristina could establish the respective, considering the fundament existing in its meteorological observing scheme.

Pristina and its surrounding could be regarded a favorable area from the bio-climatic point, recognizing the equivalent temperatures and the sultriness climate-graph and evolving the physiological effects of the climatic influence, that could be complementarily amended and adequately evaluated in accordance with other physical-geographic and anthropo-geographic pre-dispositions. As the respective is the matter of the scientific research, it should apply to the terms of the medicine policy, the tourist plans and interests, as well as, to contemporary ecological demands.

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REZIME

ELEMENTI BIOKLIMATSKIH KARAKTERISTIKA PRIŠTINE

Pecelj M. Milovan, Jović S. Goran, Stevanović Vladica

Pristina (590 m n.v.) je urbano, ekonomsko, upravno i administrativno središte Kosova i Metohije u čijoj blizini su značajni istorijsko-turistički lokaliteti i određene prirodne lepote koje bi se mogle komplementarno valorizovati, pa bi jedna ovakva bioklimatska analiza bila od koristi.

Bioklimatska analiza Prištine rađena je na osnovu ekvivalentnih temperatura (Et) i Šarlovog metoda (klimogram zapare), a antropoklimatska klasifikacija Kriger, dopunjena i prilagođena, poslužila nam je za određivanje bioklimatskih karakteristika. Ekvivalentne temperature su izračunate za meterološku stanicu Priština (period 1950-1985. god.), svrstane u pet bioklimatskih klasa i dva vremenska tipa.

Zastupljeni su bladni (5°C < Et < 22°C) i prijatni (22°C < Et < 50°C) vremenski tip, sa klasama: bladno, veoma probadno, sveže, ugadno, i toplo.

Dominira prijatni vremenski tip i traje sedam meseci. Zastupljene su sve njegove klase. Ovaj tip obuhvata celi vegetacioni period i proteže se na oktobar. Dominira klasa toplo tokom leta, delimično prelazeći u septembar (Et = 40.1 °C). Hladni vremenski tip traje pet meseci i zastupljene su klase bladno i veoma probadno. Nije zastupljena nijedna klasa koja se normativno significala kao zaparna, pa se na taj način isključuje prisustvo pregrijanog vremenskog tipa.

Koristeći Šarlov metod za određivanje zapare, preko kombinacije relativne vlažnosti vazluha i temperature, na klimogramu zapare se uočava zatvoren oblik krive, koji je prilično udaljen od granice razdvajanja zone zapare od zone konfira (ugodnih osećaja). Zato i pored visokih letnjih temperatura zapare nema
u klasičnom obliku. Razlog je u maloj relativnoj vlažnosti vazduha tokom letnjih meseci. Naravno da se na osnovu mesečnih srednjaka ne isključuju pojedini dani sa zaparom (što je opet relativizirano u okvirima samog postupka, odnosno metode).

Sa bioklimatskog stanovišta, koja uvažava ekvivalentne temperature i klimogram zapare, koje evoluiraju fiziološke efekte klimatskih uticaja Priština sa okolinom može se smatrati povoljnim prostorom, što se u skladu sa drugim fizičkogeografskim i antropogeografskim predispozicijama može komplementarno dopunjavati i adekvatno valorizovati. To je stvar ozbiljnih razmišljanja, što pripada domenima medicinske politike, turističkih planova i interesa, kao i savremenih ekoloških zahteva.

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Determination of the Insolation Relative Duration
The Example of Prizren, Pec and Pristina

TADIC Milutin
Geography Department of Faculty of Natural Sciences of The University of Pristina

ABSTRACT
Operating with relative insolation duration is more rational in case of the climatic analysis. The insolation duration is determined on the basis of effective measured and calculated potential. However, operating time of helograph is not equal to the duration of the daylight, it always starts operating before sunrise and stops before sunset, even within good weather conditions. The respective is caused by the limits of the instrument itself and the geographic horizon too. Therefore, relative insolation duration, consdered without these limitations, is not a realistic one. The paper, for example, considers three locations in Kosovo and Metohija (Prizren, Pec and Pristina) and its effective, potential and, finally, relative daily, monthly and annual insolation duration has been determined. The values obtained represent a minimal relative insolation duration, therefore, one may properly state, -- relative annual insolation duration in Prizren is more than 46.3% (Ir>46.3%), in Pec more than 43.4% (Ir>43.4%), and in Pristina more than 47.5% (Ir>47.5%). How much more, the relative insolation duration really is, should be determined by decreasing potential insolation duration, based on the recordings of extreme moments of the heliograph operating time per months, directly from the tape within a perennial period.

Key words: insolation, effective insolation duration, potential insolation duration, relative insolation duration.

INTRODUCTION
An effective insolation duration during the day (Ie) is expressed in hours, as a sum of time intervals, during which, a given position was lighted by direct sunlight. It is measured by heliograph. Based on daily measured values, monthly and annual sums are later determined, as well as, are the average daily, monthly and annual values within a perennial period. An effective insolation duration depends on the latitude and the altitude of the place, the opening of the geographic horizon (i.e. the place relief, -- the view line form in the sector limited by the solstitial points of the sunrises and sunsets), as well as, the conditions of the atmosphere. The greatest daily effective insolation duration is equal to the daylight duration, -- to the time interval from the sunrise to the sunset. This is called A potential insolation duration (Ip), and is determined mathematically-geographically, and is not dependent on the atmosphere condition. The quotient of an effective and potential insolation duration, expressed in %, represents A relative insolation duration (Ip).

The effective insolation duration is still most frequently given, although for the majority of analyses, the insolation duration given in relative form is by far more purposeful. For example, direct comparisons are possible with relative insolation duration only, in case of places located on various latitudes.

The determination of relative could be broken down into three phases, that will be discussed based on the example of three places in Kosovo and Metohija, whose meteorological stations do the measuring of the effective insolation duration. The places are Prizren, Pec and Pristina.

The Determination of the Effective Insolation Duration
Monthly and annual sums of the effective insolation duration, expressed in hours, has been given in the meteorological yearbooks (the effective insolation duration per days and per hours during single day, is given in the yearbook chapter titled as The Sun Radiation). Average values of the effective insolation duration within the period of 1960-1984 (Table 1) are determined for the three places, based on the records from the Meteorological Yearbook.1

1 According to meteorological practice, the 3rd, 4th and 5th months are considered the spring, the 6th, 7th and 8th months, the summer, the 9th, 10th and 11th months, the fall (autumn), while 12th, 1st and 2nd, the winter, although the distribution of 1st - 3rd, 4th, 6th, 7th, 9th, 10th and 11th is closer mathematics-geographic limits of the seasons.
Table 1. The Effective Insolation Duration, Total Monthly and Average Daily (Ied), in Hours, in Prizren, Pec and Pristina, within the period of 1960-1984.

<table>
<thead>
<tr>
<th></th>
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<th>II</th>
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<th>IV</th>
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<th>VI</th>
<th>VII</th>
<th>VIII</th>
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<td>8.43</td>
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Table 2. The Potential Insolation Duration (in hours) Regarding latitudes of Yugoslavia.

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<th>φ = 45°</th>
<th>φ = 45°30’</th>
<th>φ = 45°45’</th>
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<td>452.29</td>
<td>453.72</td>
<td>455.18</td>
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<td>458.17</td>
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<td>464.58</td>
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<td>1310.10</td>
<td>1313.99</td>
<td>1317.96</td>
<td>1322.00</td>
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</tr>
<tr>
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<td>463.80</td>
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<td>467.15</td>
<td>468.87</td>
<td>470.63</td>
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<td>431.07</td>
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<td>1270.82</td>
<td>1273.73</td>
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<td>DECEMBER</td>
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<td>277.89</td>
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<td>914.72</td>
<td>911.10</td>
<td>907.41</td>
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<td>1878.94</td>
<td>1873.08</td>
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<td>1861.02</td>
<td>1854.82</td>
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<td>42.13</td>
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<td>41.85</td>
<td>41.70</td>
<td>41.55</td>
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<td>4463.76</td>
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<td>(3051/24)*</td>
<td>50.90</td>
<td>50.91</td>
<td>50.92</td>
<td>50.93</td>
<td>50.94</td>
<td>50.96</td>
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Table 3. Total Monthly (Ipm) and Average Daily (Ipd) Potential Insolation Duration (in hours) at the latitudes of Prizren, Pec and Pristina.

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<th></th>
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<th></th>
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<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(φ = 42°13’)</td>
<td>Icm</td>
<td>293.96</td>
<td>295.34</td>
<td>359.22</td>
<td>400.19</td>
<td>451.50</td>
<td>456.25</td>
<td>462.87</td>
<td>430.30</td>
<td>375.82</td>
<td>344.31</td>
<td>295.34</td>
<td>284.05</td>
</tr>
<tr>
<td>Pec</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(φ = 42°40’)</td>
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<td>400.79</td>
<td>452.77</td>
<td>457.83</td>
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<td>431.41</td>
<td>375.03</td>
<td>343.82</td>
<td>294.24</td>
<td>282.54</td>
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% according to (3051/24)”
Table 4. The Relative Insolation Duration per Month (in %) at the Latitudes of Prizen, Pec and Pristina, for the Period of 1960-1984.

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
<th>XI</th>
<th>XII</th>
<th>Year</th>
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<tbody>
<tr>
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<td>67.00</td>
<td>92.45</td>
<td>141.74</td>
<td>175.94</td>
<td>222.46</td>
<td>256.37</td>
<td>298.23</td>
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<td>165.70</td>
<td>93.16</td>
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<tr>
<td></td>
<td>Ip</td>
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<td>295.34</td>
<td>369.22</td>
<td>400.19</td>
<td>451.50</td>
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<td>430.50</td>
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<td>344.31</td>
<td>295.34</td>
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</tr>
<tr>
<td></td>
<td>Ir</td>
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<td>38.39</td>
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<td>49.27</td>
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<tr>
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<td>Ie</td>
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<td>93.85</td>
<td>141.66</td>
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<td>226.18</td>
<td>268.53</td>
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<td>145.89</td>
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<td>101.84</td>
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<td>50.05</td>
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Table 5. The Effective Hours, Potential and Relative Insolation Duration (% ) per Quarters and Semesters at the Latitudes of Prizen, Pec and Pristina, for the Period of 1960-1984.

