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Investigations of Mayflies *(Ephemeroptera)* and Stoneflies *(Plecoptera)* of the Danube in the Region of the Gabčíkovo Barrage

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Abstract

The structure of mayfly *(Ephemeroptera)* and stonefly *(Plecoptera)* taxocenoses of the Danube and its anabranches (running and intermittently running arms, backwaters) was investigated. Twenty mayfly and three stonefly species were recorded. As compared with reports by previous authors, there occurred a marked decrease in the number of species, especially of stoneflies (of 8 known species, only a single autochthonous one, namely Leuctra fusca, was observed). In mayflies, species prevailed whose index of saprobity varied from 2.0 to 2.2. The index of saprobity of the Danube parts examined was from 2.2 to 2.4. These findings indicate that the originally beta-mesosaprobic Danube at present is changing to alpha-mesosaprobity.

The Czechoslovak section of the Danube (172 km) represents a large inland delta forming a very complicated ecological system. Elements of limnic and lotic environment come here together. It is inhabited by numerous interesting animals (HOLČÍK, 1981). At present, the Danube barrage system Gabčíkovo – Nagymaros is under construction there; it is aimed at using the river's energy and improving navigation. The width of the river in the section from Hrušov to Palkovičovo will be reduced by 100 m; only one forth of the original amount of water will pass through it. As a result, the level of ground water in a 10 km wide zone along the main stream will drop by 1 – 5 m and the whole inland delta will disappear. The consequences of these changes have been stressed by ROTHSCHEIN (1973), HOLČÍK (1981) and HOLČÍK et al. (1981). Numerous animals will presumably disappear and others will be endangered. The abundance of fishes in the Danube will be endagered. The abundance of fishes in the Danube will markedly decrease, the quality of surface waters will be impaired, timber production will drop and agriculture will be negatively affected. In the derivation canal, overreproduction of the mullusc *Dreissena polymorpha* will take place, with a negative impact on the work of the barrage system. On the other hand, the bottom of the latter will become stabilized, which will lead to a mass increase of some macrozoobenthos groups.

The aim of the present study was to obtain information about the actual distribution of mayflies and stoneflies in the area of the future Gabčíkovo barrage.

In the main stream, macrozoobenthos concentrates itself mainly at the littoral zone, artificially reinforced by stones, because the bottom of the medial consists of gravel and sand which are continously moving. Quantitative studies on the macrozoobenthos of the Danube were carried out by ERTLOVÁ (1967, 1968, 1970, 1973) and ŠPORKA (1979). The average biomass in the littoral zone of the Danube was found to amount to about 150 kg/ha, while in the medial it reached only 50 kg/ha. Benthic fauna was concentrated to the anabranches. In short swiftly running arms the biomass amounted to 65 kg/ha as compared to up to 178 kg/ha in slowly running arms. At high levels of the water in the Danube, part of the biomas is frequently washed out into the main stream. Reports about the aquatic fauna of the Danube have been reviewed by Ertl et al. (1961) and ŠPORKA (1979). Mayflies in the given area were studied by BALTHASAR (1936, 1938), BRTEK (1951), LICHARDOVÁ (1958), BRTEK and ROTHSCHEIN (1964), ROTHSCHEIN and HANZLÍKOVÁ (1966), ERTLOVÁ (1968), LANDA (1969) and ŠPORKA (1979) and stoneflies by BALTHASAR (1936, 1938), BRTEK (1951), WINKLER (1957), RAUŠER (1957, 1960, 1965), BRTEK and ROTHSCHEIN (1964) and ERTLOVÁ (1968).

