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The Significance of Mayflies (Ephemeroptera, Insecta) as Structural Constituents of Benthic Zoocenoses of the Maritsa River

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The hydrobiological and saprobiological characteristics of the Maritsa river were determined 1955 through 1964 (Р у с е в, 1966), 1965-1966 (Р у с е в, 1967), May, June, November 1976 and May, June, October 1977 (У з у н о в, et al., 1981; Р у с е в et al., 1981). They are indicative of the compositional and structural alterations in zoocenoses over the recent 22 years as a consequence of the increasing saprobic, toxic and inert pollution. The widely distributed and abundant mayfly larvae present in all parts of the river give a good idea of these alterations because they are well studied bioindicators with fixed saprobic valencies and indicative weights as suggested by Z e l i n k a and M a r v a n (1961), R u s s e v (1979) and J a n e v a (1979).

The data on the distribution of mayflies from Raduil to Kapitan Andreevo are used here to point out their significance in structures of zoocenoses affected by pollution and by some other ecological factors as well.

We are following the procedures of Z e l i n k a and M a r v a n (1961) using our data on the corresponding steno- and euribiotic mayflies from the Maritsa river.

We are considering the species with indicative weights of 5 or 4 (after S l a d e č e k, 1964) as perfect or very good bioindicators, those with 3 — as good, and those with 1 and 2 — as poor.

By the method of D e V r i e s (1937) we found out the frequency of occurrence *(pF)* and domination frequency *(DF)* using the equations:

$$pF=(m/n).100,$$

where m — number of samples with the species present; n — total number of samples

$$DF=[(d+cd)/n].100,$$

where cd — codominant; d — dominant.

The domination index was found by the modified method of Kozhova (К о ж о в а, 1970) and Naidenov (Н а й д е н о в, 1981), using the equation

$$Dt=(DF/pF).100.$$

Mayfly larvae in the Maritsa river amounted to 51 species belonging to 18 genera and 11 families (6 larvae with uncompleted specific determination) during the period of 1955 through 1966 while in 1976/77 these were 56 species belonging to 16 genera and 9 families respectively (10 larvae with uncompleted specific determination). The increased number of species during the second period is partly due to more detailed studies on genus *Baetis* (after the revision of Müller-Liebenau, 1969), as well as to the incorporation of some species of genus *Ecdyonurus,* undetermined previously. Nevertheless, because of deteriorating living conditions, some species such as *Isonychia ignota* Walk., *Heptagenia fuscogrisea* Retz., *Ephemerella notata* Eth., *Caenis luctuosa* Burm. (=*Cenis moesta*)[1], *Brachycercus harisella* Curt., *Habrophlebia fusca* Curt., *Ephoron virgo* Oliv., and *Ephemera vulgata* L. have disappeared (Русев et al., 1981).

We feel that *Ecdyonurus picteti* (=*austriacus* Kimm.), *E. subalpinus* (after Landa, 1969), *Rhithrogena semicolorata, R. hybrida* and *Ephemerella mucronata* need further conformation because of confusing taxonomy. *Caenis macrura* (after Macan, 1979) is too euribiotic and its saprobic valencies and indicative weight probably differ from the data published by Zelinka, Marvan (1961) and Sladeček (1973).

Ten (six of genus *Baetis* and one each of *Ecdyonurus, Rhithrogena, Ephemerella* and *Caenis*) of the 56 taxa found during 1976-1977 differed by some features from the closely related species and for this reason no precise specific determination was possible. They were not of importance though, because they were found in few cases and in minute quantities.

The mayfly species composition varies (Узунов, Ковачев, 1981, Table 1) depending on the environmental conditions, geographic and hydrological peculiarities of the upper, middle and lower courses of the river, and various pollution sources (Русев et al., 1981, Figs. 2-4).

No mayfly larvae were found in 48 of the total of 190 samples of benthic invertebrates, collected in various seasons of 1976 and 1977, mostly because of deteriorating polysaprobic and poly-α-mesosaprobic conditions (41 samples) and inadequate substrate (7 samples).

Baetis vernus was the most widely distributed and relatively abundant mayfly from Dolna Banya all the way to Kap. Andreevo. The frequency of occurrence was 46.31 and the frequency of domination — 14.74. In 7 cases it was dominating in the lithorheophilic and phytorheophilic zoocenoses and in 21 cases it was a subdominant in these plus the pelo- and psammorheophilic ones (Table 1).

