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LIMNOLOGICAL CHARACTERISTICS OF THE LISINSKI POTOK SOURCE AREA ON KOPAONIK MOUNTAIN

Yugoslavia

D. Filipović

The source area differs distinctly from the other reaches of a system of water course in physiographical, physical and chemical properties, and fauna.

The present investigations covered the source area of the Lisinski Potok brook on Kopaonik. It flows west, receiving a large tributary, Barski potok, in the Tiodža gorge; the two brooks together make the Rudnički Potok brook, which flows southeast.

Lisinski Potok and Rudnički Potok were treated as one brook ecosystem, i. e. one ecological unit. Therefore, the present work covered the initial sources of Lisinski Potok and the sources of tributaries down to the Ibar.

The sources which give rise to Lisinski Potok are located at 1730 m above sea level. They are designated I and Ia. The sources which give water to its lower reaches are situated near its mouth on the Ibar at 520 and 420 m above sea level. In addition to this, the source of a sizeable tributary of the lower reach at 750 m was also investigated. The upper sources are typical mountain sources of low yield. One of them (I) has been primitively captured for human needs. The lowest sources have a higher yield, but are more dependent on atmospheric and anthropozoogenic factors.

The highest sources occur in eruptive rocks of a granite substratum with a lot of Paleozoic schist. Lower down the substratum is serpentine, which is eventually replaced by andesite.

The upper sources lie in the belt of alpine pastures, here and there intersected by kamenjar* with juniper and pine groves. From here a belt of spruce forests stretches downstream, followed by deciduous forests. All three lower sources of tributaries are situated in the zone of deciduous Balkan submediterranean forests.

The discharge of Lisinski Potok is very variable through the year, depending on season and precipitation in a large measure. These seasonal variations are negligible in the source zone. The dense forest in the immediate

* Stony heatland with low scrub (transl. note)

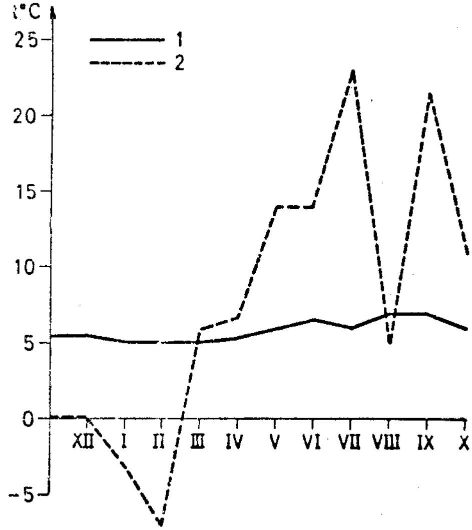

Fig. 1. Water and air temperature in source I in the course of the year
——— water, — — — — — air

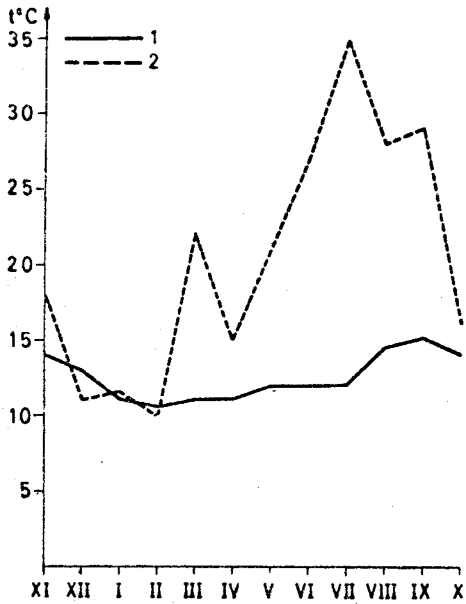

Fig. 2. Water and air temperature in the source at 520 m in the course of the year
——— water, — — — — — air

vicinity and the steep slope preclude the retention of any amounts of precipitation, so that the upper reaches are mainly supplied with water by sources.