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<th>3rd quartile</th>
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<td>62.90</td>
<td>33.71</td>
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<td>Ie</td>
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<td>604.92</td>
<td>1331.78</td>
</tr>
<tr>
<td></td>
<td>Ip</td>
<td>956.40</td>
<td>1311.39</td>
<td>1271.79</td>
<td>920.61</td>
<td>1877.01</td>
<td>2583.18</td>
</tr>
<tr>
<td></td>
<td>Ir</td>
<td>31.95</td>
<td>43.86</td>
<td>57.43</td>
<td>32.51</td>
<td>32.23</td>
<td>51.56</td>
</tr>
<tr>
<td>Pristina</td>
<td>Ie</td>
<td>319.14</td>
<td>660.42</td>
<td>800.23</td>
<td>357.27</td>
<td>656.40</td>
<td>1460.65</td>
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<td>956.40</td>
<td>1311.39</td>
<td>1271.79</td>
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<td>2583.18</td>
</tr>
<tr>
<td></td>
<td>Ir</td>
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<td>50.36</td>
<td>62.92</td>
<td>36.66</td>
<td>34.97</td>
<td>56.54</td>
</tr>
</tbody>
</table>

Instead of giving the sums and averages per calendar months and quartiles, it would be more natural that the respective are given in time intervals, between each 21st day of a month, and later per seasons within their mathematics-geographic limits. The effective insolation duration for each day should be known for the purpose of such a review.

The Determination of Potential Insolation Duration

Daily duration of potential insolation is equal to the daylight duration. Observing the upper edge of the Sun disk and considering the influence of the astronomical refraction, a potential insolation duration could be determined according to well-known formula,

\[
I_p = \frac{2}{15} \arccos \left( \frac{-\sin \varphi \sin \delta - \sin \varphi \sin \delta}{\cos \varphi \cos \delta} \right) \quad \cdots (2)
\]

in which \( \varphi \) is the place latitude, \( \delta \) the Sun declination are given for each day in the astronomical ephemeris, a year in advance, at least. When these values are applied in one of computer programs for table calculations, such, for example, is The Quattro Pro program, then, according to Formula (2), the potential insolation duration could e quickly determined for each day, followed by the sums between any of the two days. The results of such calculations for our country are given in Table 2.

Table 2 values are obtained by calculations based on the 1995 declinations. The values are correct of course. There are tables with similar data too, for example (Vujicic, 1948; Milosavljevic, 1988). In case of leap year, February sum should be added with the daylight length of the 29th day, with an average of 11.11 hours.

The potential insolation duration at the latitudes of Prizen, Pec and Pristina, the sample places has been determined in the way mentioned (Table 3).

The potential insolation duration determination could be speeded up by creating special computers programs. One of such was published in 1984, September issue of The Sky & Telescope Magazine, titled SUNSHINE BAS. The places latitude in degrees, the ordeal number of the start and the end day, within the given period of the year, should be inserted. For example, the determination order of the total potential insolation...
lation duration within the period of January 1, to March 21, in Pristina is \( \varphi = 42^\circ 40' \), as follows:

- **LATITUDE (DEGREES)**: 42.667
- **START DAY IN 1986**: ? 1
- **END DAY IN 1986**: ? 80
- **SUNSHINE =** 50,044 MINUTES
- **834 HOURS**

The potential insolation duration is obtained in minutes and hours. The values are correct, according to the Sun declination values for 1986.

### The Determination of the Relative Insolation Duration

When the effective insolation duration is measured and the potential insolation duration calculated, the relative insolation duration could be easily determined according to Formula (1). The relative insolation duration for the sample places was given in Tables 4 and 5.

### DISCUSSION

However, there is a question arising regarding the authenticity of such determined relative insolation duration? The potential insolation duration refers to the time interval limited by the moments of the sunrise and the sunset for the illusory horizon of the place given, but not regarding its actual appearance of the horizon line. Therefore, in practice, the Sun always rises later, and always sets earlier, compared to the moments determined by the Formula (2), i.e., the potential insolation duration for each day is just a little shorter, then the duration determined in a way already described. In order to determine the potential insolation duration without idealizing the horizon, the horizon line should be constructed first, as it is seen from the standing point given. The respective could be implemented by a theodolite measuring the polar coordinates of the horizon line part bracing points, within the azimuth range of solstitial points of the sunrises and the sunsets, or in a cabinet manner, from the topographic map. When the horizon line is constructed in the selected cartographic projection, then, its cross-sections are determined with the projections of the Sun illusion trajectory (Radojkovic, 1996). The insufficiency of this method is that the Sun is shadowed not only by the hills, but the buildings, the trees too.

Besides, even in the case of an ideal horizon, the heliograph can not collect sufficient beam of the Sun ray that could burn the tape, neither during the sunrise, nor the sunset. The Sun radiation intensity must rise to the point equal to the point equal to one tenth of the solar constant (An Instruction for Observation... 1974). In other words, the Sun must rise to the height (h), at which, it achieves the point of direct radiation, The height results in the atmosphere condition, and is not equal in the morning and the evening, respectively. Up to the moment, the heliograph registers no effective insolation duration.

The above means that, measuring would not indicate the effective insolation duration, equal to the potential one, even in the case of ideal conditions. The respective further means that, while determining the relative insolation duration, a decreased potential insolation duration must be operated with. However, how much decreased?

This is most effectively determined by a direct, measuring of extreme, morning and afternoon moments with the heliograph tape burns (average values over perennial period), then, by finding out at what Sun heights this happened, and finally, by determining the shortening of the potential insolation duration. In this manner, the horizon line and the limitation if the heliograph are simultaneously taken into consideration.

Unless the respective is done, the relative insolation duration determined in previous way, should be considered as minimal. Thus, a proper statement is: The relative annual insolation duration in Prizren is more than 46.3% (Ir>46.3%), In Pec more than 43.4% (Ir>43.4%), and in Pristina more than 47.5% (Ir>47.5%).

---

2 The date obtained by checking the heliograph tape, for each day, within the perennial period. The respective data are still missing in case of Prizren, Pec and Pristina. For example, there are data for Knjizvo, but only for 1996. Thus, the average Sun height in this station, during starting operation of the heliograph of the year given, amounted to \( h = 7^\circ 40' \), and \( h = 6^\circ 00' \) during the latest end of operation. The respective results in the decrease of the potential insolation duration in 1996 amounting to 13%.
REFERENCE

REZIME
ODREĐIVANJE RELATIVNOG TRAJANJA INSOLACIJE NA PRIMJERU PRIZRENA, PEĆI I PRIŠTINE
TADIĆ Milutin

Relativno trajanje insolacije se određuje na osnovu izmjerenog efektivnog, i izračunanog potencijalnog trajanja insolacije. Potencijalno dnevno trajanje insolacije jednako je dužini obdanice, dok je radno vrijeme heliografa uvjet kraće, -- zbog ograničenosti samoga instrumenta, i zbog geografskog horizonta. Zbog toga bi trebalo umaniti potencijalne trajanje insolacije, što sa sobom povlači povećanje relativnog trajanja insolacije.

Prvo je određeno efektivno trajanje insolacije (Tab. 1), onda potencijalno trajanje insolacije za pomenuta mjesta (Tab. 3) i za geografske širine naše zemlje (tab. 2), i na kraju relativno trajanje insolacije po mjesecima i kvartalima (Tab. 4, 5). Na taj način se došlo do saznanja da je relativno godišnje trajanje insolacije u Prizrenu 46.3%, u Peć 43.42% i u Prištini 47.47%. To su, ustvari, minimalne vrijednosti relativnog godišnjeg trajanja insolacije u ovim mjestima.

Korekciju ovako nađenog relativnog trajanja insolacije najefektnije je odreditinoposredno, -- zabilježiti ekstremne, prijepodnevne i poslijepodnevne, trenutke u kojima je nagorela traka heliografa (prosječne vrijednosti u višegodišnjem periodu), potom naći pri kojim se to visinama Sunca desilo, i na kraju odrediti skraćenje potencijalnog trajanja insolacije. Na ovaj način se istovremeno uzima u obzir i vidljiva linija, i ograničenost heliografa.

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The Gamma Dose Rates of Radiation in the Air and Closer and Further Surrounding of the Kosovian Coal Power Plants

ADROVIC P.¹, PAPOVIC R.², NINKOVIC M.³
¹Faculty of Natural Sciences and Mathematics, 38000 Pristina, Viševdanska 5
²University of Pristina Rectorate, 38000 Pristina
³Institute of Nuclear Sciences "Vinca", Belgrade

ABSTRACT

The results of the values gauged, concerning the gamma radiation dose rates in the air and of the natural phone level at 20 selected locations in closer and further surrounding of the Kosovian coal power plants, are presented below. The gauging was done by an autonomic ADL - drill "Gamma Tracer", the system for long term- continual gauging of the natural radiation level. The existence of an increased radiation level was determined in the settlements, located in closer surrounding, compared to the radiation levels in the places out of the reach of the coal power plants influence.

Key words: the gamma radiation dose rates in the air, coal power plants.

INTRODUCTION

Natural soil radioactivity is highly significant source of the population exposition by the ionized radiation. The processing and use of the soil materials results in an additional natural radiation. Some of the materials, such as coal, oil, are used for the production of electric energy. By drilling and using the coal, its radioactivity is redistributed from the depth of the coal layers, that did not affect the people and the bio-sphere significantly, and is brought to the land surface, thus, significantly changing the radioactivity quantity and radio-ecological picture of the living environment [1]. By burning the coal, as well as, during the process of drying, grinding and gasification, numerous chemotoxic and radio-toxic pollutants are released into the environment. Coal power plants represent one of the causes of the natural radioactivity redistribution, as by burning the organic components of the coal, the coal volume decreases to the slag and ash, inevitably leading to the concentration of radioactive material of the respective. Therefore, the concentration of natural radio- nuclides in ash and slag from the coal power plants is significantly higher, compared to their concentration in the earth core. Kosovo A coal power plant belongs to an old type of coal power plants. There are five energetic blocks, emitting over 15% of the ash, produced through its chimneys, into the atmosphere [2]. An annual production of the waste material amounts to some 1,200,000 ton from the Kosovo A coal power plant, while the Kosovo B coal power plant produces some 1,000,000 ton of ash and slag annually. Depositing of such enormous quantities of electro-filtered ash and slag represents a great problem as to the operation and functioning of the coal power plant, and consequently regarding the jeopardizing of working and living environment of the Obilic, Kosovo Polje, Pristina and near by settlements population. Numerous waste material deeps have been created within the direct vicinity of the coal power plants, with their height making them look like real small mountains. These ugly increasing deeps disturb the beauty of spacious and fertile flat, and permanently attack the health of people with its physical-chemical composition. The Kosovo A coal power plant emitting flying ash, composed not only of chemo-toxic but also of radio-toxic contaminants, from its chimneys, represents the greatest danger for the population of Obilic, Kosovo Polje, Pristina and wider area. The Kosovo A coal power plant represents a real ecological challenge for the region [3].