Besides *Baetis vernus,* the most significant mayflies in the biocenoses were *Ephemerella ignita, Heptagenia flava, Caenis macrura* and *Baetis rhodani,* with occurrence frequencies above 25% and domination frequencies above 3.

Another 16 species (listed in the beginning of Table 1) were dominating too, but in a limited number of cases.

The domination index, obtained by the combination of the occurrence and the domination frequencies, reveals the significance of various species of mayflies in the biocenoses even in cases when they are not frequently and widely distributed. For example, *Oligoneuriella mikulskii* present is summer only, was established five times but in two cases it was dominating, and in one — co-dominating. Its large competitive capability is exhibited by the high domination index — 59.70. *Ephemerella mucronata* was in similar position (28.53).

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[1] The synonym of species is according to Puthz (1978).

Table 1

Some Ecological Characteristics of Species of Order Ephemeroptera from the Maritsa River

Species	*n*	*d*	*kd*	*pF*	*DF*	*DT*	*S*	*G*	Biocenosis
Baetis vernus Curt.	88	7	21	46.31	14.74	31.83	x-α	2	ph, l, pl, ps
B. rhodani (Pict.)	45	3	17	23.68	10.53	44.47	x-α	1	l, ph, pl, ps
Heptagenia flava Rost.	54	2	11	28.42	6.84	24.07	o-β-α	3	l, ph, pl, ps
Ephemerella ignita (Poda)	55	3	7	28.95	5.26	18.17	o-α	1	ph, l, pl, ps
Caenis macrura Steph.	49	2	4	25.79	3.16	12.25	β-α	2	l, ph, pl, ps
Baetis alpinus (Pict.)	12	3	2	6.32	2.63	41.64	x-β	4	l, ph, pl
B. buceratus Etn.	23	1	2	12.10	1.58	13.05	o-α		l, ph, pl, ps
Potamanthus luteus (L.)	11	—	3	5.79	1.58	27.29	β-α	3	l, ph, pl
Oligoneuriella mikulskii Sowa	5	2	1	2.63	1.57	59.70	β	3	l, ph
Baetis atrebatinus Etn.	17	—	2	8.95	1.05	11.73	β-α		l, ph, pl, ps
Rhithrogena semicolorata (Curt.)	12	2	—	6.32	1.05	16.61	x-β	4	l
Ephemerella mucronata Bgtss.	7	1	1	3.68	1.05	28.53	x-β		l, ps
Baetis melanonyx Pict.	11	—	1	5.79	0.53	9.15	x-β-α	2	l, ph
Ephemera danica Müll.	10	—	1	5.26	0.52	9.88	o-α	1	ps, pl, l
Baetis muticus L.	8	—	1	4.21	0.52	12.35	x-β-α	2	l, ph
B. scambus Etn.	8	—	1	4.21	0.52	12.35	β-α	1	l, ph, pl
B. tricolor Tshern.	16	—	—	8.42	—	—	β-(β-α)	5	l, ph, pl, ps
Centroptilum pennulatum Etn.	14	—	—	7.37	—	—	β-α		l, ph, pl
Baetis fuscatus L.	11	—	—	6.32	—	—	x-α	4	l, ph, pl
Ecdyonurus venosus (Fabr.)	8	—	—	4.21	—	—	x-β	1	l
Epeorus sylvicola Pict.	7	—	—	3.68	—	—	x-β	2	l
Ecdyonurus subalpinus Klap.	6	—	—	3.16	—	—	x-o		l
Siphlonurus aestivalis (Etn.)	6	—	—	3.16	—	—	β-α		ph, l, pl
Ecdyonurus picteti (Meyer-Dür.)	6	—	—	3.16	—	—	x-β	4	l
Habroleptoides modesta (Hagen.)	4	—	—	2.10	—	—	x-β	1	ph, l