General characteristics of the stream

The Danube enters Czechoslovak territory at the river-kilometer 1880, at an altitude of 130 m above the sea level. In a 70 km long section up to Palkovičovo its width varies from 200 to 300 m. The littoral zone at both banks represents about 8% of the total profile of the river's bottom (HOLČÍK et al., 1981). In the area under investigation, the slope is 0.31 %; at high water levels, the stream reaches a maximal speed of up to 3,5 ms^{-1}. At an average flow rate of 2000 m^3s^{-1} this value drops to 1,78 ms^{-1}. The river shows a high-mountain outflow pattern (MAZUR et al., 1980). The average monthly temperature maxima of water in the Danube do not surpass 18 °C. In the course of the present investigations, the highest water temperatures recorded were 22 °C in the Danube and 27 °C in the anabranches. HOLČÍK et al. (1981) reported that the average oxygen and organic amnonia nitrogen concentrations reached respectively 8.9 – 9.2 and 0.66 – 0.81 mg l^{-1} in the Baka arm system. ROTHSCHEIN and HANZLÍKOVÁ (1966) characterized the Danube as beta-mesosaprobic. In the last two decades, industrialization markedly increased as did the size of town agglomerations. This was naturally reflected in the quality of Danube water. TRŽILOVÁ and MIKOŠOVIČOVÁ (1975) found that the river enters Czechoslovak territory heavily polluted. Only thanks to self-cleaning processes and to the inland delta acting as a biological filter, the amount of microbes decreases by 30 %, so that the Danube leaves Czechoslovak territory as beta--mesosaprobic. DVIHALLY (1982) reported that, after having passed the system of anabranches between Bratislava and Gabčíkovo, the absolute primary productivity of the Danube waters increases. In this connection she concluded that the anabranches pay an important role in reducing organic pollution. TOMAJKA (1980) found an oxygen deficiency of Danube water at Gabčíkovo of 1.5 mg l^{-1} as compared to 0.9 mg l^{-1} reported by Rothschein (1976). Especially in autumn, water saturation decreases below 75 % and oxygen deficiency suprasses 3 mg l^{-1}. Annual average values of BOD_5 (3.9 mg l^{-1}) are by 1 mg l^{-1} higher than those reported from the same Danube section by MUCHA et al. (1966) and LIEPOLT (1967). ARDÓ (1974) pointed out that the toxicity of the Danube is increasing. ROTHSCHEIN (1974) reported that the amount of mineral oil products in the Danube at Q_{355} above Bratislava reached 0.36 mg l^{-1} as compared to 0.51 mg l^{-1} below Bratislava. TOMAJKA (1980) found in the Danube at Gabčíkovo an average concentration of petroleum hydrocarbons of 0.09 mg l^{-1} (maximum 0.32 mg l^{-1}); the maximal allowed concentration (0.2 mg l^{-1} was exceeded in 18 % of cases during the 4-year period of observation. Petroleum hydrocarbons significantly lower primary productivity and increase BOD_5 values.

Mayflies and stoneflies were studied at the localities given in Fig. 1 and Table 1.

Table 1

Some characteristics of the localities examined

Station n.	(r. km)	DFS	Biotopes	Bottom	Max. temp. wat. C°
1.	Arm at Karlova Ves (1873)	7868	II	G, C	22,0
2.	Danube (1871)	7868	Ia	St, G	21,0
3.	Danube (1863)	7868	Ia	St	19,8
4.	Danube (1858)	7968	Ib	G, Sa	21,5
5.	Rusovce arm (1857)	7968	III	C, G	25,7
6.	Danube (1854)	7969	Ib	G, Sa	22,1
7.	Hamuliakovo arm (1851)	7969	IV	C, G	24,2
8.	Šamorín arm (1843)	7969	III	G, C	25,7
9.	Danube (1843)	8070	Ia	St	20,2
10.	Bodíky arm (1830)	8070	IV	C, G	26,1
11.	Arm at Trstená (1825)	8070	V	C	26,8
12.	Baka arm (1824)	8070	III	C, Sa	24,8
13.	Arm at Dekan	8171	V	C	27,0
14.	Irrigation channel at Gabčíkovo	8171	VI	G	17,5
15.	Danube (1818)	8171	Ia	St	19,4
16.	Danube (1810)	8171	Ia	St	21,8

Ia – regulated Danube
Ib – unregulated Danube
II – swiftly running arms
III – slowly running arms
IV – intermittent running arms
V – backwaters
VI – irrigation channels

