

BIOGEOGRAPHICAL AND FAUNISTICAL NOTES ON MAYFLIES
(EPHEMEROPTERA) OF SR SERBIA

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Mountain streams, particularly mountain brooks, which are by the classical definition comprised in the salmon region of running waters, represent the category least studied in the limnological ecosystem of our country. There exist a small number of studies on streams in Serbia, Macedonia, Bosnia, and Croatia which are primarily concerned with an analysis of the fauna of single animal groups (*Pisces*, *Ephemeroptera*, *Trichoptera*, *Diptera*, *Tricladida*) and partially with the ecology of certain animal species. There are fewer studies dealing with a biocenotic analysis of all communities in our streams.

Our country is a part of south-eastern Europe with a particular geological and geomorphological history, in addition to its special history of colonization of the inland waters. While the history of the communities living today in the running waters of middle and northern Europe dates primarily from the post-glacial period, in our waters this history reaches deeper into the ice age near the end of the Tertiary and it is closely connected with significant climatic changes in our mountain regions during the course of time. The biocenotic changes were the most significant. In the course of the ice age, an up to the late Tertiary period, the contemporary biocenoses were gradually developed. As fragmentary faunistic studies thus far have shown, in the composition of brook biocenoses in Yugoslavia there is a great number of elements of various biogeographical origin and age and their presence accounts for one of the regional characteristics of the composition of these biocenoses. The ecological study which has just begun is aimed at a closer determination of the position and state of the communities living in our mountain streams.

In principle, it can be said that the fauna of *Ephemeroptera* in Serbia is today composed not only of elements of pre-glacial fauna, which began to populate mountain brooks in south-eastern Europe at the end of the Pliocene period, but also of elements of the fauna of the Central European mountains which broke through on the Balkan Peninsula during glaciation. The third group should be comprised of those Balkan elements breaking through into the mountains of central Europe during the interglacial period. The biogeographical laws also hold for other groups on the territory of Serbia and on the Balkan Peninsula in general (MATVEEV, 1961, 1969a).

According to the well-known division into biogeographical regions (ILLIES, 1967), Serbia's mountain area is comprised of two such regions. These are: Dinar-western Balkan (No 5) and eastern Balkan (No 7).

According to the biogeographical division of the Balkan Peninsula which is based on the distribution of the faunal elements of various groups of phanerobiont organisms (MATVEEV, 1969b), on the territory of Serbia there exist the following mountainous biogeographical territories: the northern-Dinar (according to Illies in the Dinar-western Balkan), followed by the southern Dinar (according to Illies