MATERIAL AND METHODS

The gauging of the equivalent gamma radiation dose rates in the air was implemented by an autonomic ADL - drill "Gamma Tracer", the system for the continual gauging of the natural radiation level. The autonomic radiation dose gauging instrument Gamma Tracer ( - registers continually within the time intervals selected. The electronic set and the power supply are located in the water-proof box. The chip technology for power supply is free of any maintenance within full operation of the Gamma TRACER device within the three year operation with no recharging required [4]. Registered values can be, at any moment, disposed through the interactive infrared port. The gamma professional software operation communication program,
as well as the analysis software, guarantee simple, fast and safe approach to the data collected and their visualization. Figure 1 indicates the most important components of the Gamma TRACER system. The drill was located 1 meter above the land surface on IC Transmitter Two way IC Optical Link GM Detector 1 GM Detector 2 Long-Life Lithium Battery.

**Figure 1. The gamma TRACER System General Components all of the gauging points.**

Since, only one gauging drill was available, the data register time interval per gauging location duration averaged to about 2 hours. The gauging at certain location was done in longer time intervals also. The respective primarily refers to the locations with the test gauging indicating somewhat higher gamma doze radiation rates, compared to the average dozes of other gauging points. The longer time interval gauging was also done by the ADL instrument in the locations with the climate condition changing fast during the gauging. The gauging was first done within the coal power plant yard, then in the settlements near by: Krusevac, Kosovo Polje, Pletemina, Obilic, Ade and Mazgat village, then in more remote places: Babin Most, Leparne, Belacevac, Kuzmin, Pristina town, as well as, in the places 10-18 km far away from the coal power plants: Sofilja, Breznica, Laplje Selo and Janjevo. For the purpose of the gauging result comparison, three gauging points were considered: Batlava, Dobrotin and Mrmar, with the Kosovian coal power plant influence being negligible.

![Figure 2](image.png)

**Figure 2. Indicates the gauging location position.**

**Figure 2. The gauging location positions near by the Kosovian coal power plants.**

**RESULTS AND DISCUSSION**

Table 1 indicates the gamma radiation doze rate values gauged at 20 representative locations at various distances around the coal power plants within the 20 km diameter.

**Table 1. The gamma radiation equivalent doze rates in the air of the locations around the Kosovian coal power plants.**

<table>
<thead>
<tr>
<th>Br. lokacije</th>
<th>Locacije</th>
<th>Br. lokacije</th>
<th>Locacije</th>
<th>Br. lokacije</th>
<th>Locacije</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jezina ekrivalene doze gama zracenja (nSv/h)</td>
<td>Sed. vrednost</td>
<td>Min</td>
<td>Max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Janjevo</td>
<td>62</td>
<td>30</td>
<td>125</td>
<td></td>
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<td>Barane</td>
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<td>40</td>
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<td>208</td>
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<td>14</td>
<td>165</td>
<td></td>
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<td>39</td>
<td>186</td>
<td></td>
</tr>
<tr>
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<td>Mrmar</td>
<td>77</td>
<td>30</td>
<td>165</td>
<td></td>
</tr>
</tbody>
</table>

**Location No. Location The gamma radiation equivalent doze rates (nSv/h)**

<table>
<thead>
<tr>
<th>Mid value</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
</table>

As indicated in the Table given, the highest gamma radiation equivalent doze rates in the air have been gauged in the Pletemina settlement - location No. 16, with its mid values for the 10 hour gauging time interval amounted to 217 nSv/h. The settlement is located 4 km NW of the coal power plant. An insignificantly lower doze was gauged in the industrial yard of the Kosovo A coal power plant - location No. 5. The equivalent doze rate mid value at the location amounted to 206 nSv/h (Figure 3). The location was of a great research interest, thus, the doze rate gauging had been repeated several times, and at some periods the gauging was done in close time intervals simultaneously with some other locations.

**A: The Doze Rate**

**B: Temperature**

**The KosovoA CPP**

**C:**

Gamma radiation equivalent doze rate (nSv/h)

<table>
<thead>
<tr>
<th>Mid Value</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
</table>

The location No. 9 - Krusevac settlement the equivalent doze rate mid value at the location amounted to 199 nSv/h. The settlement is located directly near by the Kosovo A CPP, and enormous deeps of ash and slag are located at the very end of the
settlement [5]. The other locations, being directly near by the coal power plants, are also indicated with an increased gamma radiation equivalent dose rates, rather than the locations that are more remote from the plants. The Kosovo Polje, Obilic, then, Mazgjit, Ade settlements equivalent dose rate values are almost equal, ranging from 158 - 176 nSv/h. The places mentioned are especially exposed to enormous quantities of the flying ash during the fog and windless periods. The location is SSE of the coal power plant, with an insignificant wind direction from the plants and amounting to 28 °C annually. The location No. 13 - Pristina the equivalent dose rate mid value in the air amounted to 116 nSv/h. As the location had the gauging done almost every day, it was observed that the dose rates changed slightly during constant weather conditions, and the dose rates increase was observed during the days of an increased ash cover from the Kosovian coal power plant toward the town. Compared to the gauging points used for comparison, an increase of the equivalent dose rate was registered on the locations being even over 15 km remote from the plants. Location No. 6 - Breznica could be used as an example with the dose rate mid value amounting to 151 nSv/h. The location is N from the plants, and the wind frequency in the direction amounts to 66 °C annually. However, the location No. 1 - Junjevo, some 20 km SE far from the plants, the equivalent dose rate mid value amounted to 95 nSv/h. The wind frequency in the direction amounts to 27 °C annually. The gamma radiation dose rate values, gauged in the air at the places used for comparison, were ranging within the limits of natural variations of the general phone. The dose rate mid values of the gauging points were very close, ranging within an interval of 77-83 nSv/h. The registration of technologically increased levels of natural radioactivity, with the values, within the Kosovian coal power plant zone of influence, that were previously slightly above the present spacious variations of the natural phone, was enabled thanks to the fact that the gauging was done by the most comprehensive, fully computerized Gamma TRACER gauging system of high sensitivity (2 x 0.2 impulses/sec at 100 nSv/h).

CONCLUSION

The gamma radiation dose rate values gauged in the air surrounding the Kosovian coal power plants, using the autonomous device ADL Gamma TRACER, undoubtedly indicated the existence of the natural phone level difference between an undisturbed natural environment of the gauging places selected for comparison, and the natural radioactivity level within the Kosovian coal power plants zone of influence. The difference observed between the meteorological parameters in various time periods, explains the existence of various values of the gamma radiation dose rates, gauged in the air at the locations being within the various zones of influence of the Kosovian coal power plants. No doubt, there is a risk of the living environment radioactive pollution in near by urban and agricultural environment, caused by the Kosovian coal power plants. As natural radio nuclides concentrate in the soil, and then, are metabolically incorporated into the flora, or are directly transferred into the animals and humans, being fed by the contaminated plants, energetic steps are required regarding the efficient coal power plant electro-filter systems, full-scale re-cultiva-
tion of enormous non-conserved deeps of ash and slag, in order to decrease the consequences against the surrounding population health.

ACKNOWLEDGMENT

The author wishes to thank Dipl.Chem. Volker Genrich and Genitron Instruments GmbH from Frankfurt am Main Germany for using their Gamma TRACER system instruments.

LITERATURE


REZIME

MERENJE JAČINE DOZE GAMA ZRAČENJA U VAZDUHU U NEPOSREDNOJ I DALJOJ OKOLINI KOSOVSKIH TEMOELEKTRANA
ADROVIĆ F., PAPOVIĆ R., NINKOVIĆ M.

Sagorevajem uglja u termoelektranama, usled eliminacije organske komponente zapremina uglja smanjuje se na pepeo i šijaku, što neminovno dovodi i do povećanja koncentracije radionuklida u produk- tima sagorevanja. Glavni izvori povećane doze zra-

čenja za populaciju koja živi u blizini termoelektrana su: udisanje letećeg pepela, unosije hrane sa kon- taminiranog zemljišta, ili direktno izlaganje povećanoj deponiranoj aktivnosti. Izmerene su jačine doza gama zračenja u vazduhu u okolini kosovskih termoelek-

trana pomoću autonomnog uređaja ADL Gamma TRACER -a. Izvršena su merenja na 20 lokacija oko termoelektrana u krugu poluprečnika 20 km. Regis-

trovane su razlike nivoa prirodnog fona nenarušene prirodne okoline izabranih mernih mesta koja su poslužila za komparaciju, i nivoa prirodne radioak-

tivnosti u zoni uticaja kosovskih termoelektrana. Uočen je veliki uticaj meteoroloških uslova (formiranje i kretanje oblika lebdećeg pepela iz dimnjaka termoelektrana, padavina, brzina vjetra), tako da postoje velike varijacije koncentracija efleuenata i jačine dože u odnosu na neku prosečnu, dugotrajnu vrednost. Ovo potvrđuje i značaj detaljnih analiza u slučaju urbane zone sa termoelektrana u blizini, kao što je slučaj kod kosovskih termoelektrana. Termoelektrana Kosovo A, koja ima pet energetskih blokova, pripada starom tipu termoelektrana. Pojedini energetski blokovi ove termoelektrane preko svojih dimnjaka ispuštaju u atmosferu i preko 15 % letećeg pepela, što predstavlja glavnu opasnost od uticaja termoelektrana za stanovništvo Obilića, Kosova Polja, Prištine i okoli-
nih mesta. Osim toga, zbog slabog kvaliteta kosovskog lignita, prilikom njegovog sagorevanja, stvaraju se ogromne količine pepela i šijake, koje se odlučuju na obližnje deponije. Deponije ovog otpadnog materijala, izložene su eroziji usled deajstva vetra, površinskih i podzemnih voda, a kada se ima u vidu i permanentno izlaženje gasovitih potomaka uranove i torijumove serije, radona i torona iz ovih nepokrivenih deponija, može se proceniti da ovi nivo radioaktivnosti, iako relativno niski, nisu zanesljivi sa aspekta zaštite stanovništva od jonizujućeg zračenja. Dobijeni rezul-
tati ukazuju na potrebu redovne kontrolne radioak-

tivnosti okoline temoelektrana i korišćenje sakupljenih podataka za sistematski pristup istraživanju korelacije koje postoje između povišenog stepena radioaktivne kontaminacije životne sredine i meteoroloških uslova, jer najznačajnije opterećenje okoline od termoelek-

trana dolazi preko atmosferskog zagađivanja.