DFS – Datbank of the fauna of Slovakia
ST – stones
Sa – sand
C – clay
G – gravel

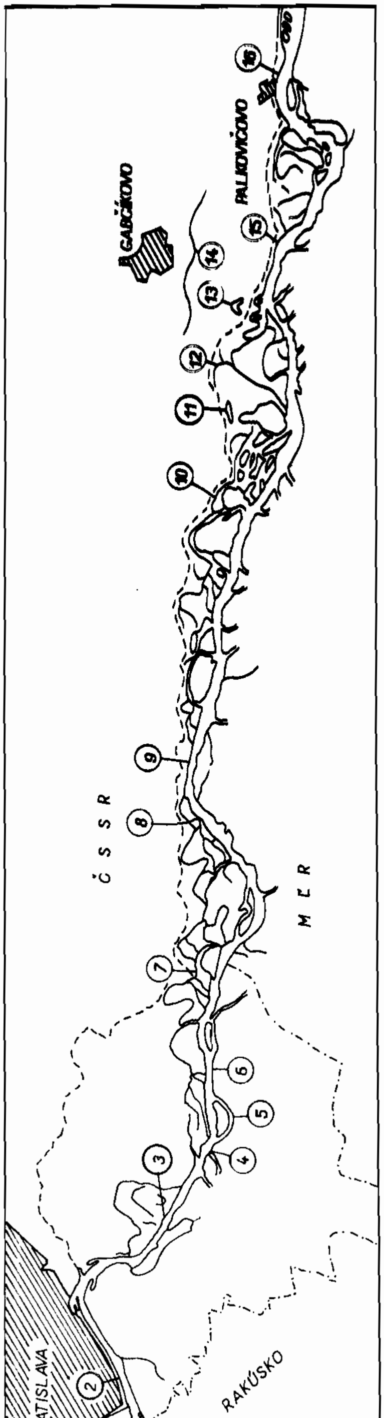

Fig. 1. Danube in the region from Bratislava to Palkovičovo

Materials and Methods

In the period from 1981 to 1984, macrozoobenthos was collected by a ring net (mesh size 0.5 mm) from the littoral zone of the Danube and its anabranches at 16 localities. The biotopes were regularly examined in February, April, May, June, July, September and December. The materials were fixed with 4 % formmalin and selected under a low power binocular microscope. Water temperature was measured regularly. Dominance of individual species was evaluated according to KRNO (1984). In the last year of observation, the whole macrozoobenthos (with the exception of Oligochaeta and Chironomidae) was identified so as to make possible the determination of the index of saprobity.

Results

In the area under study, 20 mayfly species *(Ephemeroptera)* and 3 stonefly species *(Plecoptera)* were detected (Fig. 2). A survey of mayfly and stonefly species hitherto observed in the Danube, its anabranches and intermittent water is presented in Table 2.

Ephemroptera

Siphlonuridae. 1. *Siphlonurus aestivalis* (EATON) – 9 larvae; most frequent in the spring in a backwater among aquatic vegetation.

Baetidae. 2. *Baetis fuscatus* (LINNAEUS) – 624 larvae; from the spring to the autumn the most frequent mayfly in the Danube and swiftly running arms. 3. *Baetis niger* (LINNAEUS) – 6 larvae; vary rare in the Danube and its anabranches. 4. *Baetis vardarensis* IKONOMOV – 9 larvae; new, previously unreported species from the Czechoslovak section of the Danube; this rheophilic species is bound exclusively to the main stream of the river. 5. *Baetis vernus* (CURTIS) – 52 larvae; belongs to the dominant mayfly species in irrigation channels of Žitný ostrov. 6. *Centroptilum luteolum* (MÜLLER) – 12 larvae; a rather in frequent species in the Danube and slowly running arms. 7. *Cloeon dipterum* (LINNAEUS) – 288 larvae; an eudominant stagnicolous species of Danube anabranches all the year round.

Heptageniidae. 8. *Ecdyonurus aurantiacus* (BURMEISTER) – 22 larvae; in the past, probably mixed up with *E. fluminum* PICT. (BRTEK,1951). *E. aurantiacus* prefers original gravel and sand benches of the Danube's littoral zone to the regulated banks. 9. *Heptagenia coerulans* ROSTOCK – 15 larvae; as distinct from other species of the genus *Heptagenia, H. coerulans* prefers original gravel and sand benches of the Danube's littoral zone to the regulated banks. 10. *Heptagenia flava* ROSTOCK – 371 larvae; belongs to characteristic dominant mayfly species of the main stream; it prefers especially regulated banks (stones) where it is eudominant. 11. *Heptagenia sulphurea* (MÜLLER) – 28 larvae; occurring regularly along with *H. flava.*

Ephemerellidae. 12. *Ephemerella ignita* (PODA) – 421 larvae; this euryoe-

Table 2
Mayflies (*Ephomeroptera*) and stoneflies (*Plecoptera*) of the Czechoslovak section of Danube (Bratislava-Palkovičovo), its anabranches and intermittent waters