The source depth is very small, 25 cm at the most. The upper sources are slightly deeper. They cover an area of 1 m in diameter, with a luxurient moss vegetation, especially around the edge. The two lower sources are somewhat shallower small depressions with a silty bottom, in a clearing. The middle source which lies at an elevation (750 m) between these two groups of sources is located in a fissure in the serpentine, and which — as we shall see later — has some specific features with regard to chemical composition.

All the sources examined showed slow water circulation.

Physico-chemical properties of sources

The source areas represent sites with specific thermal regimes. In the upper sources, whose temperature amplitude was 3°C, annual temperature variations were insignificant, and did not depend on external temperature. The typical seasonal oscillations were low, and occurred mainly in two periods: period of low temperature from November to April, and summer period with slightly higher temperature from April to October. The water never froze, not around the edges (Fig. 1).

The annual temperature amplitude of the source at 750 m was only 1°C. In the lower sources were more pronounced temperature variations. The annual amplitude were 4.3 to 8°C with a minimum in February (8.5°C) and a maximum in June—August (16.5°C) (Fig. 2).

The regime of O_2 and CO_2 was also observed. Only negligible variations were found in sources I and Ia through the year. The O_2 content varied between 8.5 and 10 mg/l. However, there was a certain jump in O_2 content in source Ia in May 1953 (Fig. 3).

The O_2 content of the source at 750 m showed small changes, whereas there were jumps in CO_2 content, particularly in October-February (14.0 *mg/l* in October, 3.75 *mg/l* in December, and 9.5 *mg/l* in February).

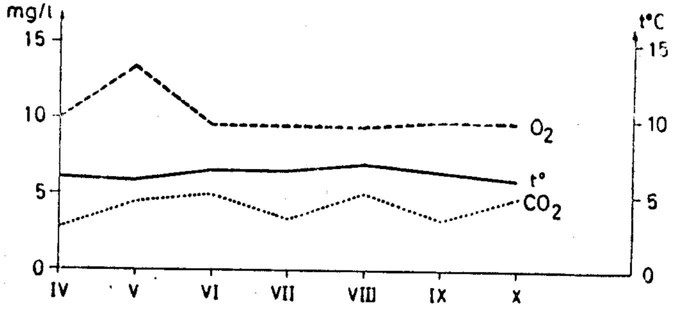

Fig. 3. O_2 and CO_2 in source Ia

The sources at the foot showed low O_2 with negligible changes 0.75 to 1.0 *mg/l*, while the CO_2 content was very high (over 80 *mg/l*), and exhibited frequent and sudden changes (Fig. 4). This indicates active decomposition of organic matter and a certain polution by man or animals, due to the close vicinity of pastures.

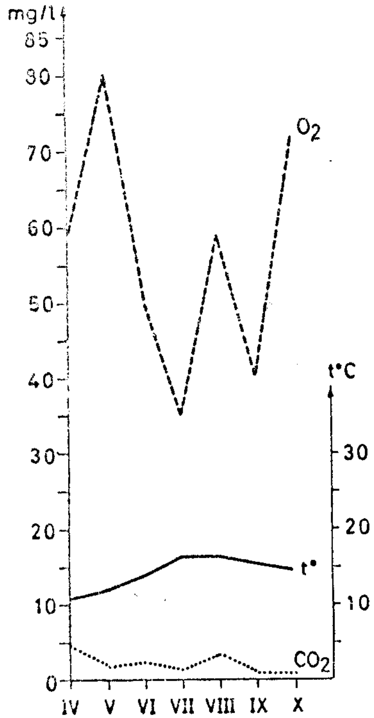

Fig. 4. Variations of water temperature and O_2 and CO_2 in the source at 420 m

Bicarbonate, alkalinity and pH were determined in the field. Considerable differences between the two groups of sources were found. The bicarbonate content was negligible in both upper sources, 23.79 *mg/l* HCO_3, whereas it was 376.98—449.57 *mg/l* HCO_3, in the lower sources. Alkalinity was rather low: 0.59 *mv/l* in the upper and 3.58—7.37 *mv/l* in the lower sources. The reaction of water in the upper sources was slightly acid, pH 6, due to the acid substratum and the close vicinity of typical sphagnum peaf bogs. In the lower sources it showed an alkaline reaction, pH 7.20—7.36, due to the presence of bicarbonate salts.