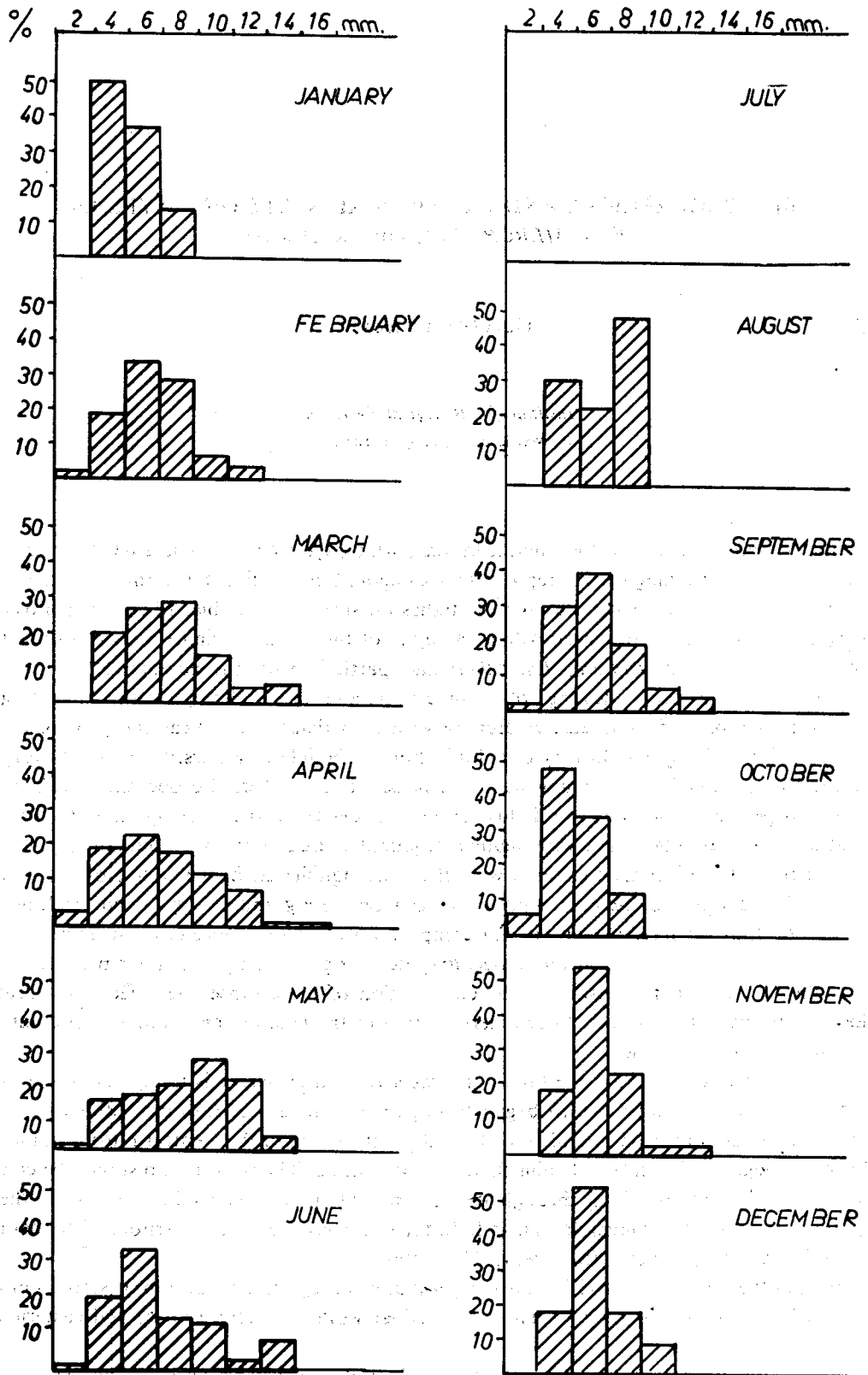


Fig. 1. Body length of the species *Rhithrogena dlaphana* NAVAS in different months in the course of 1963. Number of individuals as percentage of the monthly total (Lisinski brook — Kopaonik)

in the Greek western Balkans), the Rodopi region (according to Illies the eastern Balkans), and the Carpathians. It should be mentioned at once that the biogeographical division suggested by ILLIES in 1967 and MATVEEV in 1969b for this part of the Balkan Peninsula are very similar. The purpose of this and further studies is to develop a detailed biogeographical analysis on the basis of the original results arrived at in investigating *Ephemeroptera* in Serbia.

This report gives a brief review of the quantitative and qualitative composition of the *Ephemeroptera* in eight mountain and hill brooks in Serbia.

In the framework of the biocenotic research of the Lisinska brook on Kopaonik (which belongs to region 5), the zonal distribution of faunistic communities was studied. The peaks of Serbia's largest mountain (2017 m) are primarily composed of granite, dominating on the slopes in serpentine, while at the base are andesite and limestone. The brook flows through a coniferous forest, then through a deciduous-coniferous one, and in the lower section through pastures. On the basis of biocenotic analysis of the Lisinski brook, it was found that it is possible to differentiate three zones, by their physiographical characteristics as well. The brook as a whole belongs to the rhithron, with *Salmo trutta fario* in great part, while in the lower course *Barbus meridionalis petenyi* is found.

