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NUTRITION OF THE MUDMINNOW (*UMBRA KRAMERI* WALBAUM) IN THE BASIN OF THE ÉR RIVER

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Abstract. The study of nutrition of the mudminnow in the Ér River was performed by counting, determining and measuring the organisms found in the alimentary canal of 260 specimen, which were of different age, sex and were gathered at different date. The results were compared with literature data. It was found that the mud minnow feeds on tiny animals, mainly on the Diptera larvae. No signs of predatory behaviour were observed. It was found that the nutrition of the populations living in different territories differs significantly, and the qualitative and quantitative composition of the food is determined by the distribution of the nutrient organisms in the environment.

Keywords: nutrition, composition of food, fullness index, saturation of the stomach

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Introduction

The mudminnow is an endemic fish species in the basins of the Danube and Nester rivers. It lives in moors and swamps, and due to the reduction of its habitat the population of the mudminnow decreased in all its geographic range. Therefore, Maitland (1991) considered the mudminnow a severely endangered species.

In the literature there are several studies about the nutrition of the mudminnow. Geyer (1940) published his results about the nutrition of the mudminnow of the Balaton region based on the examination of the gut of more than 200 fish. In the material examined by him the nutrient organisms were dominated by tiny crustaceans (Amphipoda, Ostracoda, Isopoda, Copepoda), and the rest was formed by insects (Coleoptera, Ephemeroptera, Chironomidae, Odonata), snails and spiders. He found that smaller individuals were feeding more diversely. The composition of the food of the individuals gathered at different date differed significantly, moreover, this is true for individuals gathered at the same time but at different areas.

By examining the nutrition of the mudminnow populations from the lakes of the flooding areas of the Danube at the Szentendre island, Jászfalusi (1950) mentioned about mosquito larvae (Tendipedidae), tiny crustaceans (*Bosmina*, *Cyclops*), mayfly larvae and tiny bugs. However, he also found vegetal fibres in the intestines of the mudminnows.

Libosvárský and Kux (1958) published detailed nutritional data from Slovakia. They found that the majority of the food of the mudminnow was formed by inferior crustaceans. Mainly Cladocera and Ostracoda species have a major role, while Amphipoda are less important. The insects were found to be of lower importance. The most frequent insect groups were Coleoptera and Diptera, while Ephemeroptera, Odonata and Notonecta species were much less frequent. Libosvárský and Kux (1958) also found Rotatoria, Mollusca and Hirudinea, and their eggs as well, moreover, the statoblasts of Briozoa. They also found that the younger individuals were feeding more diversely compared to the older ones.

More recent data were published by Guti *et al*. (1991) about the nutrition of the mudminnow population of the Ócsa landscape protection area. Seven specimens of 33 had an empty alimentary tract. Here insects were dominant in the food of fish, mainly the larvae of *Velia* sp., followed by bugs. Among Diptera the flies (Muscidae) were dominant and surprisingly only few mosquito larvae (Ceratopogonidae, Chironomidae) were found. Some mayfly and dragonfly larvae have also been found. Surprisingly the crustaceans were represented only by Ostracoda, however, these were relatively frequent. Some molluscs and Hydracarina have also been found. Moreover, in 11 specimen remains of vegetal origin (*Lemna* sp.) were present.

Material and methods

Material used in this study was gathered between 1973 and 1995 using a scratching net. Standard and total length, as well as the weight of the individuals were taken. Age of the individuals was determined based on the annual rings of the scales (Wilhelm 2003).

The alimentary tract of the dissected fish was kept in 4% formaldehyde solution (Hyslop 1980). The alimentary tract was opened in its total length and the content was put on a watch-glass. The components were selected, determined as precisely as possible, than measured and processed after the method of Gyurkó *et al.*(1965, 1967).

Frequency of the nutrient organisms was determined by dividing the occurrence of the individual components by the number of fish. The abundance of the components was determined by dividing the number of the components by the number of the fish. This latter was not possible in the case of vegetal components. Considering the frequency and abundance data, we tried to draw conclusions regarding the preference to nutrient components of the fish species.

Based on the recalculated weight of the food components, the quantitative distribution of the food composition was determined. By comparing the total weight of food found in one specimen to the weight of the individual fish, the fullness index was calculated, that represents the intensity of feeding.