The source at 750 m, whose water flows into the lower reach of the brook, showed some specific chemical properties. This is a weak mountain source sourrounded by luxuriant vegetation. The high concentration of Mg ions (60.0 *mg/l*) is significant, especially in comparison with the other sources. The Ca ion concentration is only 20 *mg/l*. The high sulphate (55.89

mg/l SO_4), nitrate (0.625 *mg/l* NO_3) and chloride (6.0 *mg/l* Cl) is also worth noting. The water showed a pronounced alkaline reaction: pH 7.30—7.88. This chemical composition is related to the serpentine substratum, one of the causes of the high content of Mg ions, while the rich moss vegetation and periodic watering of livestock increase the phosphate and nitrate content of the water.

Table 1.

T°C	13°C	SiO_4	40.000 mg/l
O_2	9.09 mg/l	Ca	20.00 "
O_2 saturation in %	85.95	Mg	60.00 "
pH	7.70	HCO_3	366.00 "
CO_2	3.13 mg/l	SO_4	55.89 "
Alkalinity	6.18 mval/l	Cl	6.00 "
Total hardness	16.8 dH°	P	2.50 "
Carbonate hardness	16.0 dH°	NO_3	0.625 "
Dry residue at 105°	340 mg/l	N	0.375 "
		$KMnO_4$	10.06 "

Plant community

The highest sources have a silty-gravelly bottom, full of detritus and rich in moss and alga vegetation, while the lower sources had a silty bed with a dense population of higher plants.

In the initial sources the most frequent mosses were species of the genus *Mnium: M. undulatum, M. subglobosum, M. punctatum, Pellis epiphylla, Philonotis fontana, Sphagnum.*

At the lateral source at 750 m a luxuriant vegetation with diversified flora thrives. Unlike the initial sources, here there is only a depression, overgrown with *Longifolia* sp., *Veronica beccabunga* and *Tammus communis.* The stones in the source brook were covered with dense tufts of *Fontinalis antipyretica.*

In this and in the lowest sources *Phragmites* and sporadic *Typha angustifolia* were observed. In addition to mosses, the dominant vegetation in Lisinski Potok, algae are also an important component of the biological community. Their abundant growth is due to the presence of higher plants, especially mosses. In the sense cushion-like tufts of these plants a rich epiphyte and benthic flora of *Diatomeae* was observed. Sessile and epiphyte species of the genera *Gomphonema, Cymbella* and *Pinnularia* were found. A fair number of *Diatoma hiemale,* a nordic-alpine species frequently inhabiting, similar sites, is characteristic from the regional viewpoint. Some *Desmidiacease,* particularly *Cosmarium formolosum,* a sphagnum form and a usual inhabitant of sphagnum waters on Kopaonik, is also characteristic. The green filamentary algae were represented by sterile *Spyrogyra* species.

In the limnocrene source at 750 m with its high Mg content, the algal flora was rich not only in the number of species but also in biomass. *Diatomeae* were the exclusive representatives. Very numerous large individuals of *Cyclotella catenata* occurred in filaments over 100 μ long. It and *Amphora ovalis* are characteristic of this source. Species of the genera *Gomphonema*, *Synedra*, *Navicula*, etc., were represented by a few individuals. Of the green filamental elements only the sterile filaments of *Sirogyra* species were observed.

No algae were found in the sources at the foot because of the ecological conditions changed by the presence of human communities.

