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ON THE FOOD OF PIKE-PERCH FRY (*STIZOSTCDION LUCIOPERCA L.*) IN LAKE BALATON IN 1970

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Having applied stomach content analyses in fish food studies a reliable picture on qualitative and quantitative feeding relations of certain fish species can be obtained. Hence, the living conditions of the fish and their changes may be recorded to some extent.

Research on the feeding of pike-perch fry inhabiting Lake Balaton is very deficient, because the papers published on this topic contain few and more or less informative data (HANKÓ, 1928; UNGER, 1927; cit. TÖLG, 1959). The feeding relations of pike-perch fry have been explored in TÖLG's (1959) paper more profoundly. According to his statement, the pike-perch fry in Lake Balaton scarcely consume the benthic organisms following the plankton feeding stage. A great number of individuals above 35 mm of body length remain plankton feeder and probably this stock becomes mostly extinct during the winter.

The aim of this paper is to estimate changes having occurred in the food and food-supply of pike-perch of Lake Balaton since 1958.

Material and method

Pike-perch fry for food investigations had been collected by BÍRÓ (1972) using an otter-trawl of 5 mm mesh and a beam-trawl of 2 mm mesh respectively, mounted on a frame of 100×35 cm. The material studied was collected in the environs of Balatonfüred–Tihany, Balatonalmádi–Balatonfűzfő, Balatonakali and Bozsai Bay in the period from 5th June to 24th July, 1970 *(Fig. 1)*. The fish caught were fixed instantly on the site in 4–5 per cent formaldehyde solution (BÍRÓ, 1972). After taxonomic determination, the length and weight of the individuals were measured and the internal organs were prepared. Alimentary tract contents were transferred and preserved in vials until the analysis. The stomach contents were analyzed under stereomicroscope and their taxonomic status, quality and number, as well as percentual composition of the food organisms found were determined.

According to various collecting sites, the food of fry and the percentual composition of food supply of habitats were compared. To facilitate the determination of species, the food organisms were cleaned after SHERBININ's (1955)

leaching method with sodium hydroxide for 20 minutes in a maximum according to the quantity of gut content. If the weight of gut content is 0.05 g or less, the quantity of sodium hydroxide needed for hydrolysis is only 3 – 4 drops. The leaching was finished with washing by distilled water. The material studied was divided into five size-groups on the scale of 10 mm and in the appraisal of stomach contents this division was followed.

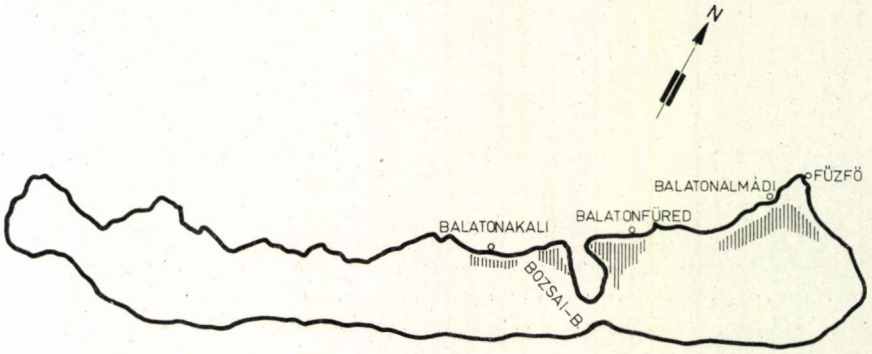

Fig. 1. Collecting sites in Lake Balaton

The present paper summarizes the results on the stomach content analyses of pike-perch fry collected in summer of 1970 (studied in 1975). At the same time it has been connected with BÍRÓ's (1972) growth studies made on the same specimens.

Results

1. Individuals originating from the water area between Balatonfüred and Tihany belonged to size-groups of 11 – 20 mm and 41 – 50 mm *(Table I)*.

The main food items for the specimens belonging to size-group of 11 – 20 mm were *Diaphanosoma brachyurum* occurring in 60 per cent, and *Eudiaptomus gracilis*, as well as *Mesocyclops leuckarti* both in 18.8 per cent. Among crustaceans of greater body dimensions only the *Leptodora kindtii* occurred in 2.4 per cent.