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Theoretical Approach which Predicts the Possible Existence the Tenth Planet in Solar System

TODOROVIĆ B. Zoran
Faculty of Natural Sciences-Mathematics, Department of Physics, University of Pristina, SR Yugoslavia

ABSTRACT

The Bohr's model of the Hydrogen atom has supplemented by means of the electron whose the picture in nonrelativistic case could not be like as spherical symmetric particle. With the help of the results of the quantum mechanical theory [5,6] it has been shown the meaning of the definition of the Fine Structure Constant and it has been explained the concept of the classical radius of the electron. On the basis of the proposed classification of Solar System it has been shown that the dimensions and the position of each planet in Solar System are connected with the Fine Structure Constant and the existing Solar System could to be possesses one additional planet whose dimensions and position are given.

Key words: Solar System, Fine Structure Constant

In this work we shall discuss and prove the physical foundation of the basic suppositions what are the reasons of introducing the fine structure constant as a parameter that controls the size and the position of planets in Solar System.

We shall try the answers in the frame of quantum mechanics. In our consideration we should to find the space dimension of the nonrelativistic electron. In previous works [5,6,10] analyzed the physical state of Cooper pair and found the following equation for the electrical current density for one electron

\[ j_v = \frac{e^2 A^\varphi}{m_0} (\Psi^* \Psi) \]

where vector potential \( A^\varphi \) is equal to

\[ A^\varphi = \frac{1}{2} B \cdot \rho \bar{v}^\varphi, \quad A_\rho = 0, \quad A_z = 0 \]

The field \( B \) comprehends as actual value of magnetic field of an electron [5]

\[ B = \frac{m_0 c^2}{\mu n} \]

where \( e \) is the electron charge
\( m_0 \) is electron mass in the rest
\( \mu \) is Bohr's magneton

The wave function \( \Psi \) for the electron is determined by relation

\[ \Psi = R(\rho) \Phi(\varphi) Z(z) \]

\[ \int \int \int \Psi^* \Psi \rho d\rho d\varphi dz = 1, \quad \int \rho^2 R \rho d\rho = 1, \quad \int \Phi^* \Phi d\varphi = 1, \quad \int Z^2 Z dZ = 1 \]

\[ R(\rho) = \frac{1}{\lambda_0} e^{-\frac{\rho^2}{4\lambda_0^2}}, \quad \lambda_0 = \hbar / 2 m_0 c \]

\[ \Phi(\varphi) = \frac{1}{\sqrt{2\pi}} \]

\[ Z(z) = \text{const.} \]

The differencial element of the intensity of electrical current for one electron is

\[ dI_e = J_e d\rho d\varphi dz = e \omega_o \rho \quad R^2 d\rho \Phi^2 Z^2 d\varphi dz \]

and the total current is

\[ I_e = \int \int dI_v = \frac{e^2 B}{m_0} \int \rho R^2 d\rho \Phi^2 \int Z^2 d\varphi dz \]

\[ \frac{e \omega_o}{2\pi} \bar{v}^\varphi = \frac{e^2 B}{m_0} \frac{1}{2\pi} \bar{v}^\varphi = \frac{ec}{2\pi \lambda_0} \bar{v}^\varphi \]
The differential element of the electrical current produces the differential element of the magnetic momentum of the electron

\[
(10) \quad d \mu_B = dI_e S = \frac{e^2}{m_o} A \Psi^* \Psi d \rho \ d z \pi \rho^3
\]

\[
= \frac{e}{c} \rho^3 \int_0^\infty \int_0^{2\pi} \int_0^\infty R^2 \ d \rho \ d \theta \ d z
\]

\[
= \frac{e}{c} \rho^3 \int_0^\infty \int_0^{2\pi} \int_0^\infty \frac{1}{2 \pi} \ d \rho \ d \theta \ d z
\]

\[
= \frac{e}{2c} \rho^3 \int_0^\infty \int_0^{2\pi} \int_0^\infty \ d \rho \ d \theta \ d z
\]

and the total magnetic momentum of the electron will be by definition

\[
(11) \quad \mu_B = \int d \mu_B = \int_0^\infty \int_0^{2\pi} \int_0^\infty \ d \rho \ d \theta \ d z
\]

The integral represents the average value of the operator \( \rho^3 \) expressed by relation

\[
\int_0^\infty R^2 \rho^3 \ d \rho = \langle R | \rho^3 | R \rangle = \frac{1}{2c} \int_0^{2\pi} \int_0^\infty e^{-\frac{\rho^2}{2c^2}} \ d \rho
\]

This integral we will solve using the following exchange:

\[
(12) \quad \rho^2 = 2x_o^2 \ t, \ \rho = \sqrt{2} x_o \ t^{\frac{1}{2}}, \ d \rho = \sqrt{2} x_o \ t^{-\frac{1}{2}} \ d t
\]

\[
= \frac{1}{2c^2} \int_0^\infty 2x_o^2 \ t^{\frac{1}{2}} x_o \ t^{-\frac{1}{2}} e^{-\frac{\rho^2}{2c^2}} \ d t
\]

\[
= 2x_o^2 \int_0^\infty t^{\frac{1}{2}} x_o \ t^{-\frac{1}{2}} e^{-\frac{t}{2}} x_o \ d t
\]

Using (12) we get magnetic momentum

\[
\mu_B = \frac{e}{2c} 2x_o^2 x_o = e c x_o = e c \ h/2 m_o c = e \ h/2 m_o
\]

which coincides with the Bohr's magneton. In the first step we shall calculate the electrical current using the Hall resistance formula [8]

\[
(14) \quad R_B = \frac{b}{e^2 i}, \ (i = 1, 2, 3, ...)
\]

We shall suppose for \( i = 1 \) that the equation (14) gives the Hall resistance for single electron. Making the elementary transformation in (14) one obtains

\[
(15) \quad \frac{b}{e^2} = \frac{1}{2 \pi m} = \frac{1}{2 \alpha \cdot c \cdot \varepsilon_o}
\]

If we consider the linear velocity \( v \) within the frame of classical physics we get

\[
(16) \quad v = n_0, \omega_o = n_0 \frac{c}{x_o} = 2 \alpha \ \omega
\]

That velocity will be the linear velocity of the points at such a distance of the electron center that it rotates with the angular velocity of \( \omega_o \).

The meanings of the magnitudes in (16) are:

\( c \) is the speed of light,

\( \alpha \) is the Fine Structure Constant.

Applying the law of classical electrodynamics and considering an electron as is a circular current carrying loop we find for the electrical current

\[
(17) \quad I_e = e v_0 = e \frac{\omega_o}{2 \pi} = \frac{e \cdot c}{2 \pi \cdot x_o}
\]

which is equivalent to the quantum mechanical value expressed by (9).

If we try the limit point in the space of an electron we shall get the space dimension using the following relation

\[
(18) \quad c = x_o \omega_o
\]

\[
\omega = \frac{c}{x_o}
\]

According to (17), (18) and (9) immediate follows that the proposed quantum mechanically procedure is in agreement with the relativistic theory.

The angular velocity we can get using (15) in the form

\[
(19) \quad \frac{h}{e^2} = \frac{1}{2 \pi m \omega_o} = \frac{1}{c e \omega_o}
\]

Obviously the relation (19) is similar to a capacity impedance with capacitance \( \varepsilon_o \) that satisfy the rest energy of the electron
(20) \( E = m_o c^2 = \frac{1}{2} \frac{e^2}{\epsilon_0}, \quad (r_o = \frac{e^2}{4\pi \epsilon_o m_o c^2}) \)

The other way for the angular velocity is

(21) \( \omega_o = \frac{eB}{m_o c} = \frac{e}{m_o} \frac{m_o c}{x_o e} = \frac{c}{x_o} \).

On the base of the theory of quantum mechanics [4] follow that an nonrelativistic electron is not a point charge, but a distribution of that charge characterized by linear dimension of

(22) \( r = \hbar / m_o c = 2 x_o \).

Using relation (14) we can conclude that the space dimensions of the electron, in one plane, according to classical physics, are limited within the area of \( \pi x_o^2 \).

According to the quantum mechanical theory the average area within which appears the quantum of magnetic flux is determined by relation [10]

(23) \( \langle \Psi | \Phi | \Psi' \rangle = B \langle S \rangle = B \pi \times \langle \rho^2 | \Psi \rangle = \)

\( = B \pi \int_0^{2\pi} \int_0^{2\rho_o} \int_0^\rho \Phi^2 d\rho d\phi dz = B \pi (\sqrt{2} x_o)^2 = \pi \hbar / e \)

This quantum of magnetic flux is the cause of that one predicted by BCS theory[1].

We can notice that the quantum mechanical average value (24) is equal to the square root of the product \( x_o \times 2 \). \( x_o \).

(24) \( \sqrt{\chi^2} = \sqrt{\langle \chi \rangle (2 \chi)} = \sqrt{2} x_o \)

In order to find the third dimension of the electron we shall use the following formula [10]

(25) \( \mu_H \Phi_o = E \pi (\sqrt{2} x_o)^2 = \mu_B B \pi (\sqrt{2} x_o)^2 \)

(26) \( E = m_o c^2 = H B V = \mu_B B \)

(27) \( V = \frac{\mu_H}{H} = (2 r_o) \pi (\sqrt{2} x_o)^2 \)

where \( \Phi_o \) is quantum of magnetic flux and \( V \) is the volume of the electron in the standstill.