Paraleptophlebia submarginata (Steph .)	4	—	—	2.10	—	—	o-α	3	l, ph, pl
Cloeon dipterum (L.)	4	—	—	2.10	—	—	β-(β-α)	2	ph
Baetis macani Kimm.	3	—	—	1.58	—	—	β-α		pl, ph
Cloeon simile Et n.	3	—	—	1.58	—	—	β		ph
Baetis gemellus Etn.	2	—	—	1.05	—	—	β	4	l, ph
Ecdyonurus insignis (Etn.)	2	—	—	1.05	—	—	β	3	l
paraleptophlebia werneri Ulmer	2	—	—	1.05	—	—	x		l, ph
Habrophlebia lauta Etn.	2	—	—	1.05	—	—	β	1	l
Caenis robusta Etn.	2	—	—	1.05	—	—	α		ph
Centroptilum luteolum (Müll.)	2	—	—	1.05	—	—	β	3	ph
Baetis pavidus Grandi	1	—	—	0.52	—	—	β	5	ph
B. trachaeatus Keff.&Machel	1	—	—	0.52	—	—	β		ph
Ecdyonurus dispar (Curt.)	1	—	—	0.52	—	—	o	3	l
Rhithrogena hybrida Etn.	1	—	—	0.52	—	—	x	5	l
Ephemerella mesoleuca (Brauer)	1	—	—	0.52	—	—	β	5	ph
Ecdyonurus quadrilineatus (Landa)	1	—	—	0.52	—	—	β		l
Heptagenia sulphurea (Müll.)	1	—	—	0.52	—	—	β	3	l
H. coerulans Rost.	1	—	—	0.52	—	—	β	4	l
Caenis robusta Etn.	1	—	—	0.52	—	—	α		ph
C. horaria (L.)	1	—	—	0.52	—	—	β		ph
Epeorus alpicola Etn.	1	—	—	0.52	—	—	x	5	l

Explanations. *S* — indication of saprobity; *G* — indicative weight; x — xenosaprobity; o — oligosaprobity; o-β — oligo-beta-mesosaprobity; β — beta-mesosaprobity; β-α — beta-alpha-mesosaprobity; α — alpha-mesosaprobity; l — lithorheophilic; ph —phytorheophilic; pl — pelorheophilic; ps — psammorheophilic.

The domination and co-domination of mayflies in various zoocenoses of the Maritsa river show the significance and the capability of these insects to withstand and win the competition of other benthic invertebrates. Our analyses revealed that various mayflies were dominating in 14.21% and co-dominating in 41.05% of the samples from different zoocenoses.

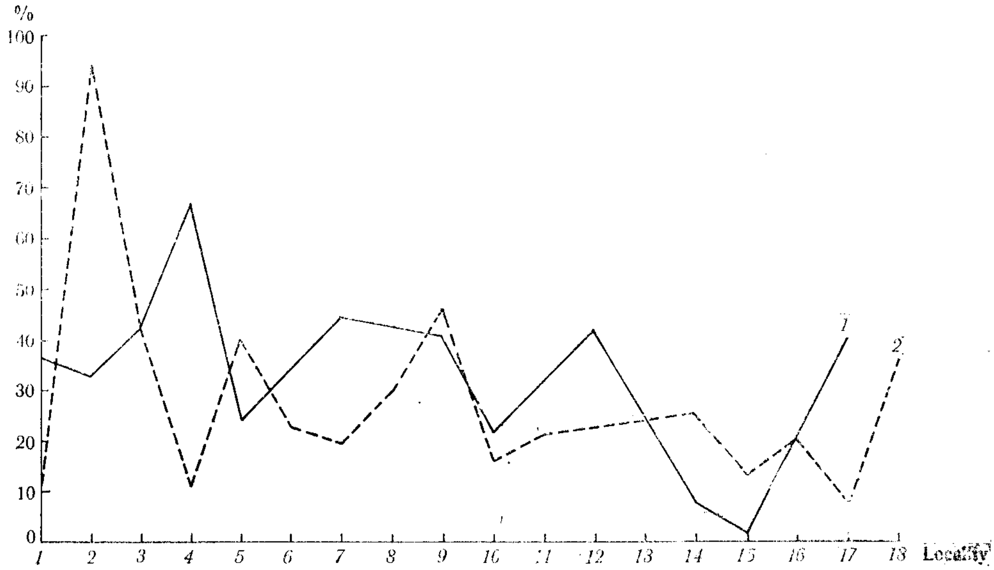

Fig. 1. *Ephemeroptera* average percentage in litho- (1) and phytorheophylic *(2)* zoocenoses structure

The cenotic distribution of mayfly domination was as follows: 66.67% — in lithorheophilic, 29.63% — in phytorheophilic, and 3.7% only — in psamorheophilic zoocenoses. The co-domination distribution was 58.67%, 32.00% and 9.33%, respectively (the latter including the pelorheophilic zoocenosis). This is clear evidence that mayflies are most abundant and significant in litho- and phytorheophilic zoocenoses.