In its quantitative representation the *Ephemeroptera*, in relation to the entire bottom community, increases from the source region where it represents 8% (six species) through the zone of the upper course with 28% (forty species), and the zone of the middle course with 32% (twelve species), while it is somewhat less in the lower course 26% (twelve species).

In the source region, according to the degree of abundance (over 20%), the species *Baetis alpinus* and *Ecdyonurus venosus* dominate. In the zone of the upper course three species were determined, limited to that zone only. These are *Ecdyonurus zelleri*, *Ameletus inopinatus*, and *Ephemerella unicolorata*. In the zone of the middle course there are no species limited only to this zone, but we can separate those species in this part of the current having the greatest percentage abundancy, such as *Rhithrogena diaphana* and *Baetis rhodani*. In the zone of the lower course *Rhithrogena diaphana* is also characterized by a high degree of abundancy. In source at a height of 400 m. *Ephemeroptera* were entirely lacking.

On this occasion the dynamics of the population *Rhithrogena diaphana* was observed. In the Lisinski brook this species was found in localities five to sixteen, i.e. a part of the upper, then middle and lower course. The numbers of individuals per locality is between 3–52 per m². The greatest density of this species is seen in the middle course where the water current is also the fastest owing to a sharp fall in the riverbed. The dynamics of the population of this species is given through the structure of the population and its density. The density is expressed by the frequency of longitudinal values. Considering that in question here is an expressly torrential form which changes its habitat depending on the water current, the given values may taken as relative. But in spite of this it can be clearly seen from the assembled data that the maximum of emergence is in the month of July. The same was concluded by IKONOMOV from his observations in the waters of Macedonia. Measurements were taken in longitudinal units of half a millimetre and later fitted into the millimetre scale. The limits arrived at were between 2–16 millimetres, but on the average the largest number of forms had a length of 6–8 millimetres throughout the year (Fig. 1).

The growth rate observed during the whole year through the entire stream and is graphically shown in Fig. 2. The growth rate was calculated from the longitudinal size and shows the same rhythm at a large number of localities. Prior to the period of emergence there is a visible rise in the growth rate which usually reaches its maximum in May. In June mass emergence begins. Noted in the majority of localities is a certain stagnation in the growth rate in the period November–January, which is followed by a noticeable increase with rising intensity until the moment when emergence begins.

It should be mentioned that the percentage abundance of the species *Rhithrogena diaphana* in the framework of the group *Ephemeroptera* in this stream was followed through two seasonal aspects, summer and winter, and it was always greater in the winter period. For example, in the upper course this percentage was 6.2 in the summer and 9 in the winter period; in the middle course 10.5 in summer and 39.7 in winter; and in the lower reach this relationship was 12.2 in summer and 58.0 in the winter period.

The river Katušnica on Zlatibor, which forces its way through serpentines and limestone deposits, was studied in the autumn period. The differences in altitude of the part of the current examined was between 750 and 500 m. In the *Ephemeroptera* community the following species are distinguished according to their abundance: *Ephemerella major*, *Ephemerella danica*, *Baetis* sp. and *Habroleptoides modesta*. Above this river, on Mt. Zlatibor, at an altitude of 1000 m. in July of this year what was probably the species *Habrophlebia pauliana* GRND., new to Serbia and thus far known to area No 4 of the Alps, was found in the field brooks. Mt. Zlatibor belongs to area No 5.

A one year cycle of research on the Grošnička river, which flows through beech and oak forests. The difference in altitude is between 700 and 200 m above sea level. The bank of the lower current passes through suburban communities.