According to (27) follow that nonrelativistic electron could not be a spherical symmetric particle and we can see that the dimensions of nonrelativistic electron are under control of the Fine Structure Constant. Namely, the ratio between half of depth of the electron and the diameter of its base is in the classical sense (18)

(28) \( \frac{r_o}{2x_o} = \alpha = \frac{1}{137} \)

In Fig. 1 is shown the approximate estimate of the aspect of the nonrelativistic electron where the space dimension with radius \( x_o \) is according with the picture of classical physics (18) and \( 2 x_o \) belongs to the quantum mechanical one. Using the relation (18), (22), (23) and (27) we can draw the picture of the nonrelativistic electron.

The Fig. 1 we can throw into Bohr's model of the hydrogen atom. In that case aspect of the supplemented Bohr model of the hydrogen atom would be as it is shown in Fig. 2.

N. Bohr derived for the hydrogen atom the following formula

(29) \( \frac{r_o}{r_H} = \alpha^2 = \frac{1}{(137)^2} \)

where \( r_H \) is the classical radius of the Bohr's orbeite.

This formula we can transform by the following manner

(30) \( \frac{r_o}{2x_o} \frac{2x_o}{r_H} = \alpha \cdot \alpha \)

and the derived relation immediate follows from Fig. 2.

In Fig. 3 it is shown the part of Solar System: Earth-Sun-Moon.
Tab. 1.

<table>
<thead>
<tr>
<th>n</th>
<th>-∞</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>planets</td>
<td>Mercury</td>
<td>Venus</td>
<td>Earth</td>
<td>Mars</td>
<td>As. Belt</td>
<td>Jupiter</td>
<td>Saturn</td>
<td>Uranus</td>
<td>Neptune</td>
<td>Pluto</td>
</tr>
</tbody>
</table>

Fig. 3

The question is now: can we use the formula (30) for the calculation of the parameters of the orbits of Earth and Moon? We shall try it to see what are the results.

(31)

\[
\frac{r_{E}}{2X_{EM}} \cdot \frac{2X_{EM}}{r_{ES}} = \frac{r_{E}}{r_{ES}} = \left( \frac{1}{137 - 19} \right)^{3} \left( \frac{1}{137 + 58} \right) = \left( \frac{1}{137 + 14} \right)^{3} 
\]

where

- \( r_{E} \) is the Earth radius
- \( X_{EM} \) is the distance between the Earth and Moon
- \( r_{ES} \) is distance between the Earth and the Sun

We shall compute the a numbers for the remaining planets of Solar System introducing the rules for the choice the following reference system:

a) The formulas (30) we shall use for the following planets: Mercury, Venus, Earth and Jupiter. We take reference point for them to be the center of the Sun.

b) The center of the nearest planetoid from the Asteroid belt let is the reference point for Mars.

c) For the following planets: Saturn, Uranus, Neptune and Pluto the rule for the choice the reference points are as follows: The center of the Pluto is reference point for Neptune. The center of the Neptune is the reference point for Uranus. The center of the Uranus is the reference point for Saturn.

All calculations have connected with the planets ordered in one plane taking into account the average distance from the Sun.

In Astronomy there is the well-known Titius-Bode law describing the distance between planets and the Sun is determined by the following empirical relation [15]

(32)

\[ R_{n} = 0.4 + 0.3 \times 2^{n} \quad (\text{in } A. \text{ U.}) \]

where the values of \( n \) are shown in Table 1.

Also with respect to the volume density of the matter we choose the Venus as a reference planet for the row of planets under a). For the planets under c) the reference planet would be planet Saturn.

Introducing the reference planets into account we get:

(33)

\[
\frac{T_{n}}{R_{n}} = \frac{\rho_{n}^{3}}{5.2} = \alpha_{n}^{3}
\]

where the integer \( n \) has the following meaning:

- \( n = 1 \) Mercury
- \( n = 2 \) Venus
- \( n = 3 \) Earth
- \( n = 4 \) Jupiter

\( \rho_{n} \) is the volume density of the planet matter and \( T_{n} \) is the actual value for planet's radius taking into account its volume density of matter. For Venus \( \rho_{2} = 5.2 \text{ g/cm}^{3} \).

For the row of the planets: Saturn, Uranus, Neptune and Pluto we have

(34)

\[
\frac{T_{n}}{R_{nm}} = \alpha_{n}^{3} = \left( \frac{\rho_{n}^{3}}{5.2} \right)
\]

where

- \( n = 1 \) Pluto
- \( n = 2 \) Neptune
- \( n = 3 \) Uranus
- \( n = 4 \) Saturn

where \( R_{nm} \) is the distance between appropriate neighboring planets.

For Saturn \( \rho_{4} = 0.7 \text{ g/cm}^{3} \)

\[ R_{11} = 39.1 - 30.07 = 9.17 \text{ A. U. (Pluto-Neptune)} \]

\[ R_{22} = 30.07 - 19.18 = 10.84 \text{ A. U. (Neptune-Uranus)} \]

\[ R_{33} = 19.18 - 9.54 = 9.64 \text{ A. U. (Uranus-Saturn)} \]

(1 A. U. = 149.6 x 10^{6} \text{ km})

This distances have been calculated under the condition that the planets order in on plane with respect there half of the big axis.

If we taking into consideration the derived rules we shall obtain the results for a numbers is shown in Table 2.
Table 2. Calculated $\alpha$ numbers,
Tabela 2. Izračunati $\alpha$ brojevi

<table>
<thead>
<tr>
<th>Object</th>
<th>$\alpha$ number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>$\frac{1}{137 + 15}$</td>
</tr>
<tr>
<td>Venus</td>
<td>$\frac{1}{137 - 3}$</td>
</tr>
<tr>
<td>Earth</td>
<td>$\frac{1}{137 + 14}$</td>
</tr>
<tr>
<td>Mars</td>
<td>$\frac{1}{137 + 51}$</td>
</tr>
<tr>
<td>Jupiter</td>
<td>$\frac{1}{137 + 16}$</td>
</tr>
<tr>
<td>Saturn</td>
<td>$\frac{1}{137 + 19}$</td>
</tr>
<tr>
<td>Uranus</td>
<td>$\frac{1}{137 + 54}$</td>
</tr>
<tr>
<td>Neptune</td>
<td>$\frac{1}{137 + 37}$</td>
</tr>
<tr>
<td>Pluto</td>
<td>?</td>
</tr>
<tr>
<td>X new planet</td>
<td>?</td>
</tr>
</tbody>
</table>

For the planet Pluto there is not the possibility for computing it's $\alpha$ number. According to our knowledge it is rear planet of Solar System. The impossibility for computing $\alpha$ number for Pluto might be to mean that our knowledge about Solar System is not full. In the other words Solar System is not complete. Under such circumstances immediate follows that in Solar System could be one more planet. If this does then the center of new planet will be the reference point for Pluto. If the planet X is rear planet of Solar System it could be as the same as Pluto. Then the center of Pluto will be the reference point for planet X. This means that Solar System might be completed by a pair of equal planets placed at its back side. In that case their a number is mutual. If we take for instance the possible value for $\alpha$ number with respect to T.I for Pluto and planet X.

$$\alpha = \frac{1}{137 + 29}$$

then the distance between them would be approximately in the range, according to their half of the big axis

$$R_{1x} = (35 - 45) \times 10^6 \text{ km}$$

and the diameter of the planet X would be as the same as diameter of Pluto

$$d_x = 3000 \text{ km}$$

The small probability would be for $\alpha = 1/137$. In that case the distance between them would be

$$R_{1x} = 28.153.500 \text{ km}$$

The proposed approach has an advantage with respect to the Tycius - Bode law giving the possibility for determining both the distances and radius of planet simultaneously and it points out that all planets of Solar System possess a numbers that have connected with the Fine Structure Constant. Because of the necessity for computing the appropriate a number for the planet Pluto immediate follows the possible existence one more planet in Solar System. We notice that this computation comprehends the isolated Solar System. The influence of other system on the Solar System, probably in reality, can change this ideal picture.

**Supplement 1**

The equations of dynamically motion for three bodies in barycentrical coordinate system has the form [15].

$$m_j \ddot{x}_j = \frac{\partial U}{\partial x_j}, m_j \ddot{y}_j = \frac{\partial U}{\partial y_j}, m_j \ddot{z}_j = \frac{\partial U}{\partial z_j}, (j=1,2,3)$$

and

$$U = \int \left( \frac{m_1 m_2}{r_{12}} + \frac{m_1 m_3}{r_{13}} + \frac{m_2 m_3}{r_{23}} \right)$$

is the force's function.

$$r_{jk} = \sqrt{\left( x_k - x_j \right)^2 + \left( y_k - y_j \right)^2 + \left( z_k - z_j \right)^2}$$

The integrals of the areas have the form

$$\sum_{j=0}^{2} m_j (x_j \dot{y}_j - y_j \dot{x}_j) = c_1$$

$$\sum_{j=0}^{2} m_j (x_j \dot{z}_j - z_j \dot{x}_j) = c_2$$

$$\sum_{j=0}^{2} m_j (x_j \dot{y}_j - y_j \dot{x}_j) = c_3$$

The projections of the appropriate forces on the coordinate axis are:

$$\sum_{j=0}^{2} m_j \ddot{x}_j = 0, \sum_{j=0}^{2} m_j \ddot{y}_j = 0, \sum_{j=0}^{2} m_j \ddot{z}_j = 0.$$
If we do not go deeper into that theory, we can see, that all equations (1.1-1.5) comprehend the existence of all bodies at the same time and any instance from the beginning of such system. In the other words, the absence only one body of that system, could mean the impossibility of holding the Hill's criterion of absolute stability for the system.

**The examples of the three bodies system Sun-Neptune-Pluto**

The calculation shows the absence of the absolute stability by Hill [15]. It means that they could not exist at the time from their genesis.

The absence of the absolute stability could mean that the Pluto is not rear planet of Solar System. In the other words, the considered Solar System which is consisted of nine planets is not completely. It means that in Solar System must exist a additional planet or several ones.

![Diagram](image)

**Fig. 4.** The expected supplement of the calculations for the absolute stability by Hill designated by broken lines. The minus sines mean unstable system.