Composition of animal communities

The initial sources of Lisinski Potok are characterized by stenibionte and euribionte forms. In addition to insect groups, *Crustacea* (fam. *Gammaridae*) make a big contribution. The population pattern of the three orders of aquatic insects: *Ephemeroptera*, *Pleccoptera* and *Trichoptera* were studied in detail, while other components of the community, particularly of the groups *Amphipoda*, *Diptera*, *Coleoptera*, *Hydracarinae* and *Molluscs*, were also quantitatively analyzed. The proportions of the main groups of the source community were as follows:

Amphipoda	38%	*Ephemeroptera*	8%
Diptera	25%	*Plecoptera*	7%
Trichoptera	11%	*Coleoptera*	4%
Molluscs	2.70%	*Hydracarinae*	0.70%
Planaria	2.10%	other groups	1.50%

The following *Ephemeroptera* were found in the sources of Lisinski Potok:

*Baetis carpatica**	(26.2%)	*Habroleptoides modesta*	(16.5%)
Ecdyonurus venosus	(23.9%)	*Baetis pumilus*	(13.9%)
Baetis rhodani	(18.2%)	*Ameletus inopinatus*	(3.2%)

All these species are inhabitants of high-altitude cold waters, and from the upper reaches penetrate into the sources themselves. No crenobiont form was observed.

According to Ikonomov (Ikonomov, '59) no specific from of *Ephemeroptera* was found in Macedonian mountain sources either. In these sources the most frequent were *Habroleptoides modesta* and *Baetis rhodani*. In the sources of the Katušnica Potok brook (western Serbia) *Ephemeroptera* were not observed at all. The absence of *Ephemeroptera* in many sources of northern Germany was noted by Thienemann (Thienemann, '26), whereas in the sources of the stream Mölle only the species *Ecdyonurus venosus* and *Habroleptoide modesta* (Illies, '52) were found.

* The figures in parentheses are the abundance relative to the whole group.

The dominant *Ephemeroptera* in Lisinski Potok were *Beatis carpatica* and *Ecdyonurus venosus* (over 20%).

Plecoptera were represented by six species in the sources of Lisinski Potok:

Nemoura cinerea	(40.4%)	*Perlodes intricata*	(6.3%)
Arcynopteryx compacta	(26.2%)	*Isoperla tripartita*	(3.7%)
Leuctra fusca	(20.2%)	*Capnia vidua*	(3.1%)

These species too inhabit mostly high mountain waters. However, *Arcynopteryx compacta* is a typical crenobionte and boreal species, observed in cold sources of Scandinavia and Central Europe but not in the Alpe. This species is a true relict form, which was found for the first time in Yugoslavia in springs on Korab (Brinck, '49). This is the second recovery in Yugoslavia. The presence of the cold stenothermic species *Capnia vidua* is also noteworthy.

The following species of *Trichoptera* were found:

Drusus sp.	(30.2%)	*Rhyacophila* sp.	(5.1%)
Thremma anomalum	(20.2%)	*Sericostoma pedemontanum*	(4.3%)
Stenophylax sp.	(7.5%)	*Wormaldia occipitalis*	(2.2%)

The first two can be considered crenophile.

The presence of *Thremma anomalum*, a Mediterranean stenothermic form of cold waters, confined to the Balkan Peninsula, is of particular biogeographical interest. It has only been in Greece, southern Yugoslavia and the south Carpathians. Its larvae and nymphs were described for the first time on material from Yugoslavia (Stanković, '34). The other forms of *Trichtoptera* were typical inhabitants of mountain waters, which from the upper reaches penetrate into the source area.