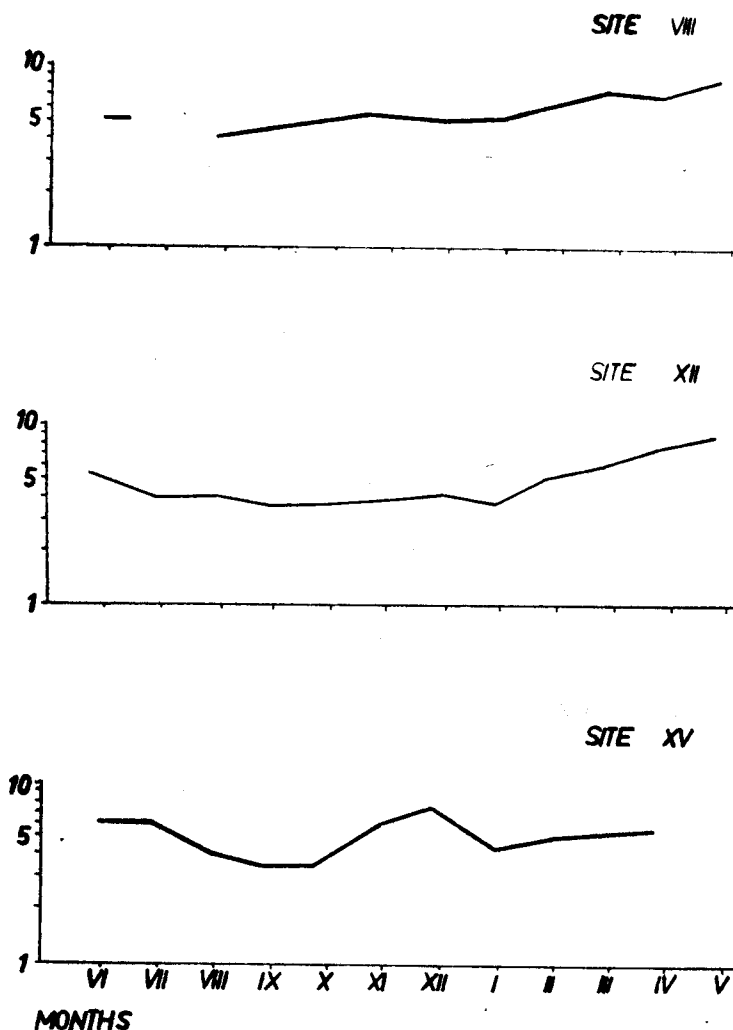


Fig. 2. Growth rate of the species *Rhithrogena diaphana* NAVÁS on the sites VIII, XII, and XV in the course of 1963 (Lisinski brook — Kopaonik)

The river basin of the Grošnička river lies in the most easterly part of the Dinar-western Balkan region so that elements of the neighbouring regions can be expected here. The majority of *Ephemeroptera* found in this river belong to the species which are widely distributed throughout Europe. However, the species *Baetis alpinus* belongs to the Carpathian fauna, while the species *Ecdyonurus mazedonicus* (IKN.) has so far only been found in Macedonia and has a distinctly northern distribution. From quantitative analyses it can be seen that in the autumn, spring, and summer sampling, *Ephemeroptera* showed

the greatest numerical value in relation to the zoobenthos community. However, among the most abundant of the *Ephemeroptera* species in this river are included *Ecdyonurus venosus*, *Baetis rhodani*, *B. vernus*, and *Baetis* sp., *Paraleptophlebia submarginata*. According to the biocenotic analyses, this river is divided into three zones, of which the first two primarily belong to hyporthithron while in the third forms characteristic to epipotamon appear.

In the summer period 1967 materials were gathered from the river Studenica whose source is 1600 m above sea level and which flows into the Ibar at 329 m. It is 60 km long. Taking the insect community as a whole, it can be concluded that in this river the community of *Trichoptera* has the greatest quantitative representation (from 5 to 82%) while the representation of *Ephemeroptera* is from 2 to 42%. Following the longitudinal succession of this group downstream, it is noted that the family *Baetidae* is very numerous in the upper part of the stream (*Baetis rhodani*, *B. fuscatus*, *Baetis* sp.). Then, in this river the most frequent species are: *Ephemerella unicolorata*, *Habroleptoides modesta*, *Epeorus sylvicola*, *Ecdyonurus zelleri*, *Heptagenia* sp., *Rhithrogena diaphana*, and *Paraleptophlebia submarginata*. After the tributary Savošnica and Brevina in which two population of *Ephemerella ignita* is very numerous, this species also appears in the Studenica although not in significant number. Close to the mouth of the river the species *Oligoneuriella rhenana* is also found. This river belongs to area 5.