The individual-per-sample percentage shows even better the mayflies' significance in the structures of various zoocenoses. The 1976-1977 data indicate that they accounted for 13.44% of the numerical abundance of the macrozoobenthos of all zoocenoses. In litho- and phytorheophilic zoocenoses mayflies account for over 1/4 (27.95%) of the numerical abundance of all benthic groups.

The mayflies' significance varies depending on the ecological factors such as: flow rate, substrate type, temperature, saprobity, inert and toxic pollution, etc.

The substrate type is of importance for avoiding the effect of high flow rate and for the nutrition of rheobionts, including that of mayflies. The effect of the substrate of the Maritsa river on the structure of macrozoobenthic communities was discussed by Uzunov and Kovachev (Узунов, Ковачев, 1981).

Mayflies have more competitors in the phytorheophilic zoocenosis inhabiting partially submerged land vegetation, compared to the lithorheophilic one, where they account for a higher percentage (Fig. 1). On the other hand, euribiotic species of mayflies that find favourable conditions in both zooce-

Table 2

Percentage of Mayflies within Zoocenoses along the Maritsa River

№	Locality	Year	May (1976, 1977)				July (1976) August (1977)				November (1976), October (1977)			
			l	ph	ps	pl	l	ph	ps	pl	l	ph	ps	pl
1	before Raduil	1976	48.15			4.76	40.69			2.94	19.89		*	
		1977	52.03	11.76			18.02				39.53			
2	after D. Banya	1976	56.39			5.69	4.19				26.37			17.86
		1977	37.66	93.85	8.36		40.00				32.39			
3	after Kostenets	1976	93.89			0.28	16.62		*		32.14			
		1977	17.85				18.52				72.73	41.67		*
4	after Belovo	1976	92.31			29.03		13.95	66.67			*		
		1977	7.29	18.04			100.0							
5	after Septemvri	1976		9.09				26.56				61.90		
		1977	23.44	100.00					*			6.09	8.70	
6	after Pazardžik	1976		*		*		5.27		*		25.00		*
		1977		49.39		2.04		6.25	*			49.20		*
7	at Al. Stambolijski	1976		29.54	7.14	20.07		4.34		0.49	62.50	17.69		
		1977	70.0	5.02				58.62			*	0.60		3.87
8	before Plovdiv	1976		24.61		*		38.28		1.89		33.12		8.11
		1977		21.95		6.67		26.95		0.32		33.33	5.38	
9	after Plovdiv	1976	50.71			*	31.04			*		29.17		1.78
		1977		49.36		1.29		77.78				28.57		*
10	at Popovitsa	1976	*			*	43.32			12.50		0.35	*	*
		1977		33.33		*			29.49			14.19		*
11	at Parvomaj	1976		54.28		*		38.85		*		5.36		*
		1977		18.40		0.96		7.22		24.00		2.78		1.06
12	before Dimitrovgrad	1976	40.91			*		55.75		*		16.98		14.28
		1977		31.55		16.67		3.77		*		6.92		*
13	after Dimitrovgrad	1976				*				*				6.25
		1977								11.35				4.76
14	at Simeonovgrad	1976				*		40.91		*		25.81		*
		1977	5.64	35.71		7.41	2.35	5.74		*	13.64	19.10	*	*
15	at Preslavets	1976	1.57	7.14		0.60		20.83		*		6.88		
		1977		10.84		0.16		5.71		*		28.57		*
16	at Ljubimets	1976		7.72		11.54		37.44		*		20.69		*
		1977		23.67		0.16				1.49		11.02		5.77
17	at Svilengrad	1976		1.03		*	35.33			1.30				
		1977	44.87	19.23		*						0.82		1.92
18	after Kap. Andreevo	1976		9.12		*		60.00		*				
		1977		61.54		*						13.04		*

* Cases with no mayflies found are asterisked.

noses are more abundant on the vegetation when the gravel subtrate is limited or not available.