The saturation of the stomach was scored on a scale from 1 to 5, using the method suggested by Hynes (1950). These data were compared to the number of fish. These data also represent the

Table 1. The frequency distribution of the different food items according to sex, season and age

Food components	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2years	3 years	4 years	5 years	6-7 y-s
Oligochaeta	0.054	0.039	0.068	0.036	0.040	0.083	0.013	0.214	0.045	0.077	0.000	0.000	0.000	0.000
Hirudinea	0.012	0.000	0.023	0.000	0.000	0.008	0.027	0.000	0.000	0.011	0.000	0.059	0.100	0.000
Gastropoda	0.004	0.000	0.008	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.143
Phyllopoda	0.027	0.016	0.030	0.107	0.000	0.015	0.013	0.000	0.011	0.033	0.031	0.000	0.000	0.143
Cladocera	0.046	0.039	0.053	0.107	0.080	0.023	0.053	0.000	0.011	0.044	0.125	0.118	0.100	0.000
Ostracoda	0.077	0.070	0.083	0.214	0.000	0.053	0.093	0.071	0.067	0.077	0.156	0.059	0.000	0.000
Amphipoda	0.065	0.031	0.098	0.143	0.000	0.023	0.013	0.071	0.045	0.022	0.125	0.118	0.100	0.429
Ephemeroptera l.	0.119	0.117	0.121	0.107	0.240	0.114	0.093	0.071	0.101	0.110	0.188	0.176	0.100	0.143
Odonata l.	0.027	0.023	0.030	0.107	0.000	0.030	0.000	0.000	0.022	0.011	0.094	0.059	0.000	0.000
Heteroptera	0.031	0.016	0.045	0.036	0.000	0.023	0.053	0.000	0.000	0.033	0.031	0.118	0.100	0.143
Coleoptera l.	0.042	0.039	0.045	0.000	0.080	0.053	0.000	0.214	0.034	0.044	0.031	0.000	0.000	0.000
Coleoptera p.	0.012	0.023	0.000	0.000	0.000	0.023	0.000	0.071	0.011	0.11	0.000	0.000	0.000	0.000
Coleoptera ad.	0.038	0.055	0.023	0.036	0.000	0.068	0.000	0.214	0.034	0.022	0.031	0.059	0.000	0.000
Trichoptera l.	0.058	0.039	0.076	0.036	0.200	0.045	0.040	0.071	0.045	0.044	0.063	0.059	0.100	0.286
Diptera l.	0.808	0.820	0.795	0.750	0.760	0.856	0.760	0.857	0.876	0.802	0.844	0.706	0.500	0.429
Diptera p.	0.196	0.172	0.220	0.143	0.000	0.288	0.120	0.286	0.247	0.143	0.156	0.176	0.100	0.286
Diptera ad.	0.008	0.008	0.008	0.000	0.000	0.015	0.000	0.000	0.022	0.000	0.000	0.000	0.000	0.000
Hymenoptera ad.	0.012	0.016	0.008	0.071	0.000	0.000	0.013	0.000	0.000	0.011	0.063	0.000	0.000	0.000
Araneidae	0.004	0.008	0.000	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.000	0.000
Hydracarina	0.015	0.008	0.023	0.000	0.000	0.030	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000
Invertebrate eggs	0.119	0.117	0.121	0.250	0.040	0.121	0.093	0.143	0.135	0.121	0.063	0.118	0.000	0.143
Scale	0.015	0.016	0.015	0.000	0.040	0.008	0.027	0.000	0.011	0.022	0.031	0.000	0.000	0.000
Algae	0.062	0.039	0.083	0.000	0.000	0.083	0.067	0.071	0.067	0.033	0.125	0.000	0.200	0.000
Plant remain	0.050	0.063	0.038	0.036	0.120	0.053	0.027	0.071	0.045	0.044	0.031	0.176	0.000	0.000
Plant seed	0.050	0.039	0.061	0.000	0.080	0.076	0.013	0.071	0.079	0.033	0.000	0.118	0.000	0.000
Debris	0.688	0.719	0.659	0.679	0.680	0.750	0.587	0.643	0.787	0.681	0.563	0.588	0.500	0.714

intensity of feeding.

The data were calculated for sex, season and age groups as well.