In the area of Eastern Serbia the river Crni Timok and its two tributaries were studied. This area is described as a typical limestone terrain, comprised of Jurassic, Tertiary, and volcanic limestone. There is a number of fossils. The immediate surroundings of these streams are composed of oak and beech forests. The difference in altitude is from 700 and 300 m. above sea level. The samples were taken at seasonal intervals between 1967 and 1969. The water has a mild alkaline reaction and calcium is the dominating ion. These streams belong to area 7, Eastern Balkan.

In the source of the River Radovanska *Ephemeroptera* have a very variable representation (from 3 to 21%). Here in number *Rhithrogena semicolorata*? and *Epeorus sylvicola* stand out. However, in the period from October to February along the entire length of the stream (12 km) these two species maintain their numerical domination. In the winter period, at the mouth of this river, the constant presence was noted of the species *Ephemerella major*, *Habroleptoides modesta*, and *Habroleptoides* sp. In the lower course, *Ephemerella ignita* had a different numerical quality. In addition to the above-mentioned species, in this stream there were great numbers of species from the family *Baetidae*, among which *Baetis rhodani*, *B. lutheri*, *Centroptilum* sp. should be stressed. However, a quantitatively small but constant representation of the species *Ecdyonurus venosus* should be mentioned. To some extent the stream Mirovštica differs in its *Ephemeroptera* composition. Species from the family *Baetidae* remain the greatest in number here also, followed by *Ephemerella ignita*, *Ephemerella vulgata*, *Ephemerella* sp., *Caenis macrura*, and *Oligoneuriella rhenana*. In this region, in the Šaška stream, *Habroleptoides carpatica* B. et C. were found in their adult stage, a species which is new in Serbia and thus far familiar to region 10 (the Carpathians).

Last year in the immediate vicinity of these rivers, research began on River Pek, as it is an interesting subject for investigation. In February 1974, through a fissure, a huge quantity of sludge from a cupriferous mine spilled into this river. The sludge from the copper mine represents great mechanical pollution in addition to its content of copper, arsenic, and iron. Field work was carried out from May to October along the length of the entire river (90 km). From quantitative analyses it was established that the dominant insect group was *Ephemeroptera* and that its relative abundance in relation to the entire bottom community was from 45.90 to 92%.

In the distribution of the species *Ephemeroptera* along the length of this stream a regularity was noticed which was maintained throughout the investigation period. In the upper part of the stream (localities 1 and 3) domination of the species *Ephemerella ignita* was observed with quantitative representation at 90%. Downstream, this species was found sporadically and only in small numbers. At the spot where the sludge had spilled into the Pek this species was not present at all. It can be presumed that the species was introduced into the Pek by its tributary, Crna reka. Constantly accompanying the species *Ephemerella ignita*, although in small numbers, were the species *Oligoneuriella rhenana* and *Rhithrogena diaphana*. The composition of the *Ephemeroptera* down river changes greatly.

Dominating are species of the family *Baetidae* — *Baetis rhodani*, *B. vernus*, *B. lutheri*, *B. gemellus*, and *B. fuscatus*, in number being particularly outstanding, and from the family *Caenidae* *Caenis macrura*. Species of the family *Baetidae* are known as of some kinds of pollution.

When comparing this fauna with the *Ephemeroptera* from the River Radovanska, a clean mountain brook not far from the Pek, certain differences in composition can be seen. In the River Radovanska, the species *Epeorus sylvicola*, *Rhithrogena semicolorata*, and *Habroleptoides modesta* are very numerous. In the Pek, the first mentioned species is totally lacking, while the other two are represented in much smaller numbers. These two species require a high oxygen content in the water. The River Pek belongs to region 7, Eastern Balkan.