The seasonal fluctuation of the specific and numerical mayfly composition depend on various factors with the temperature and water amount being of

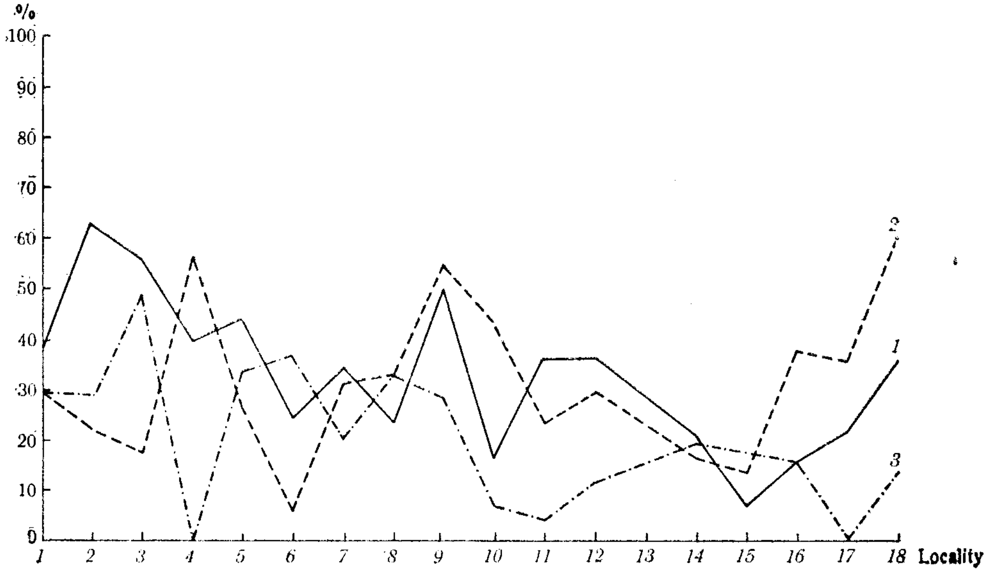

Fig. 2. *Ephemeroptera* average percentage in litho- and phytorheophylic zoocenoses structure in spring *(1)*, summer *(2)* and autumn *(3)* 1976 and 1977

primary importance. The fall mayfly percentage is generally lower than the spring and summer ones in the two zoocenoses along the river (Fig. 2). We assume that the reason for this is the reduced water amount and hence the increased pollution. Another reason is the completed metamorphosis of a large number of species during this time of the year.

The uneven participation of mayflies in various zoocenoses along the river (Figs. 1, 2) is due to varying pressure from competitive species as affected by varying ecological factors.

Few mayflies adapt towards relatively permanent residence in pelo- and psamorheophilic zoocenoses. *Ephemera danica* is the sole psamobiont inhabiting the sand substrate mixed with silt and detrittus along the upper and middle courses of the river. The 16 species found in the pelo- and 9 — in the psamorheophilic zoocenoses (Table 1) are either euribiotic (in terms of various substrates) or are carried by the stream and incidentally found there. For this reason mayflies have a very limited participation in the structures of these two zoocenoses (Table 1). Just under Belovo only they reached 66.67% on sandy bottom in July 1976 and 29.03% on silty bottom in May 1976. The three individuals are likely to have been carried incidentally by the stream with the toxic pollution making other benthic species extinct.

Saprobic conditions considerably affect the significance of mayflies in structures of benthic zoocenoses. The data on litho- and phytorheophilic zoocenoses offering the best living conditions to mayflies are reported in Table 2. The xeno-oligosaprobic conditions from Raduil (location 1) upstream do not favour any of the benthic groups because of stable saprobic status and limited amount of nutritive substances. Here mayflies account for 24.07% of the total numerical abundance. At Dolna Banya (S_R 56.82) this percentage is the highest (63.34%) due to optimal conditions, sufficient amount of dissolved and readily available organic and inorganic nutritive substances and high competitiveness of various mayflies.