Gammarus (R) pulex fossarum was the dominant component of the community of the highest sources of Lisinski Potok. This is a markedly stenothermic subspecies of *G. pulex* whose main distribution center is in the Alps (Pljakić, '52). This form inhabits the mossy tufts of the source biotope. The other animal groups were not faunistically investigated. Of the *Diptera* the following species were found: *Disranota bimacutata*, *Atherix* sp., *Atalanta* sp., *Tipula* sp., *Hemerodromia* sp., and a number of species of the groups *Ceratopogonidae* and of *Chironomidae (Procladius*, *Tanytarsus*, *Ablabesmya* and *Orthocladius* groups). The *Diptera* group is also an important component of the source community.

Of the *Coleoptera* the constant presence of *Lathelmis perrisi* and *Hydraena gracilis*, and periodic presence of *Hydrobius fuscipes* was observed.

The Hydracarina were represented by six species of the following genera: *Lebertia*, *Sperchon* and *Panissus*.

Heteromurus major, a Mediterranean species, and *Isotoma montana* a mountain species, represented the *Collembola*.

The molluscs *Stagnicola palustris*, *Galba truncatula* and the form *Sphaerium corneum*, the latter typical for the mountain sources, were also constantly found.

An ecologically interesting finding was *Planaria gonocephala (Tricلada)*. The source area and upper reaches of mountain brooks on Kopaonik are a typical region for the high altitude Balkan species *Crenobia montenegrina*, whereas *Pl. gonocephala* does not usually inhabit the zone of high mountain sources. However, on other Serbian mountain massifs too this form sometimes penetrates into the high source region (Stanković, '34).

In addition to the Lisinski Potok initial sources, the communities of the three lower sources was also partly studied.

The source at 750 m was also inhabited by *Gammarus (R) pulex fossarum*, but in a less dense population than in the upper sources. After the brook of this source joins the main course of Lisinski Potok, this species lives in a mixed population with *Gammarus (R) balcanicus*.

This source is characterized by the presence of interesting representatives of *Trichoptera*. Besides the forms *Thremma anomalum* and *Sericostoma pedemontanum*, a species of the genus *Helicopsyche*, whose species can be found on all continents, especially in the tropics, was found. This was the first recovery of this genus in Yugoslavia. In the brook of this source the following forms of *Trichoptera* were observed: *Stactobia* sp., *Adicella filicornis*, *Beraea articularis*, *Diplectrona atra* and *Glossosoma boltoni*.

The two lowest sources were inhabited by a rich population of *Gammarus (R) balcanicus*, but had almost no representatives of *Ephemeroptera* and *Plecoptera*. *Paracyclops fimbriatus (Crustacea)*, characteristic of small sources with abundant vegetation, occurred here in a considerable number. *Eucypris pigra (Ostracoda)*, known in northern Europe and Eurasia, lives here. It can be found in fresh water of various types, but is characteristic of source communities. The species *Heteromurus major* and *Entomobrya* sp. *(Collembola)* were constantly present in moderate numbers.

In all three lower sources the Molluscs were better represented: *Stagnicola palustris*, *Gabla truncatula*, *Vallonia pulchella*, *Vertigo pygmaea*, *Carichius tridentatum* and *Theba carthusiana*.

Seasonal changes in the bottom fauna

With regard to the number of individuals in the source community, *Gammaridae*, and the insect groups, *Chironomidae* and *Trichoptera* are of particular importance. A wide fluctuation in abundance with the annual cycle was characteristic of these three components.

In source I *Gammaridae*, represented only by *Rivulogammarus pulex fossarum*, showed four peaks (April, June, October, December) up to 73%, whereas the minima (2—15%) were in May, August, September and November.

Chironomidae also showed wide fluctuations in number. The maximum abundance of this family (May, 75%) coincided with the minimum of the *Gammaridae* family, and *vice versa*. The succesion of these two families is characteristic, particularly in summer (Fig. 5).