Ephemeroptera:	Danube	Anabranches, intermittent waters
Siphlonurus aestivalis (ETN.)	3	4,6
Siphlonurus lacustris (ETN.)		1,4
Siphlonurus lineatus (ETN.)		6
Baetis rhodani (PICT.)		4
Baetis fuscatus (L.)	6	4
Centroptilum luteolum (MÜLL.)		4
Cloenon dipterum (L.)		1,3,4,6
Cloeon simile ETN.	3,6	
Procloeon bifidum BGTSS.		4
Rhithrogena alpestris ETN.	6	
Rhithrogena hybrida ETN.		4
Heptagenia coerulana ROST.	6	
Heptagenia flava ROST.	6,9	
Heptagenia fuscogrisea (RETZ.)	3,6	
Heptagenia sulphurea (MÜLL.)	1,3,6,9	10
Ecdyonurus aurantiacus (BURM.)		4
Ecdyonurus venosus (FABR.)	3,5,9	4
Ephemetella ignita (PODA.)	5,6,9	4
Ephemerella mucronata BGTSS.		4
Ephemerella notata ETN.	6	
Caenis horaria (L.)		4,6,10
Caenis luctuosa (BURM.)		4
Caenis pseudorivulorum KEFF.		10
Caenis robusta ETN.		3
Paraleptophlebia submarginata (STEP.)		4
Habroleptoides modesta (HAG.)		3
Paligenia longicauda (OLIV.)	6	
Ephemera vulgata L.		4
Potamanthus luteus (L.)	3,6	4
Plecoptera:		
Nemoura cinerea (RETZ.)	3,7	
Protonemura auberti ILL.	3,7	
Leuctra fusca (L.)	2	
Perlodes disper (RAMB.)	8	
Perlodes microcephala (PICT.)	3,5,7,9	
Isoperla difformis (KLAP.)	3,7	7
Isoperla obscura (ZETT.)	2,7	1

1 – BALTHASAR (1936)
2 – BALTHASAR (1938)
3 – BRTEK, ROTHSCHEIN (1964)
4 – LICHARDOVÁ (1958)
6 – LANDA (1969)
7 – RAUŠER (1957)
8 – RAUŠER (1965)
9 – ROTHSCHEIN, HANZLÍKOVÁ (1966)
10 – ŠPORKA (1979)
11 – WINKLER (1957)

cous species lives in the Danube inundation area in most varied types of water; it is most frequent on the original gravel and sand substrate of the Danube, where it represents an eudominant summer mayfly species.

Caenidae. 13. *Caenis horaria* (LINNAEUS) – 21 larvae; rather infrequent in Danube's anabranches. 14. *Caenis luctuosa* (BURMEISTER) – 39 larvae; regularly occurring with, though less frequrntly than, *C. macrura.* 15. *Caenis macrura* STEPHENS – 96 larvae; an eudominant species of slowly running arms. 16. *Caenis pseudorivolurum* KEFFERMÜLLER – 72 larvae; as distinct from the preceding *Caenis species,* this one prefers Danube's main stream. 17. *Caenis robusta* EATON – 19 larvae; a characteristic species of backwaters.

Ephemeridae. 18. *Ephemera vulgata* LINNAEUS – two larvae on clay substrate of an intermittent arm.

Palingeniidae. 19. *Palingenia longicauda* (OLIVIER) – 4 larvae; in the 19th century, this species was common in lowland rivers in Central Europe (SOLDÁN, 1978). LANDA (1969) reported that it disappeared from the western part of the Czechoslovak section of the Danube and that it occurs in it only at Komárno. According to my observations, *P. longicauda occurs* rarely in the Danube at Bratislava and adjacent swiftly running arms.

Potamanthidae. 20. *Potamanthus luteus* (LINNAEUS) – 4 larvae. BRTEK and ROTHSCHEIN (1964) reported this species as very freguent in the main stream of the Danube. At present it became very rare both in the main stream and in the adjacent anabranches.

Plecoptera

Nemouridae. 1. *Nemurella picteti KLAPÁLEK.* Only a single larva was collected during high water-level of the Danube. Probably an alochthonous species, washed down from Danube's tributaries situated at higher altitudes.

Leuctridae. 2. *Leuctra fusca* (LINNAEUS) – 6 larvae; at present so far the only autochthonous stonefly species in the Danube and its anabranches. 3. *Leuctra inermis* KEMPNY – only a single larva was collected during high water-level of the Danube. Probably an alochthonous species washed down from alpine tributaries.

Discussion

Based onb the slope, temperature and ichthyological characteristics, HOLČÍKet al. (1981) considered the Czechoslovak section of the Danube to represent a transition between the submountain and lowland zone. Accordfing to mayfly taxocenosis, in which *Heptagenia flava, Baetis fuscatus, Ephemerella ignita* and *Caenis pseudorivolorum* are the dominant species, the Czechoslovak section of the Danube can be classified as epipotamal (SOWA, 1975, 1980).