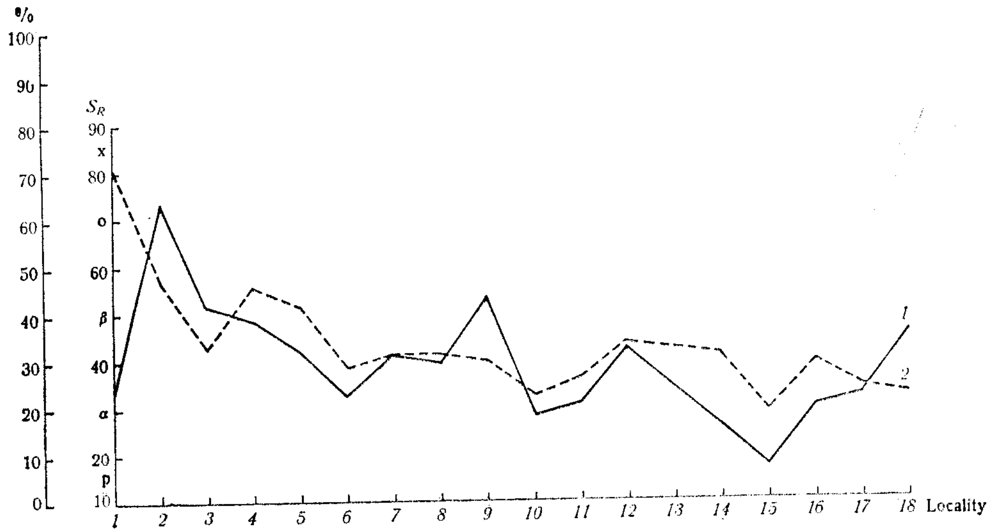

Fig. 3. *Ephemeroptera* average percentage litho- and phytorheophylic zoocenoses (taken together) structure *(1)* and depending on river average saprobal conditions *(2)*

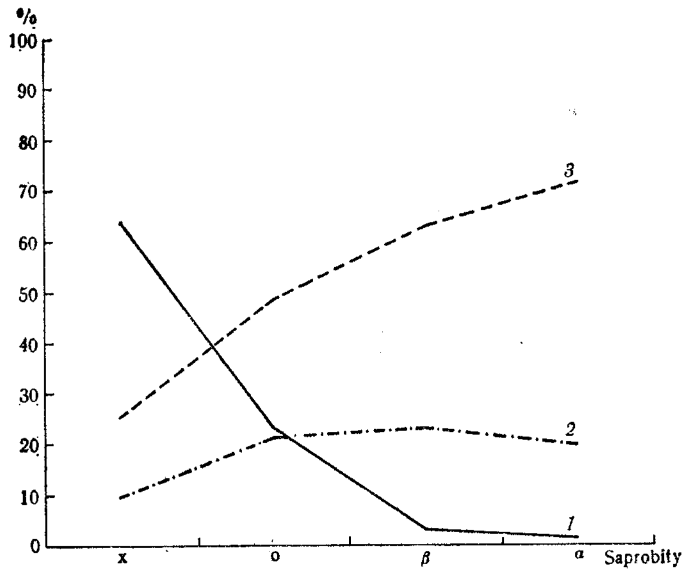

Fig. 4. Relation between *Ephemeroptera* steno- and euribiontic bio-indicators in different saprobal lengths of the river

1 — "perfect" and "very good" bio-indicators; *2* — "good" bio-indicators; *3* — "poor" bio-indicators

Under declining β-mesosaprobic conditions (S_R around 40) mayflies' participation is around and//or under 40%. Under Kostenets it is 41.82%, at Septemvri — 32.08%, under Stamboliiski — 31.74%, above Plovdiv — 29.81%, above Dimitrovgrad — 32.38%, etc.

Under improved α-mesosaprobic conditions (S_R above 34) the mayflies' share is reduced to about 20%. Under Pazarjik (S_R 38.15) it is 22.52% and at Svilengrad — 23.56% of the total number of individuals of all benthic groups.

Under stable or declining α-mesosaprobity (S_R around or below 30) fewer mayfly species withstand the deteriorating living conditions and their abundance is reduced, too. At Preslavets village their participation is only 7.45%.

Although the S_R value was 29.29 (stable α-mesosaprobity) no mayflies were found under Dimitrovgrad, mostly because of impaired oxygen intake by the sensitive tracheal branchiae caused by suspended coal dust as well as by the lack of adequate substrate.