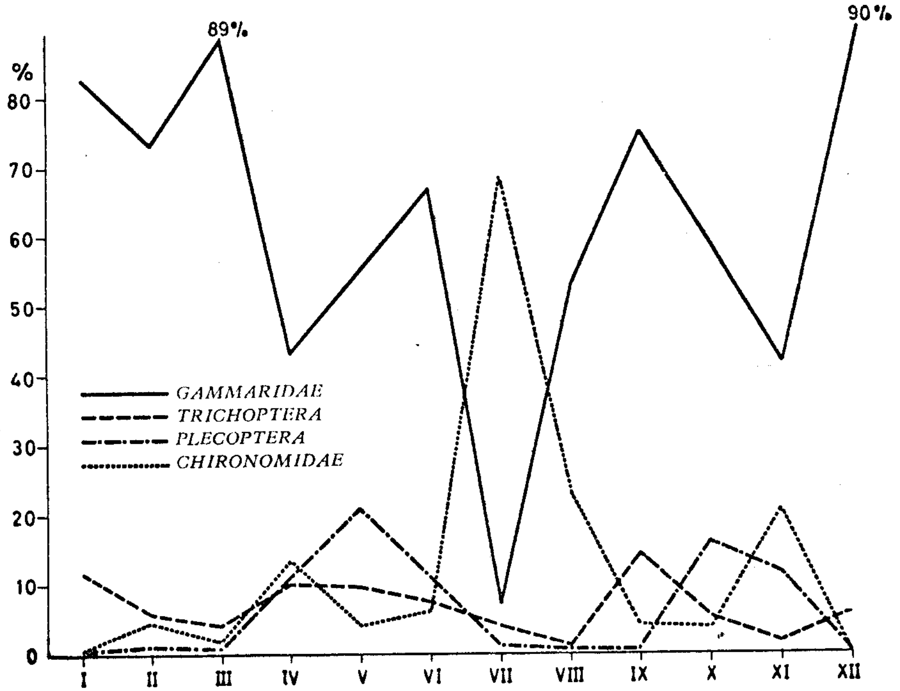

Fig. 5. Numerical proportions of faunal groups in source I during the year

Trichoptera was considerably less frequent, with a maximum of (30%) in April, and only about 10% during the rest of the year.

The other groups were numerically unimportant.

The second source at the same elevation (Ia) had the same faunal composition. *Gammaridae* and *Chironomidae* were the dominant species, but their percentage distribution during the annual cycle showed considerable differences as compared to the first source.

Gammaridae constituted over 50% throughout the year except for July, when their abundance dropped below 10%. At this time *Chironomidae* dominated (70%) (Fig. 6). The numerical succession of these two families in source Ia was also more pronounced in summer period.