**REFERENCES**


REZIME

TEORIJSKI POSTUPAK KOJIM SE PREDVIDA MOGUĆNOST POSTOJANJA DESETE PLANETE U SUNČEVOM SISTEMU

Todorović, Z.


Za sada nemamo osnove da možemo da elektron predstavimo u obliku strujne petlje sastavljene od nekoliko elemenata klasični model elektrona su pretpražnjeni. Takođe se navodi da za sada nemamo zadovoljavajuću kvantnomojevičku teoriju elektrona. Nedavno je predložena kvantnomojevička teorija jed- nego elektrona [6], koja kao glavni rezultat ima tačno izračunatu vrednost kvanta magnetnog fluksa [1], a kao novi rezultat u fizički određuje površinu na kojoj se pojavljuje taj fluksa.

Iz formule za kvant magnetnog fluksa, Sokolov [3] kaže da je izvor kvanta magnetnog fluksa u Kupero- vom paru, magnetni moment jednog elektrona:

\[ \Phi_0 = \frac{\hbar}{e} = \frac{\mu B}{2 \alpha} = \mu_0 \frac{I_e}{2 \alpha} \]

U daljem transformisanom obliku, vidi se da se taj rezultat pojavljuje intenzitet električne struje \( I_e \) i površine \( S \). Na osnovu predložene kvantnomojevičke teorije izračunata je električna struja elektrona \( I_e \)[10]. Ona se poklapa s vrednošću dobijena iz Klectricove formule [8], na osnovu zakona klasične elektrodinamike. Kla- ste transformisani oblik formule za kvant magnetnog fluksa sugeriše na neposredan način oblik zakona za magnetno polje nerelativističkog elektrona. Uopšteno govoreći, polje elektrona u oblasti obuhvaćenoj površinom \( S \) je nehomogeno [10]. Međutim, dejstvo toh homogenog polja može se zameniti efektivnim poljem \( B \), skoro homogenom u pomenutoj oblasti. Iz toga proizilazi da bi mogli da stanovista klasične elektrodinamike da elektron predstavimo u obliku kružnog kola kružnog oblika, kroz koji teče struja intenziteta \( I_e \) i da ona stvara skoro homogeno polje u površini obuhvaćenoj tom konturom strujom, a koja iznosi tačno \( \pi (\sqrt{2} \cdot a) \).

Prema kvantnomojevičkoj teoriji [4], nerelativistički elektron nije tačno nenelektrisan \( e \), već je on "razmanjan" u oblasti određen radijumom \( r = 2 \cdot x \).

Predložena teorija [6] računanjem kvanta magnetnog fluksa, dobija da bi radijus elektrona mogao biti \( \sqrt{2} \cdot x \), i to bi bila projekcija u jednoj ravni. Treću dimenziju elektrona možemo da vidimo iz relacije (27).

Relacija (25) predstavlja izraz jedne izmeđe kvantno mejevičke veličine: jedna je magnetni moment elektrona, pozna kao Borov magneton, i druga kvant magnetnog fluksa. Ovaj izraz pokazuje da se energija mirovanja elektrona \( m \cdot c^2 \) javlja u prostoru oblika disksa sa bazama od \( \pi (\sqrt{2} \cdot x) \). Za procenu treće dimenzije elektrona, iskorištena je relacija (a). Iz njegove neumazanosti se izvede da je treća dimenzija elektrona \( 2 \cdot r \).

Iz dobijenih prostornih dimenzija (27) sledi da elektron ne bi mogao biti česta sa sfernom simetri- jom. Ako sačinimo odnos između dimenzija elektrona (28), dobijemo vrednost konstantu fine strukture \( \alpha = \frac{\alpha}{\sqrt{2} \cdot x} \).

Sada u svetu predložene teorije vidimo značenje klasičnog radijusa elektrona. Dakle, to nije radijus u klasičnom smislu te reći. To je poludebljina treće dimenzije nerelativističkog elektrona. Naziv klasični radijus elektrona osnovio je jubilatu, pa su prvo Lorenc, a zatim i Pauli [9] računajući linearnu brzinu rotacije spoljašnje površine elektrona, posmatrajući ga kao...
sferu radijusa \( r_0 \) dobili da bi ona iznosila skoro 70 c. Naravno, kao što je poznato klasičnu sliku ovakvog elektrona, oba ovi fizičara su odbacili, jer se rezultat kosi sa teorijom relativnosti.

Kao što se može videti brzina (16) je sa stanovišta klasične fizike jednaka dvostrukoj vrednosti brzine elektrona u Borovom modelu atoma vodonika, što je u saglasnosti sa teorijom relativnosti.

Sa stanovišta ovako predložene teorije, za atom vodonika su sačinjeni odnos (30) u kojima se vidi da je treća dimenzija elektrona bila "sakrivena" u samoj Borovoj formuli. Formulu za Borov model atoma vodonika možemo primeniti na deo Sunčevog sistema: Sunce, Zemlja, Mesec. Ovdje planetu Zemlju i Mesec posmatramo kao prostorni pojas oblika diska debljine jednake prečniku Zemlje i radijusa baze jednak srednjem udaljenju Meseca od Zemlje. Ostale planete posmatramo na isti način, ali bez satelita, direktno primenjujući formulu (29).

Prema saznanjima u današnjoj astronomiji, broj planeta, koje ulaze u sastav Sunčevog sistema, iznosi devet. Njihove pozicije u odnosu na središte Sunca su definisane velikim poluosiama, vrednosti kojih se računa prema poznatom Ticijus-Bodeovom zakonu (32).

Ideja je bila da se koristeći formulu (29) odredi pozicija planeta u Sunčevom sistemu. Za razliku od Ticijus-Bodeovog zakona, ona povezuje radijus plane sa njenom pozicijom preko \( \alpha \) broja, poznatog kao konstanta fine struktura, koji je približno jednak 1/137. Drugim rečima, ideja se sastoji u tome da se odredi za svaku planetu njen \( \alpha \) broj. Dakle, veza između radijusa planete i njene pozicije u Sunčevom sistemu treba da daje jednu vrednost \( \alpha \) broja.

Da bi se izračunao \( \alpha \) broj za svaku planetu, pošlo se od sledećeg razmatranja:


Sledeći korak je bio u određivanju referentne planete. Onu se određuje na osnovu dobijene najbolje vrednosti za \( \alpha \) broj prema formuli (29). Za prvi podsistem to je planeta Venera. Za drugi Saturn a za treći podsistem planetu Mars. Zatim je izvršena redukcija formule (26), uzimajući u obzir gustinu materije referentne planetne. Tako su dobijeni efekativni radijusi planeti, izraženi formulama (33) i (34). Efekativni radijusi planeti podrazumijevaju one radijuse planeti koji bi odgovarajuća planeti imala pod pretpostavkom da je njen materijalni sastav identičan materijalnom sastavu referentne planetne.

Postavljeno je zatim pravilo izračunavanja \( \alpha \) broja. Ono je povezano sa izborom referentne tačke. Za prvi podsistem referentna tačka je Sunce. Za drugi podsistem referentna tačka se uzima kao središte planetu na sledeći način: središte Plutona predstavlja referentnu tačku za Neptun; središte Neptuna je referentna tačka za Uran; središte Urana je referentna tačka za Saturn.

Prema primenjenoj metodologiji računanja \( \alpha \) broja, ispalo je da se za planetu Pluton \( \alpha \) broj ne može odrediti. Nemogućnost određivanja \( \alpha \) broja za Pluton sugerisala je mogućnost postojanja neke referentne tačke van poznatog Sunčevog sistema. Ta referentna tačka u tom slučaju trebala bi da predstavlja središte nepoznate planete i to bi bio uslov za određivanje \( \alpha \) broja za planetu Pluton. Isto tako i za nepoznatu planetu je potrebno odrediti njen \( \alpha \) broj. Ako je ona zadnja u Sunčevom sistem, onda bi po veličini i materijalnom sastavu trebala biti identična Plutonu. Pod tom pretpostavkom središte Plutona bi bilo referentna tačka za planetu X. Pozicija nepoznate planete, može se odrediti uzimanjem idealne vrednosti za \( \alpha \) broj 1/137. U tom slučaju srednje rastojanje između Plutona i planete X iznosilo bi 28.153.500 km. Međutim ako uzmemo u obzir moguće odstupanje od idealne vrednosti \( \alpha \) broja, recimo 1/137+29, onda bi to rastojanje iznosilo oko 35 miliona kilometara.

Primjenjujući zakone klasične fizike, određene su prostore dimenzije elektrona [formula 14 i formule (a) i (b) iz rezimea]. U skladu sa zakonima klasične fizike dobijen je dopunjen izgled Borovog modela atoma vodonika (slika 2). Slika svake je sumnje da između njega i dela Sunčevog sistema (Sunce-Zemlja-Mesec), na prvi pogled, postoji određena sličnost (slika 3). Naravno da u realnosti takva sličnost ne bi značila ništa, ako ne bi postojalo matematički dokaz da su prostore dimenzije oba sistema, jednog koji pri pada mikrosvetu i drugog iz mikrosvetova, pod kontrolom jednog zajedničkog parametra. Ispostavilo se da je taj zajednički parametar jednak 1/137, poznat kao konstanta fine struktura. Na osnovu pomenute sličnosti, priročno se nametnulo pitanje da li se formu (30) može primeniti kako na pomenuto deo Sunčevog sistema, tako i na ceo sistem. Ako može, što je krajnji rezultat?

Očigledno je da nije dobijena idealna vrednost alfa broja za sistem S-E-M, već postoji određeno odstupanje. Postavlja se pitanje, ako postoji realna fizička zasnovanost na osnovu koje alfa broj kontroliše dimenzije čestica mikrosveta i prostore dimenzije mikrosveta, zašto za sistem Sunce-Zemlja-Mesec nije postignuta idealna vrednost? Odgovor bi mogli da potražimo u sledećem razmatranju: Poznata je činjenica da se Mesec udaljava od Zemlje, godišnje oko 15 cm. Prema formuli (31), ako se pretpostavi da je \( n_\xi = const \) vidi se da će količnik \( 2 \rho_\xi / \eta \) vremenski konvergirati ka idealnoj vrednosti alfa broja tj. 1/137.