Results

Regarding the number of the food components, altogether 26 components were identified, including worms, snails, inferior crustaceans, insects, spiders, algae, vegetal tissues and seeds, and in addition eggs of invertebrates, fish scales and undeterminable debris. There is little difference between the qualities of food of the two sexes: there were no leeches and snails in case of males and no beetle’s pupae and spiders in case of females. However, the difference between the seasons is much more important. While the spring and autumn food spectra contain the whole menu, the nutrition in summer (11 components) and winter (18 components) is much less diverse. Regarding the different age groups, the most diverse is the menu of the 1, 2 and 3-year-old group, while later feeding gets stabilized and the number of components decreases.

The frequency distribution of the different food components (Table 1.) shows that in all groups the most frequent components are the Diptera larvae and pupae: the most frequent of them are *Chaoborus, Tendipes, Ablabesmyia, Culicoides*. The same frequency is reached only by the debris; a part of this is made of undeterminable animal remains. Among the insects mayfly larvae (*Cloëon, Ephemerella*) are relatively frequent, however, the larvae of dragonflies (*Calopteryx, Agrion*), aquatic bugs (*Corixa, Sigara*) and beetle larvae are much rarer. The occurrence of different inferior crustaceans is surprisingly low (Copepoda: *Cyclops*; Cladocera: *Moina, Bosmina, Daphnia*; Ostracoda; Amphipoda: *Gammarus*). The Oligochaeta (*Tubifex, Nais*) are eaten only by the younger age groups, while snails (young *Viviparus*) are preferred only by the older specimen. The Hymenoptera are represented by ants fallen into the water.

Regarding the abundance of the different food components (Table 2.), a leading role of Diptera larvae and pupae was found here as well, showing that these are consumed not only frequently but also in a large amount. Mayfly larvae and eggs of invertebrates are also consumed abundantly and frequently, while from the inferior crustaceans only the Cladocera, Ostracoda and Copepoda are consumed abundantly but only occasionally.

Table 2. The abundance distribution of the food items according to sex, season and age

Food items	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
Oligochaeta	0.096	0.070	0.122	0.035	0.040	0.015	0.013	0.571	0.101	0.087	0.000	0.000	0.000	0.000
Hirudinea	0.011	0.000	0.022	0.000	0.000	0.007	0.026	0.000	0.000	0.010	0.000	0.058	0.100	0.000
Gastropoda	0.026	0.000	0.053	0.250	0.000	0.000.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Phyllopoda	0.115	0.039	0.075	0.250	0.000	0.015	0.080	0.000	0.011	0.076	0.031	0.000	0.000	0.857
Cladocera	0.246	0.039	0.446	1.785	0.080	0.037	1.400	0.000	0.011	0.560	0.187	0.294	0.100	0.000
Ostracoda	0.223	0.226	0.219	0.857	0.000	0.090	0.293	0.142	0.112	0.168	0.750	0.294	0.000	0.000
Amphipoda	0.173	0.078	0.265	0.285	0.000	0.060	0.386	0.071	0.123	0.021	0.250	0.352	0.200	2.142
Ephemeroptera larvae	0.192	0.187	0.196	0.178	0.520	0.189	0.093	0.142	0.202	0.120	0.281	0.470	0.100	0.142
Odonata larvae	0.111	0.187	0.037	0.857	0.000	0.037	0.000	0.000	0.258	0.021	0.093	0.058	0.000	0.000
Heteroptera	0.103	0.015	0.189	0.107	0.000	0.113	0.120	0.000	0.000	0.043	0.031	0.235	1.200	0.857
Coleoptera larvae	0.069	0.054	0.083	0.071	0.120	0.098	0.000	0.571	0.033	0.054	0.062	0.000	0.000	0.000
Coleoptera pupae	0.011	0.023	0.000	0.000	0.000	0.022	0.000	0.071	0.011	0.010	0.000	0.000	0.000	0.000
Coleoptera adults	0.038	0.054	0.022	0.035	0.000	0.068	0.000	0.218	0.033	0.021	0.0312	0.058	0.000	0.000
Trichoptera larvae	0.076	0.039	0.113	0.035	0.200	0.060	0.080	0.071	0.067	0.043	0.062	0.058	0.100	0.714
Diptera larvae	6.400	5.578	7.196	4.642	5.520	6.666	6.880	5.857	6.752	6.945	7.093	3.117	6.300	0.857
Diptera pupae	0.657	0.414	0.893	0.250	0.000	1.121	0.213	0.857	1.168	0.340	0.428	0.352	0.100	0.285
Diptera adults	0.011	0.007	0.015	0.000	0.000	0.022	0.000	0.000	0.033	0.000	0.000	0.000	0.000	0.000
Hymenoptera adults	0.011	0.015	0.007	0.071	0.000	0.000	0.013	0.000	0.000	0.010	0.062	0.000	0.000	0.000
Araneidae	0.003	0.007	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.058	0.000	0.000
Hydracarina	0.026	0.015	0.037	0.000	0.000	0.053	0.000	0.000	0.033	0.043	0.000	0.000	0.000	0.000
Invertebrate eggs	1.146	1.703	0.606	7.960	0.080	0.265	0.506	0.214	2.460	0.626	0.281	0.411	0.000	1.142
Scales	0.015	0.166	0.015	0.000	0.000	0.007	0.026	0.000	0.011	0.021	0.031	0.000	0.000	0.000