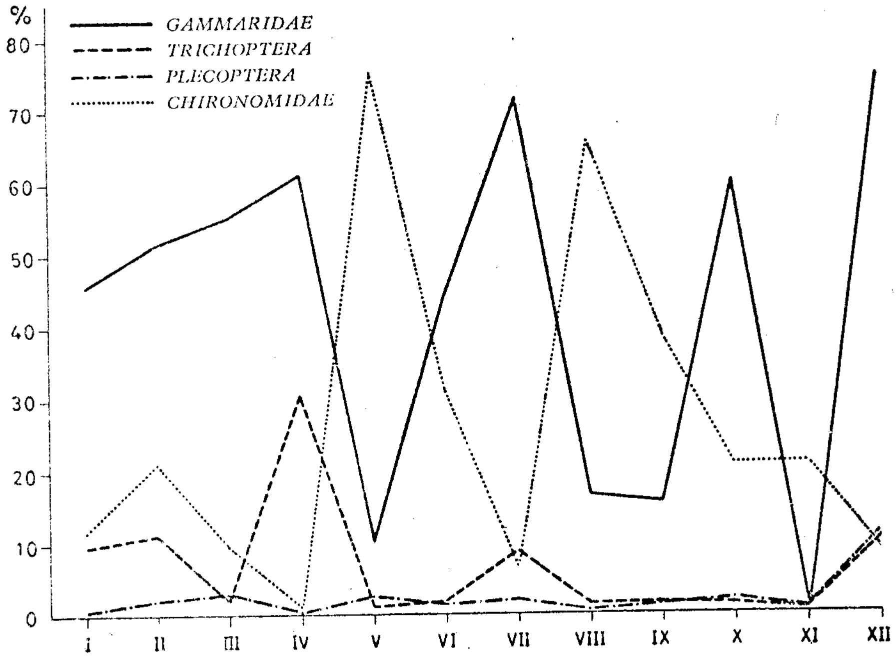

Fig. 6. Numerical proportions of faunal groups in source Ia during the year

The limnocrene source at 750 m differed considerably from the upper sources in the proportions of faunal groups. The order *Trichoptera* was dominant throughout the year (with a maximum of 57% in July). *Gammaridae* (30%) and *Chironomidae* (28%) were considerably less frequent. Of other groups the *Gastropoda* showed a high abundance (45% in August) (Fig. 7).

The two lowest sources (at 520 and 420 m) are helo- and limnocrene sources. The bottom fauna composition with regard to the animal groups mentioned above was similar to that of the upper sources, but with different ratios between particular groups. Unlike the upper sources, the participation of *Chironomidae* was insignificant, while *Thrichoptera* constituted 25% in March and in June. The other insect groups were unimportant.

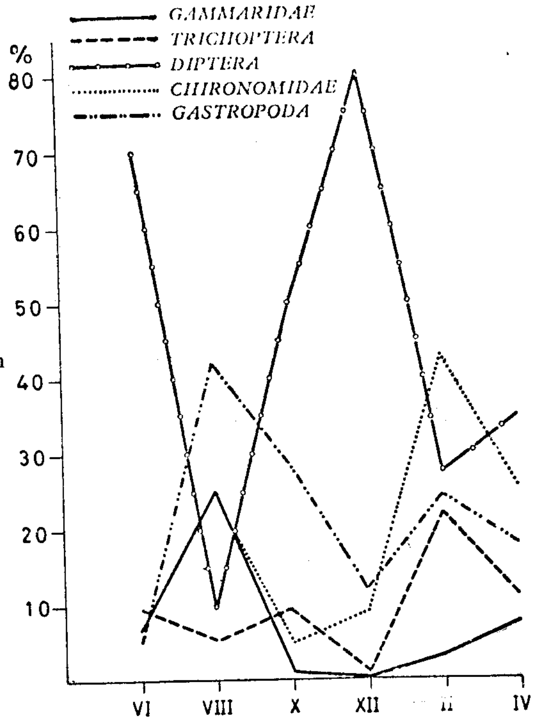

Fig. 7. Numerical proportions of faunal groups in the source at 750 m during the year

CONCLUSION

The source area of Lisinski Potok is located on Kopaonik (Serbia) whose height exceeds 2000 m. The substratum is impermeable (granite, serpentine, andesite and dacite).

Lisinski Potok rises above the timberline, at 1700 m above sea level, and empties into the Ibar at 420 m. The watershed of this brook covers an altitude range of 1300 m.

1. In addition to other ecological factors the altitude range of the source area exerts a considerable influence on its physico-chemical nature. The source at higher elevation are rheocrene with pronounced homothermy, whereas the sources at the foot showed some oscillations of temperature, and had a seasonal character. They all belong to the category of cold sources of constant yield.

The ionic reaction of the water of the upper sources was in the acid range (6.1—6.5), while it was 7.3 in the lower sources.