According to the mayfly taxocenoses in the area under study (Fig. 2), swiftly running and intermittent arms form a kind of transition between the Danube and slowly running arms or else slowly running arms and backwaters.

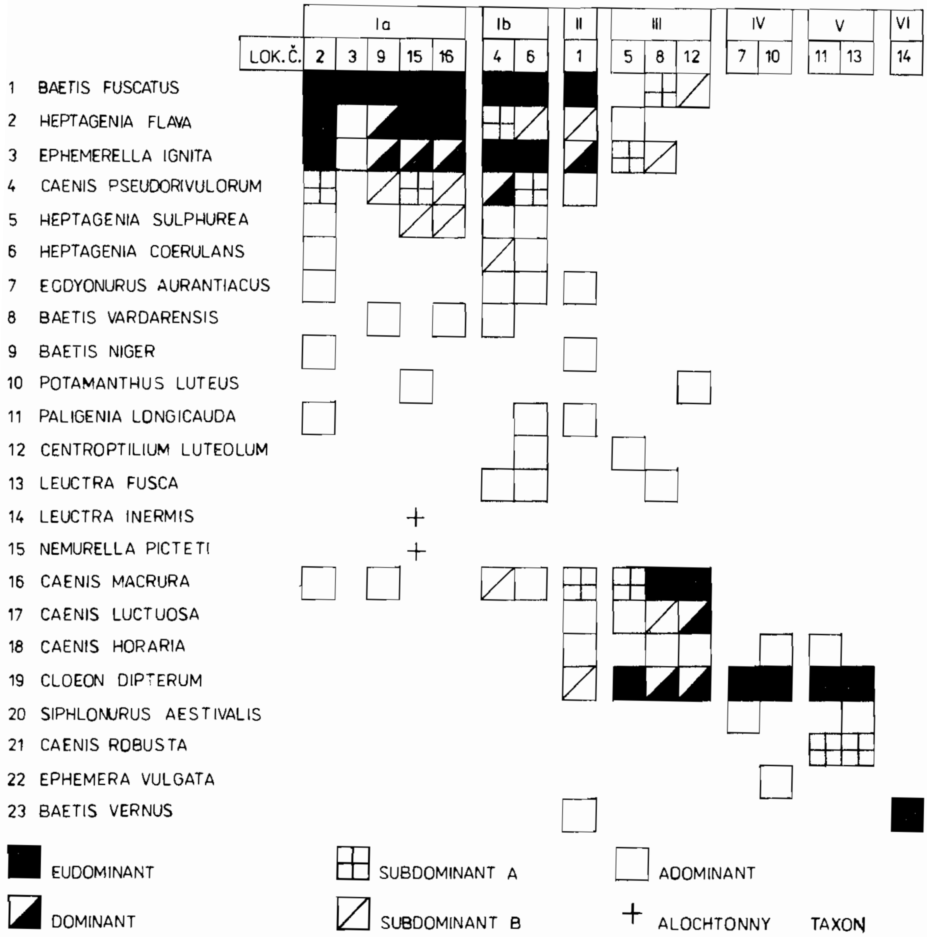

Fig. 2. Structure of mayfly (Ephemeroptera) and stonefly (Plecoptera) communities in the Danube and its anabranches

Ia – regulated Danube river bed
Ib – original Danube river bed
II – swiftly running arm
III – slowly running arm
IV – intermittent arm
V – backwater
VI – irrigation channel

ROTHSCHEIN and HANZLÍKOVÁ (1966) found that in the period from 1950 to 1962 the composition of benthic fauna of the Danube remained practically unchanged. But, as shown in Table 2, a marked pauperization of the original fauna took place in the last decades. In addition to other mayfly species I did no more encounter such previously common species like Baetis rhodani and