Table 3. Percentage distribution of the recalculated weight of different food components according to sex, season and age

Food items	Total	Males	Females	Seasons				Age						
				Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
Oligochaeta	0.47	0.53	0.44	0.30	0.26	0.86	0.11	1.81	0.67	0.54	0.00	0.00	0.00	0.00
Hirudinea	0.28	0.00	0.46	0.00	0.00	0.09	0.68	0.00	0.00	0.12	0.00	2.40	1.95	0.00
Gastropoda	0.85	0.00	1.37	6.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.67
Phyllopoda	1.15	0.95	1.27	3.29	0.00	0.23	1.71	0.00	0.13	1.32	0.41	0.00	0.00	11.19
Cladocera	2.98	0.74	4.38	15.12	1.28	0.46	1.83	0.00	0.07	6.43	2.45	6.51	1.17	0.00
Ostracoda	1.23	1.52	1.04	3.59	0.00	0.70	1.26	0.80	0.87	1.02	3.26	1.71	0.00	0.00
Amphipoda	4.25	1.58	5.91	4.94	0.00	1.02	8.90	0.40	2.27	0.30	5.30	10.27	4.67	33.58
Ephemeroptera larvae	2.82	3.47	2.42	2.10	11.48	2.74	1.26	2.41	2.67	1.74	4.08	9.93	1.17	1.12
Odonata larvae	0.81	1.47	0.39	4.19	0.00	0.56	0.00	0.00	1.67	0.24	1.09	1.03	0.00	0.00
Heteroptera	2.34	0.32	3.59	1.80	0.00	2.65	2.68	0.00	0.00	0.72	0.82	4.79	18.68	13.43
Coleoptera larvae	1.01	0.95	1.04	0.90	2.30	1.63	0.00	8.85	0.53	0.84	0.82	0.00	0.00	0.00
Coleoptera pupae	0.14	0.37	0.00	0.00	0.00	0.33	0.00	0.40	0.20	0.18	0.00	0.00	0.00	0.00
Coleoptera adults	0.44	0.68	0.29	0.45	0.00	0.88	0.00	2.41	0.40	0.24	0.27	1.37	0.00	0.00
Trichoptera larvae	1.25	0.79	1.53	0.45	3.32	0.93	1.48	1.21	0.93	0.78	0.54	0.68	1.17	8.58
Diptera larvae	61.91	68.84	57.60	37.43	69.64	62.36	68.95	58.75	65.71	69.01	66.44	43.49	63.81	5.22
Diptera pupae	5.72	3.78	6.92	2.25	0.00	10.59	2.34	12.88	9.94	2.94	5.03	3.42	0.78	1.87
Diptera adults	0.08	0.11	0.07	0.00	0.00	0.19	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00
Hymenoptera adults	0.20	0.37	0.10	1.05	0.00	0.00	0.17	0.00	0.00	0.18	0.95	0.00	0.00	0.00
Araneidae	0.04	0.11	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00
Hydracarina	0.16	0.11	0.20	0.00	0.00	0.37	0.00	0.00	0.20	0.30	0.00	0.00	0.00	0.00
Invertebrate eggs	2.62	2.10	2.94	8.83	0.51	1.58	2.00	2.01	2.40	3.54	1.22	4.11	0.00	3.36
Scales	0.08	0.11	0.07	0.00	0.26	0.05	0.11	0.00	0.07	0.12	0.14	0.00	0.00	0.00

The quantitative composition of the food (Table 3.) shows that in the Ér basin the main food of the mud minnow is represented by the larvae (61.91%) and pupae of mosquitoes. As secondary food debris (7.83%), Amphipoda (4.25%), mayfly larvae (2.82%) and eggs (2.62%) are considered. The rest of the animals is only an occasional food source, while the vegetal components are probably only additional nutrients.