2. These sources have a specific and relatively rich flora of *Diatomea*, plus numerous moss species and other plants.

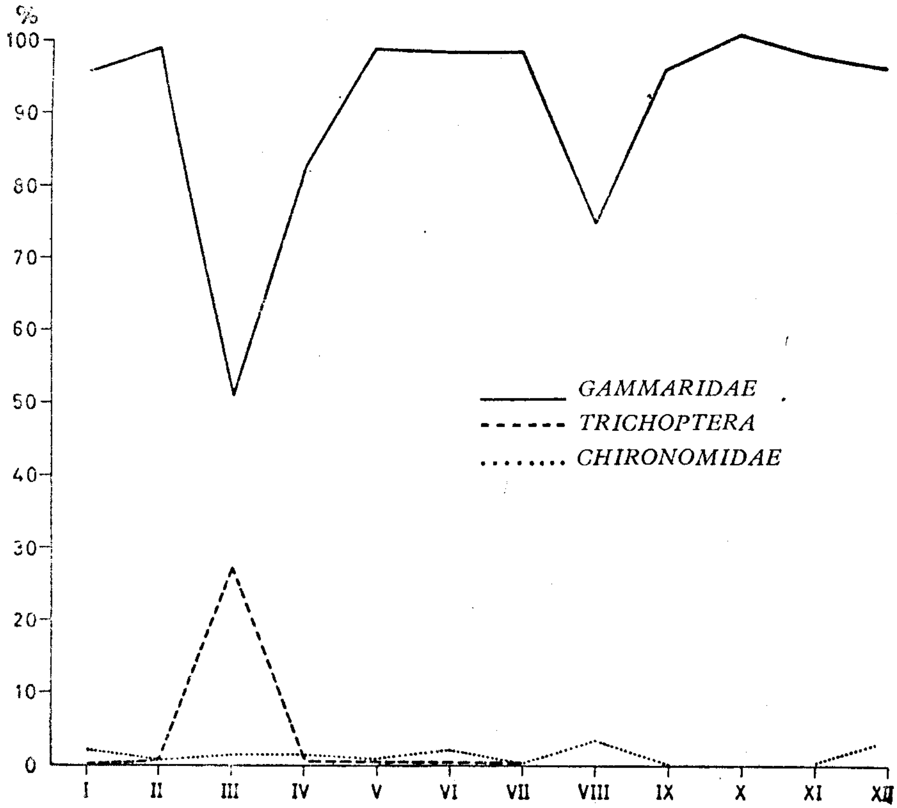

Fig. 8. Numerical proportions of faunal groups in the source at 420 m

3. The animal community of the bottom was quantitatively and qualitatively investigated. A closer study was made of the aquatic insects *Ephemeroptera*, *Plecoptera*, *Trichoptera*, and of *Amphipoda*. The composition of other animal groups was not studied. However, their abundance was established.

The high altitude form *Arcynopterx compacta* was characteristic of the upper sources, a high abundance of *Stactobia* sp. and the presence of *Helicopsyche* sp. of the source at 750 m. *Eucypris pigra*, a spring form but of a wide ecological range, inhabiting other types of water, was characteristic of the two lowest sources.

4. Two *Amphipoda*, *Gammarus (R) pulex fossarum* and *Gammarus (R) balcanicus*, inhabit the Lisinski Potok Sources. The former in pure population is confined to the initial upper sources, while the latter in pure population inhabits the lateral sources of the tributaries.

5. The sources and upper reach of Lisinski Potok reach to the very border of the ancient glaciation, while its upper course today flows through a spruce forest, the highest forest belt on this mountain. The connection with the glaciation was also confirmed by a faunistic analysis of the community of aquatic insects, which showed that it was primarily composed of north--European cold stenothermic forms, today's thermal conditions being suitable to them. Undoubtedly, these forms can be classified among the species called "Gletscherrandarten" by German authors which during the Ice Age inhabited mountain streams fed by water flowing out of the glaciers and permanent snow. Such are the Balkan prediluvial mountain species, such as *Ecdyonurus epeorides* and *Chitonophora unicolorata* of the *Ephemeroptera*, and *Diplectrona atra* and *Thremma anomalum* of the *Trichoptera*.

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Institute for Biological Research
Beograd

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