The River Dobranjska is a direct tributary of the Danube in a sector of Lake Deddap and it is 12 km. long. In May of this year in three localities near the mouth of the river, the dominance of *Ephemeroptera* was clearly expressed in relation to the entire bottom community. The quantitative representation of this group was between 51 and 64%. Most represented was the species *Ephemerella ignita* (70 to 80%) and followed quantitatively by *Baetis fuscatus*, *B. lutheri*, and *Caenis macrura*. This stream also belongs to area 7.

Making a summary review of the species found in 8 studied streams in Serbia it can be concluded that the most frequent species were:

In the western-Dinar Balkans: *Ecdyonurus venosus*, *E. zelleri*, *Rhithrogena diaphana*, *Baetis alpinus*, *B. rhodani*, *Ameletus inopinatus*, and *Ephemerella unicolorata*.

In the eastern-Balkans: *Epeorus sylvicola*, *Rhithrogena semicolorata*, *Ephemerella ignita*, *E. major*, *Habroleptoides modesta*, *Baetis rhodani*, *B. fuscatus*, *B. lutheri*, and *Centroptilum* sp.

Conclusions

1. According to general biogeographical regularity materials collected from recent research in Yugoslavia, the following suppositions concerning the origin and the distribution trends on the Balkan Peninsula and in Serbia can be made.

Connections with the mountains of central Europe:

a) Via the Carpathians: *Ecdyonurus zelleri* ETN., *Heptagenia flava* ROST., *Rhithrogena germanica* ETN., *Habroleptoides carpatica* B. et C., *Ephemerella krieghoffi* ULM., *Ameletus inopinatus* ETN.,

b) Via the Alps: Connections with the mountains of western and central Europe: *Ecdyonurus fluminum* PICTET, *E. forcipula* PICTET, *Rhithrogena diaphana* NAVAS, *Rh. semicolorata* CURTIS, and *Oligoneuriella rhenana* IMHOFF.

2. In relation to the distribution of 36 species of *Ephemeroptera* which have thus far been determined in the mountain streams of Serbia, 42.90% of the species are distributed throughout Europe. 25.70% belong to the mountains of central Europe, 8.57% to the Carpathian species, 5.70% to the Balkan species, and 2.80% to the Alpine ones.

3. In the *Ephemeroptera* fauna of Serbia there are not only western-Dinar elements but also Alpine and Carpathian and southern-Dinar (Greek) ones. It can be supposed that the alpine (*Habrophlebia pauliana* GRND.) and the Carpathian (*Habroleptoides carpatica* B. et C., *Rhithrogena germanica* ETN. and *Rh. cf. gorganica* Klapálek) elements are of glacial origin, while the southern-Dinar ones (*Ecdyonurus mazedonicus* IKN. and *Ephemerella hellenica*) are preglacial.

In accordance with this, the distribution of *Ephemeroptera* in Serbia follows the general biogeographical laws which were pointed out by ILLIES and MATVEEV for the Balkan Peninsula.

SUMMARY

Biogeographical and faunistic notes on mayflies (Ephemeroptera) of SR Serbia

Yugoslavia is a part of south-eastern Europe with a particular geological and geomorphological history, and accordingly, history of colonization of inland waters.

Ephemeroptera in Serbia is today composed of elements of preglacial fauna and also of those of the fauna of the central European mountains which emerged on the Balkan Peninsula during glaciation. The third group are the Balkan elements breaking through into the mountains of mid-Europe during the interglacial period.

According to the well known division into biogeographical regions (ILLIES, 1967), Serbia's mountain region is composed of two such regions. These are: Dinar-western Balkan (No 5) and eastern Balkan (No 7).

This paper gives a brief review of the quantitative and qualitative composition of the *Ephemeroptera* in eight mountain and hill brooks in Serbia.

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