Ecdyonurus venosus which prefer purer water. As to the latter taxon, probably a species of the group *E. venosus,* namely *Ecdyonurus macani* THOMAS et SOWA involved; this occurs regularly in the epipotamal of Central European rivers (PUTHZ, 1978). The most marked is the almost total disappearance of the species *Potamanthus luteus,* in the past one of the componest mayflies of the Danube. At present, species with a saprobity index of 2.0 – 2.2 prevail in the Danube (RUSSEV, 1979, SLÁDEČEK et al., 1981). The degradation of the original Danube's stonefly taxocenose was even more marked. In spite of that presumably neither in the past did stoneflies represent an important component of macrozoobenthos, *Isoperla obscura* and *Isogenus nubecula* belonged to common species of the benthic fauna of the whole Czechoslovak section of the Danube (RAUŠER, 1957; BRTEK, ROTHSCHEIN, 1964). Also other species like *Nemoura cinerea* and *Perlodes microcephala* occurred in the Danube regularly, though in lower numbers. KITTLEL (1976) observed that lowland stonefly species occur regularly in the beta-mesosaprobic section of the river Pilica, but that they rapidly disappeared after transition to alpha-mesosaprobity. At present, in the Danube's macrozoobenthos there prevail taxa with low requirements for water purity like, e.g., *Dugesia lugubris, Erpobdella octoculata, Bithynia tentaculata, Lymnea peregra, Pisidium* sp. div., *Sphaerium rivicola, Asellus aquaticus, Dikerogammarus villosus, Jaera sarsi* and *Hydropsyche contubernalis.* The index of saprobity at individual Danube profiles was as follows (according to ZELINKA, 1978): Bratislava – PKO 2.2, Rusovce 2.2, Čuňovo 2.2, Vlčie Hrdlo 2.4, Hrušov 2.3, Gabčíkovo 2.3 and Palkovičovo 2.2. All these facts indicate that the originally typically beta-mesosaprobic Danube is at present at a transition to alpha-mesosaprobity. Similar conclusions were reached by CHANTARAMONGOL (1983) based on an analysis of Trichoptera taxocenoses in the Danube at Voröce. According to this author, an eudominant incidence of Hydropsyche contubernalis is characteristic of Danube waters that had reached such a degree of pollution. This trichopteran species belongs to the most resistant taxa of large rivers in Central Europe, while other species occur very rarely in such environment.

In connection with the construction of the Danube barrage system it can be presumed that disapperance of the inland delta will be followed by a marked decrease in the amount of organic detritus eluted from the river's anabranches at high water-levels. This will lead to a reduced incidence of filtrators *(Bivalvia, Trichoptera),* shredders of coarswe detritus *(Isopoda, Amphipoda)* and collectors of fine detritus *(Oligochaeta, Ephemeroptera, Chironomidae).* On the other hand, overreproduction of periphyton scrapers *(Gastropoda, Ephemeroptera)* can be anticipated. In the Hrušov barrage this will apply to *Oligochaeta* and *Chironomidae.*

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Výskum podeniek *(Ephemeroptera)* a pošvatiek *(Plecoptera)* Dunaja v oblasti vodného diela pri Gabčíkove

I. KRNO

Súhrn

V práci sa sledovala štruktúra taxocenóz podeniek *(Ephemeroptera)* a pošvatiek *(Plecoptera)* Dunaja a jeho priľahlých ramien (prietočných, periodicky prietočných a mŕtvych). Zaznamenalo sa 20 druhov podeniek a 3 druhy pošvatiek. V porovnaní s prácami iných autorov sa zaznamenalo, najmä u pošvatiek (z 8 známych druhov sa zaznamenal len jeden pôvodný autochtónny druh *Leuctra fusca*), výrazný pokles druhov. U podeniek prevládajú druhy, ktorých sapróbny index je od 2,0 do 2,2. Pričom sapróbny index jednotlivých profilov Dunaja kolísal od 2,2 – 2,4. Tieto fakty signalizujú, že pôvodne beta-mezosapróbny Dunaj v súčasnosti postupne prechádza do alfa-mezosaprobity.

Изучепие подёнок *(Ephemeroptera)* и веснянок *(Plecoptera)* Дуная в обалсти плотины около Габчиково

И. КРНО

Резюме

В работе нами исследована структура таксоценозов подёнок *(Ephemeroptera)* и веснянок *(Plecoptera)* Дуная и его прилегающих рукавов (проточных, периодически проточных и мёртвых). Обнаружено 20 видов подёнок и 3 вида веснянок. В сравнении с исследованиями других авторов нам удалось наблюдать, особенно у веснянок (между 8 известными видами мы обнаружили только 1 аутохтонный вид *Leuctra fusca* (выразительное понижение видов). У подёнок преобладают виды, сапробный индекс отдельных регионов Дуная колеблитця оф 2,2 – 2,4. Эти факты сигнализируют, что основной бета-ммзосапробный Дунай в настоящее время постепенно переходит в альфа-мезосапробный.