Neregularan karakter ostatka alfa broja prema T.1 bi mogao da se poveže sa vremenom nastanka planeta. To znači da ova neregularnost bi mogla da znači da planete verovatno nisu iste starosti. U dopuni I analizirani su proračuni apsolutne stabilnosti vezane za teoriju problema dinamičkog kretanja tri tela po Hillu [15]. Tu se posebno ističe:


- c) izostanak apsolutne stabilnosti po Hillu za sistem Sunce-Neptun-Pluton.


Za konstantu fine strukture \( \alpha = 1/137 \) u udžbeniku fizike Univerziteta u Berkliju, kvantna fizika (sveska, strana 40-41) se kaže da je ona za sada često empirijska konstanta u smislu da nestamo teorijskog objašnjenja za njenu veličinu, koja je definisana formulom:

\[
\alpha = \frac{e^2}{4 \pi \varepsilon_0 \left( \frac{\hbar}{m_0 c} \right) m_0 c^2} = \frac{\alpha_0}{2 X_0} = 1/137
\]

Prema navodima u citiranoj knjizi se kaže: To je konstanta koja meri veličinu vezivanja elektrona sa elektromagnetnim poljem ili bi to bila elektrostatička energija odbijanja dva elektrona razdvojenih za prirodnu jedinicu dužine \( \hbar / m_0 c = 2 X_0 \). Prema preloženoj teoriji prizilazi teorijsko objašnjenje za konstantu fine strukture, gde se vidi da je njena izvorna definicija prirodno povezana sa prostornim dimenzijama elektrona (formula 28).

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On the Eigenvalue Problem of some Coupled Equations of Motion

BASIL Dragoslav
University of Pristina Civil Engineering Department

ABSTRACT

The subject of the paper is the eigenvalue problem of a system of coupled equations describing mechanical vibrations of some complex continuous systems. Instead of separating the unknown response functions, the analysis of such mechanical systems is performed in the matrix form. The property of selfadjointness of the matrix operator is proved and the orthogonality condition is constructed. The eigenvectors are then used to solve the nonhomogeneous problem in the series form. Contrary to the procedure of initial parameters, the technique used in this presentation gives a much better insight into the physical ground of the solution as well as the simplicity in handling the appropriate eigenvalue problem.

Key words: Differential equations, eigenfunctiones, eigenvalues, matrix operator, seladjointness, orthogonal functions, vibrations.

INTRODUCTION

The eigenvalue problem is an inevitable part of the analysis in mechanical vibrations. It seems to be a relatively simple problem when we deal with the discrete systems, but it appears to be a complex one if the continuous systems are to be analyzed. Further on, the coupling in the equations of motion makes the eigenvalue problem even more complex.

In order to make the solution procedure simple, a few steps should be followed. Instead of dealing with a system of equations describing mechanical vibrations, a functional vector should be formed with the unknown functions as elements. Next, the whole system and the resulting eigenvalue problem should be treated in matrix form. To do so it is needed to answer if the matrix operator fulfills the property of selfadjointness. Resolving this question, the basis to construct the orthonormality condition is formed. With the orthonormality condition at hand, we can solve the nonhomogeneous problem as well.

This approach originated when dealing with vibrations of curved thin-walled beams. The motion in this case is described with two coupled differential equations of the forth order with two unknown response functions. The purpose of this article is not to investigate different dynamic aspects of the problem, instead it is oriented toward mathematics as a tool to yield a most elegant solution. It is worth mentioning here how other authors approached the same problem. A solution for the dynamic response of a curved beam to a moving load, using the variation of initial parameters approach, was given in [1]. With the use of Rayleigh-Ritz method, the frequency spectra were calculated for the various boundary conditions in [2]. A consideration of the eigenvalue problem was given in [3], but the problem was substantially simplified by neglecting the warping and torsional inertia terms. A rigorous analysis, with a comparative study of the influence of different inertia and rigidity terms is presented in [4]. None of these authors was concerned with the relevant eigenvalue problem in a matrix form nor examined its properties, what is actually the objective of the present analysis. The resulting elements could be used in a solution for the frequencies and for the dynamic response of a curved beam applying, for example, the mode superposition technique.

The homogeneous problem

If in the case of lateral vibrations of curved beams we attempt to perform any analysis by separating the unknown functions, we will come to the differential equations of the eighth order which will bring many difficulties and make the analysis impractical. For this reason it is advisable to proceed the analysis in a matrix form, introducing a displacement vector

\[ \Psi (\theta, t) = \begin{bmatrix} \eta \\ \beta \end{bmatrix} \]

where: \( \eta = \eta / R \) is a nondimensional function representing lateral displacements, \( \beta \) is a function representing the angle of twist, \( R \) is the constant radius of curvature of the central line, and \( t \) is the time.

The resulting matrix equation will have the form

\[ A \Psi'' + B \Psi'' + C \Psi + D \Psi + F \Psi'' = G \Omega \]

with primes indicating differentiation with respect to the geometric coordinate \( \theta \) and with the dots indicating the time differentiation.
The meaning of the constant matrices $A, B, C, D, F$ and the load vector $Q$ in (2) is as follows (3)

$$
A = \begin{bmatrix} 1 + A_w & A_w \\ A_w & A_w \end{bmatrix}, \quad B = \begin{bmatrix} A_K & 1 + A_K \\ 1 + A_K & A_K \end{bmatrix}, \quad C = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix},
$$

$$
D = \begin{bmatrix} K_1 & 0 \\ 0 & K_2 \end{bmatrix}, \quad F = \begin{bmatrix} K_3 & K_4 \\ K_4 & K_4 \end{bmatrix}, \quad Q = \begin{bmatrix} P_p(0 R, t) \\ M_c(0 R, t) \end{bmatrix}.
$$

The constant $C_2$ in (2) and all other parameters in (3) represent geometrical and physical properties of the mechanical system as well as the external force distribution. There is no need to comment on these parameters since the mathematical aspects are of our interest at present. The only important property we should notice here is the symmetric form of all matrices in (3). It is the consequence of energy conservation principle in linear elastic materials.

To analyze the case of free vibrations, we introduce

$$
\Psi(\theta, t) = \Psi_\theta \sin \omega t
$$

and the appropriate eigenvalue problem is described by the equation

$$
(5) \quad A \Psi_\theta' + B \Psi_\theta'' + C \Psi_\theta = \omega^2 (D \Psi_\theta + F \Psi_\theta'').
$$

In this equation $\Psi_\theta = \begin{bmatrix} Y(\theta) \\ B(\theta) \end{bmatrix}$ is an eigenvector and in the theory of vibrations it is named as the mode-shape vector. The frequency is an eigenvalue of the problem.

Introducing some symbolic matrix operators, for the left and the right side of equation (5), we can write that equation in the form

$$
(6) \quad (\Psi_\theta) = \omega^2 (D \Psi_\theta + F \Psi_\theta').
$$

It should be pointed out that the eigenvalue problem for linear scalar operators is already very well established. On the contrary, the matrix operators still need some precise statements. The conditions for the property of selfadjointness, which L. Collatz [5] stated for a linear scalar operator, are generalized in this presentation and applied to the matrix operators in eq.(6). Due to the symmetry of operators, for two eigenvectors $\Psi_{\theta K}$ and the following holds $\Psi_{\theta n}$

$$
\int_0^{\theta_1} \Psi_{\theta K} (\Psi_{\theta n}) d\theta = [L.B.C.]^{\theta_1}_{\theta_0} + \int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta K}) d\theta.
$$

$$
\int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta n}) d\theta = [N.B.C.]^{\theta_1}_{\theta_0} + \int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta n}) d\theta.
$$

The symbols $|L.B.C.|$ and $|N.B.C.|$ represent two equations resulting from the partial integration and they contain the boundaries of the vibrating system. It can be proved that for any boundary conditions, i.e. for any mechanical constraints, these two boundary equations are equal to zero. If these two terms disappear then the equations (7) are stating that the present eigenvalue problem is selfadjoint. As a direct consequence of this property, the orthogonality condition of eigenvectors follows. Also, it can be proved that for any eigenvector $\Psi_{\theta n}$ the integral

$$
\int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta n}) d\theta
$$

has the same sign. With this, the existence of real eigenvalues is assured.

For two different eigenvalues, $\omega_K \neq \omega_n$, the respective eigenvectors and $\Psi_{\theta K}$ and $\Psi_{\theta n}$ fulfill the orthornormality condition

$$
\int_0^{\theta_1} \Psi_{\theta K} (\Psi_{\theta n}) d\theta = 0.
$$

$$
\int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta n}) d\theta = \int_0^{\theta_1} \Psi_{\theta n} (\Psi_{\theta n}) d\theta
$$

in which besides the eigenfunctions $Y_\theta$ and $\beta_\theta$, the constants are related to the geometry and material properties of the vibrating system. At this point different degrees of approximation are possible but those are dynamic problems in its essence.

The nonhomogeneous problem

The orthornormality condition has to serve as a tool to derive the uncoupled equations of motion and to construct the nonhomogeneous solution. If the mode superposition technique is used, which means the use of eigenfunction series, the nonhomogeneous solution may be written in the form

$$
(9) \quad \Psi(\theta, t) = \sum_n \sum_i z_{ni}(t) \Psi_{\theta ni}.
$$

where $z_{ni}$ is the so-called normal coordinate. Summation over $i$ means that for every eigenfunction representing the lateral mode $n$, there are two possible twisting modes, $i = 1, 2$. Also, the term on the right side in eq. (2), which in mechanics has the meaning of a load vector, has to be expressed in the series form

$$
(10) \quad Q(\theta, t) = \sum_n \sum_i q_{ni}(t) (D \Psi_{\theta ni} + F \Psi_{\theta ni}).
$$
where \( q_{nl}(t) \) is the generalized load function. Using the orthonormality condition (8), \( q_{nl} \) can be calculated from the equation

\[
q_{nl}(t) = \int_{0}^{\theta} \mathbf{Q}^T \Psi_{nl} d\theta.
\]

(11)

Entering eq.(2) with (9) and (10), differential equations in normal coordinates follow

\[
\ddot{Z}_{nl} + \omega^2 Z_{nl} = C_q q_{nl}(t), \quad n = 1, 2, \ldots \infty
\]

\[i = 1, 2.
\]

Equations (12) can be understood as the result of the uncoupling procedure of the original equations of motion (2). With this, all the basic elements for a nonhomogeneous solution are derived. The physical ground of this solution, i.e. the dynamic side of the problem, was presented and explained in [6].