There are no significant differences regarding the two sexes. In case of males the dominance of Diptera species and debris is even more pronounced, while the leeches and snails are missing. In case of females the later are present. Moreover, the number of Cladocera, Amphipoda and aquatic bugs is higher.

There are differences in the food composition among different seasons. Although Diptera species are dominant in every season, in spring they represent a much lower amount. Snails are only present during spring (6.29%) (later they probably grow too big for such a small fish species). At this time crustaceans become the most important (Copepoda 3.29%, Cladocera 15.12%, Ostracoda 3.59%, Amphipoda 4.94%), and also the eggs of invertebrates (8.83%). In summer, beside the Diptera larvae, the dominant components are mayfly larvae (11.48%), Trichoptera larvae (3.32%) and beetle larvae (2.29%). In autumn the food is very diverse, the most important components are the Diptera larvae and pupae, and debris. Furtehrmore, mayfly larvae (2.74%) and aquatic bugs (2.65%) represent major components. In winter the nutrition is much less diverse, debris (5.70%) is the most important beside Diptera, completed by Amphipoda (8.90%) and bugs (2.65%).

Composition of the food of the different age groups is very interesting. Oligochaeta worms are consumed only by younger age groups, while leeches are consumed by the older ones. The role of Copepoda and Amphipoda increases with the age and the role of Diptera decreases. Snails are consumed only by the older age groups. The older age groups, however, consume almost no vegetal food. In short, the food of the younger age groups is much more diverse.

The fullness index (Table 4.) shows a more intensive feeding of the females compared to that of males. In spring and autumn, i.e. during preparations for mating and winter, respectively, the intensity of feeding is maximal. In winter the feeding intensity is the lowest, although the mudminnow is feeding during the whole year.

Table 4. The fullness index of different groups

Groups	Total	Sex		Seasons				Age						
		Males	Females	Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
n	260	128	132	28	25	132	75	14	89	91	32	17	10	7
Fullness index	0.078	0.662	0.094	0.135	0.034	0.112	0.017	0.0209	0.094	0.071	0.027	0.061	0.018	0.093

The number of full stomachs of males (Table 5.) is higher than those of females, and regarding the seasons the stomach fullness is higher in winter. This is probably due to the slower digestion. Regarding the age groups, stomach fullness is surprisingly high in case of very young and very old individuals; it is impressively high at two-year old individuals.

Table 5. The number of full stomachs

Groups	Total	Sex		Seasons				Age						
		Males	Females	Spring	Summer	Autumn	Winter	0 year	1 year	2 years	3 years	4 years	5 years	6-7 years
n	260	128	132	28	25	132	75	14	89	91	32	17	10	7
Full stomachs	2.94	3.931	1.977	1.625	1.460	1.971	5.625	2.571	1.878	4.966	1.796	1.705	0.900	3.214

Discussion

The mudminnow is a typically tiny animal-consuming (zoophagous) fish. Although Otto Herman (1887) considered it a predator inclined to cannibalism and several review studies (Bănărescu, 1964; Gyurkó, 1972; Pintér, 1989; Harka and Sallai, 2004) mention about occasional fish consumption, no signs of this were found in either any detailed study or in the present work.

Different authors describe different data regarding the composition of the food. According to Geyer (1940) and Libosvárský and Kux (1958) the main food components are represented by tiny crustaceans, according to Jászfalusi (1950) by mosquito larvae, according to Guti *et al.* (1991) by the aquatic bugs and beetle larvae. According to our studies the mosquito larvae are primordial. Considering all the above data, we can conclude that the mudminnow is an euriphagous, opportunistic species, capable of exploiting the available nutritive resources.

Both Geyer (1940) and Libosvárský and Kux (1958) underline the more diverse feeding of the younger ages. This is supported by our studies as well.

According to the studies of Jászfalusi (1950) and of Guti *et al.* (1991) from the Danube region, vegetal components can also be found in the food of the mudminnow. Our results are in accordance with these data, since the mudminnow population of the Ér basin consumes occasionally not only algae, but the remains of higher plants and the seeds of these as well.

Several studies suggest that it would be worth spreading the mudminnow for mosquito destruction instead of the mosquitofish (*Gambusia*) of Central American origin, since this way we would support one of our rare and endemic fish species, and not an introdused species. For this reason first we need to solve the problem of large scale artificial breeding of the mudminnow.

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