On the basis of studies on saprobic conditions in the Maritsa river by the saprobic valencies technique, largely including mayfly larvae (Р у с е в et al., 1981), a correlation between steno- and euribiotic mayflies was developed as a criterion of these conditions. The stenobionts (perfect and very good bioindicators) account for 63.4% of the total numbers in the cleanest xenosaprobic zones of the river, 22.67% — in olygosaprobic, 2.27% — in β-mesosaprobic and just 1.15% — in α-mesosaprobic zones (Fig. 4). The euribionts (poor bioindicators) showed a reversed trend: 25.4% — in xenosaprobic zones, 48.52% — in oligosaprobic, 62.95% — in β-mesosaprobic, and 71.33% — in α-mesosaprobic zones. Mayflies with indicative weight of "3"— (good bioindicators) accounted for 9.8%, 20.90%, 22.91% and 19.78%, respectively.

The results indicate that almost no mayfly species became stenobionts adapted to more polluted (α-mesosaprobic) zones. Some euribionts only, such as *Baetis rhodani, B. fuscatus, Ephemerella ignita, Potamanthus luteus,* etc. were relatively adapted. In such cases mayflies avoid litho- and prefer phytorheophilic biocenoses (partially submerged land vegetation) because of the additional oxygen originating from this vegetation. It is not sufficient, though to alter the river saprobity as a whole.

Conclusions

Mayflies are of considerable significance for the structure of benthic and particularly of litho- and phytorheophilic zoocenoses of the Maritsa river. They account for over 1/4 of the total numerical abundance of the two zoocenoses. Various ecological factors affect this significance with the gravel substrate providing the best conditions. When gravel is limited or not available, mayflies move in larger numbers to the submerged vegetation, and vice versa. In spring and summer their participation in zoocenoses is larger compared to the autumn.

The Maritza river saprobic conditions strongly affect their competitiveness. Mayflies are most competitive under improved β-mesosaprobic conditions (at S_R 56.82 the corresponding abundance percentage is 63.34%), while under α-mesosaprobic conditions it is around 20%. Clean xeno- and olygosaprobic waters do not favour any benthic group and in this case the average percentage abundance of mayflies is 24.07%.

The increased organic pollution favours eurybiotic mayflies whose percentage is increased at the expense of stenobiotic ones. This phenomenon can be used to develop an additional criterion for the saprobic conditions in rivers.

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Значение представителей отряда Ephemeroptera (Insecta) для формирования структуры зооценозов бентоса реки Марица

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(Р е з ю м е)

В результате сапробиологических исследований р. Марица в участке от с. Радуил до с. Капитан-Андреево в течение трех сезонов 1976 и 1977 гг. установлено 56 таксонов отряда Ephemeroptera (из которых 46 определены до вида). Восемь видов того же отряда, распространенные в р. Марица в период 1955—1966 гг., не были обнаружены в настоящем исследовании, вероятно, вследствие большего загрязнения вод.

Анализ участия отдельных видов поденок в различных биоценозах на базе частоты встречаемости и доминирования, показатель доминирования и диапазон сапробности свидетельствуют об их значении для реки. Некоторые виды являются доминантными в 14,21% проб и кодоминантными в 41,05% проб, взятых из различных зооценозов. Доминантность поденок и их доля в структуре особенно лито- и фитореофильных зооценозов очень велики. В обобщенном виде более 1/4 всей численности представителей этих зооценозов (27,95%) приходится на личинок поденок. В зависимости от различных экологических факторов это значение является бо̀льшим или меньшим. Галечный субстрат создает наилучшие условия для жизни поденок. При его уменьшении в реке поденки населяют в большей мере высшую прибрежную растительность и наоборот. Весной и летом процентное участие поденок в структуре обоих зооценозов большее, чем осенью. Сапробность р. Марица имеет большое значение также для преодоления конкуренции с другими ее обитателями. Наиболее успешно эту конкуренцию поденки превозмогают при повышенной β-мезосапробности, в условиях которой их численность достигает 63,34% всего состава зообентоса, а труднее всего — в α-мезосапробных зонах. В полисапробных водах поденок вообще не установлено. Чистые ксено- или олигосапробные воды не создают условий для выраженного преобладания какой бы то ни было из групп бентоса, причем усредненная численность поденок составляет 24,07% численности тех же зооценозов.

Вычислено соотношение между „отличными" и „очень хорошими" биоиндикаторами (стенобионтными организмами), с одной стороны, и „плохими" биоиндикаторами (эврибионтными организмами) — с другой, в разных сапробных зонах р. Марица. Установлено, что с увеличением органического загрязнения уменьшается процентное участие стенобионтных поденок за счет возрастающей доли эврибионтных.