CONCLUSION

In mechanical vibrations of some complex continuous systems, the analysis becomes simple and elegant if it is performed in matrix form with a functional vector which has system’s responses as its elements. The eigenvalue problem of the resulting matrix differential equation asks for some statements which are similar to those in linear scalar operators. Above all, the statement has to be made regarding the property of selfadjointness. Due to the symmetry of operators, this property is proved to exist. Based on this property, the orthogonality condition for the eigenvectors is constructed which makes the nonhomogeneous solution in series form possible.

It has to be stated here that, despite of the mathematical elegance of the considered eigenvalue problem, practical dynamic analysis is difficult to perform. For all boundary conditions different from the simple supports, an iterative approach has to be employed in order to find the frequencies. Still, the present eigenvalue analysis offers some valuable conclusions. It was used in Šiđić to derive some quantitative and qualitative data regarding dynamics of curved beams.

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REZIME

O SOPSTVENOM PROBLEMU NEKIХ VEZANIХ JEDNAČINA KRETANJA
Bašić Dragoslav

U ovome radu se tretira sopstveni problem jednog sistema vezanih jednačina koje opisuju mehaničke vibracije nekih kompleksnih kontinualnih sistema. Umesto da se izvodi separacija nepoznatih funkcija odgovora, što bi dovelo do jednačina veoma visokog reda, analiza ovakvih mehaničkih sistema se izvodi u matričnoj formi i to preko vektora sopstvenih funkcija. Svojstvo samogradnjevost matričnog operatora se ovde dokazuje a na osnovu tog svojstva gradi se uslov ortogonalnosti sopstvenih funkcija. Sopstveni vektori se zatim koriste da bi se rešio nehomogeni problem u obliku reda. Suprotno postupku početnih parametara, postupak korišćen u ovom radu pruža bolji uvid u fizičku stranu rešenja kao i jednostavnost u tretiranju odgovarajućeg sopstvenog problema.

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On the Equation of the Focusing Mirror

NIKOVIĆ Radovan
Department of Mathematics, Faculty of Science, University of Pristina, Yugoslavia

ABSTRACT
In this paper we shall describe a new approach to the derivation of the focusing mirror differential equation.

Key words: focusing mirror, reflected ray, incoming ray, Fermat’s principle

1. Introduction

From mathematical aspect, the problem of the focusing mirror reduces to the determination of the equation of its vertical section. The vertical section equation we are going to find on the form \( y = y(x) \).

Dimitrovski and Mijatović in [1], and Nikolić in [2] solved this problem. They assumed that the incident ray intersect \( y \)-axis at an angles \( \varphi \), strikes the mirror at the point \( M(x, y) \), reflects from its and comes to the focus \( O(0, 0) \).

The authors [1,2] solved this problem in three steps:
(a) First, they determine the reflected ray equation

\[
Y - y = \frac{y'^2 - 2y' \tan \varphi - 1}{y'^2 \tan \varphi + 2y' - \tan \varphi} (X - x).
\]

(b) Then, by using the equation of the reflected ray (1.1), and fact that all reflected rays pass thought the focus, they obtain the differential of the problem

\[
y = \frac{y'^2 - 2y' \tan \varphi - 1}{y'^2 \tan \varphi + 2y' - \tan \varphi} x.
\]

(c) At the end, they solve the equation (1.2).

The equation (1.2) was solved both by Dimitrovski [1] and Nikolić [2]. Dimitrovski’s solution is fourth degree equation, while Nikolić’s is given by

\[
\sqrt{x^2 + y^2} - y \cos \varphi + x \sin \varphi = C.
\]

2. New method

Our intention are to show that using another approach this problem can be solved much simpler. Also, we will show that the reflected ray equation (1.1) is not necessary in obtaining the differential equation of the mirror.

The direction cosines of the incident ray are (Fig.1)

\[
\begin{align*}
\cos \alpha_i &= \cos \left( \frac{\pi}{2} - \varphi \right) = \sin \varphi, \\
\cos \beta_i &= \cos(\pi - \varphi) = -\cos \varphi,
\end{align*}
\]

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and reflected ray

\[
\begin{align*}
\cos \alpha_r &= -\frac{x}{r}, \\
\cos \beta_r &= -\frac{y}{r},
\end{align*}
\]

where is \( r = \sqrt{x^2 + y^2} \), and the units vectors of the same rays are

\[
\vec{a}_0 = (\sin \varphi, -\cos \varphi), \quad \vec{r}_0 = \left( -\frac{x}{r}, -\frac{y}{r} \right).
\]

Besides the tangent vector of the curve \( y = y(x) \) in point \( M(x, y) \) is \( \vec{t} = (1, y') \).

Using the Fermat's principle*, it follows that \( \angle(\vec{t}, -\vec{a}_0) = \angle(-\vec{t}, \vec{r}_0) \) or

\[ \angle(\vec{t}, \vec{a}_0) = \angle(\vec{t}, \vec{r}_0). \]

Construct the parallelogram with vertex \( M(x, y) \) and sides \( \vec{a}_0 \) and \( \vec{r}_0 \). This parallelogram is rhombus, and the direction vector of its diagonal with the initial point \( M(x, y) \) is

\[
\vec{d} = \vec{a}_0 + \vec{r}_0 = \left( -\frac{x}{r} + \sin \varphi, -\frac{y}{r} - \cos \varphi \right),
\]

and clearly satisfies the equality

\[ \angle(\vec{d}, \vec{a}_0) = \angle(\vec{d}, \vec{r}_0). \]

This situation is graphically described in Fig.1.

![Fig.1](image)

From (2.1) and (2.2) it follows that the vectors \( \vec{t} \) and \( \vec{d} \) are collinear, that is

\[
\frac{1}{-\frac{x}{r} + \sin \varphi} = \frac{y'}{-\frac{y}{r} + \cos \varphi}.
\]

From the last equation we obtain the required differential equation in form

\[ y' = \frac{y + \sqrt{x^2 + y^2 \cos \varphi}}{x - \sqrt{x^2 + y^2 \sin \varphi}}. \]

* The incident and reflected rays are equally inclined to tangent of the curve \( y = y(x) \) at its point \( M(x, y) \).
If we transform the equation (3.2) into polar coordinates \((\rho, \varphi)\), we have

\[
\frac{d\rho}{\rho} = \frac{\cos(\varphi - \varphi) d\rho}{1 - \sin(\varphi - \varphi)}
\]

By integrating we obtain

\[
\rho = \frac{C}{1 - \sin(\varphi - \varphi)}.
\]

Returning into rectangular coordinates, we find

\[
\sqrt{x^2 + y^2} - y \cos \varphi + x \sin \varphi = C,
\]

and this is the equation (1.3).

3. Conclusion

1° It is clear that differential equation (2.3) derived in this paper has much simpler form than the equation (1.2), and therefore it's solution is simpler too.

2° Rotating the coordinate system, for the angle \(\varphi\), it is easy to verify that the curve given by (1.3) is a parabola, and its canonical equation is

\[
\eta = \frac{s^2}{2C}.
\]

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О ЈЕДНАЧИНИ ФОКУСИРАЈУЋЕГ ОГЛЕДАЛА

Радован Николић

ИЗВОД

У овом раду је, на основу изложеног и једноставнији начин, састављена диференцијална једначина траженог фокусирајућег огледала. Осим тога, овако добијена једначина је и једноставнија за решавање од једначине (1.2).

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Malo je događaja u životu koji toliko govori ljudskoj duši kao turistička putovanja, posebno ako su to učeničke i studenteke ekzurzije. Neki ljudi nastoje da one budu česte i sadržajne. Počasno mesto medju njima, bez sumnje, pripada dr. Stevanu M. Stankoviću, redovnom profesoru Geografskog fakulteta u Beogradu. Ovaj veliki srpski i jugošсловenski geograf objavio je 20 knjiga i više od 400 radova u domaćim i stranim časopisima iz oblasti limnologije, geografije Jugoslavije i turističke geografije. Početkom ove godine pojavilo se iz štampe treće izdanje knjige PUTEVIMA JUGOSLAVIJE, koje po obimu, koncepciji i ilustracijama prevazilazi ranije objavljena. Upoznavanje prirodnih i antropogenih vrednosti naših prostora putem ekzurzija je njena osnovna tematika, a rezultat je višegodišnjeg naučnog istraživanja i boga- tog profesorskog iskustva autora. Njegova želja, kako sam ističe u predgovoru, je "da napiše pričučnik koji se čita pre odlaska na ekzurziju, koji se čita na ekzurziji i koji se čita posle ekzurzije". Knjiga ima 267 stranica teksta, ilustrovano 72 fotografija, 32 tabelarnih priloga i 5 šematskih prikaza. Autor nakon predgovora, stilizovanog na njemu, i samo njemu svojstven način, jednostavno i slikovito, poput rezimea, slaže mozaik koji počinje od žitorodne ravnice i salaša Bačke, Paličkog jezera, Novog sada i fruškogorskih manastira ("srpske Svete Gore"), Banata i Dunava od Bezdana do Prahova, a onda ide "Beogradu u pohode, veličan- stvenom gradu da ga nije moguće opisati", izraslom na obalama Save i Dunava sa neponovljivim geografskim položajem koji mu je uslovio isto tako neponovljivu burnu istoriju i izузетne događaje. A onda, severozapadna Srbija sa ravnom Mačom, Cvijićevom Loznićom, Vukovim Tršićem i Desankinom Brankovinom.


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Opšti je utisak da ovo delo odiše duhom čoveka koji je našen uzletima i padovima zapadne civilizacije shvatio da treba proživeti ljudski život, ali i da treba bogatstva prirode ostaviti i potomicama. U podsticaju na razmišljanje o imperativu našeg opstanka najveće je vrednost ove knjige. Sütina knjige je ukazivanje na globalne vrednosti planete oko kojih treba da se gradi strategija borbe za opstanak ljudske vrste. Uvedbeni smo da će ova knjiga biti višestruko korisna različitim profilima korisnika i sa zadovoljstvom je preporučujemo.

P. Jakšić

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P. Jakšić
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P. Jakšić
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EDITOR
Predrag Jakšić, Ph. D.
Faculty of Science
Vidoevanska b.b.
38000 Pristina
Yugoslavia

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