For the other size-group it is characteristic that more *Diaphanosoma brachyurum* was found in the stomachs, and *Daphnica cucullata* was also observed; compared to the previous group the number of *Leptodora* also increased *(Fig. 2b)*. In the case of both size-groups the main food item was *Diaphanosoma* which according to the frequency of occurrence was followed by *Daphnia*, *Eudiaptomus*, *Leptodora* and *Mesocyclops*. No fish remains were found.

2. Specimens of 11 – 20 mm length collected in the environs of Balatonalmádi and Balatonfüzfő mainly consumed *Eudiaptomus* and *Diaphanosoma*. According to their frequency of occurrence, the secondary food organism consumed were as follows: *Daphnia* (8.1 per cent), *Leptodora* (7.6 per cent), *Mesocyclops* (4.2 per cent), *Limnomysis* (0.8 per cent) and tubificids (0.5 per cent) *(Fig. 3a)*.

In the food spectrum of fry belonging to size-group of 21 – 30 mm, the same species were present as in the case of the previous group *(Fig. 3b)*. The only difference is that the pike-perch fry of greater length and mean weight consumed more food. *Diaphanosoma* (19 per cent) and *Eudiaptomus* (32.8 per cent) served as main food supply for them. The remaining 13 per cent comprised mainly *Daphnia*, *Mesocyclopos*, *Limnomysis*, *Leptodora*, as well as larvae of chironomids in a sequence of decreasing frequency. Increasing number of bigger food organisms *(Lymnomysis* 79 per cent) could be observed.

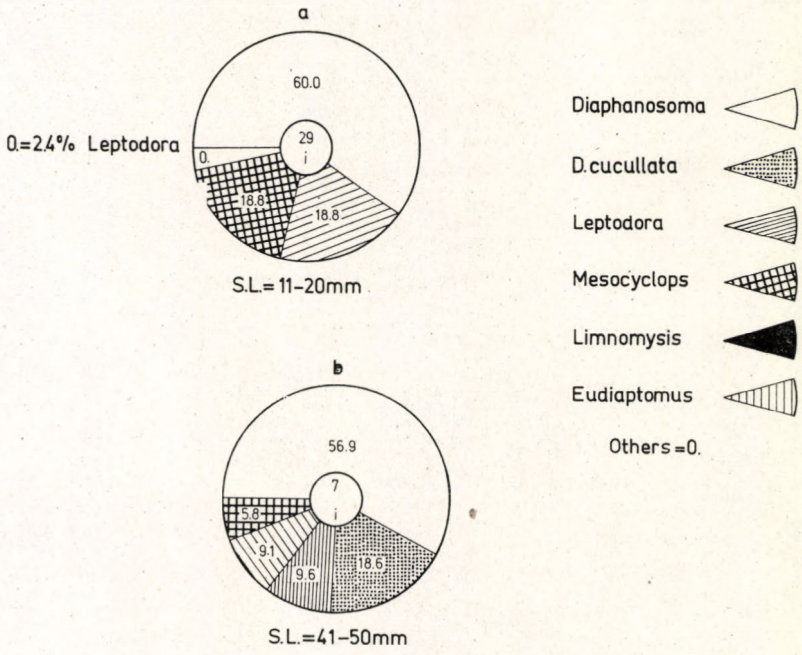

Fig. 2. Percentual composition of stomach content of pike-perch fry (Balatonfüred—Tihany, 5th June, 1970)

For the fry of largest body dimensions (31 – 40 mm) a more intensive food consumption is characteristic, proved by numerous food organisms in the stomach contents *(Table I)*. We did not find any sign of predation in these size-groups of fry.

3. Pike-perch fry collected in the environs of Balatonakali were arranged in three size-groups: 31 – 40 mm, 41 – 50 mm and 51 – 60 mm *(Table I)*.

The primary food of pike-perch fry of 31 – 40 mm body length were *Eudiaptomus* (35.8 per cent) and *Diaphanosoma* (34.1 per cent) *(Fig. 4a)*. Apart from these a great amount of *Daphnia* (26.5 per cent) was also found in their stomachs. *Mesocyclops*, *Leptodora* and pupae of chironomids also occurred in some per cent.

Some 0.2 per cent of the fry of 31 – 40 mm were infected by nematodes which on the basis of their frequency of occurrence is said to be insignificant. In the stomach of a specimen a branchial arch with lamellae belonging to percids was found.

TABLE I

Data on the food composition of pike-perch fry collected during the summer of 1970

Site and date of collection in 1970	Standard length (mm)	No. of samples	Mean weight (g)	Food organisms		
				Item	Total no. of indiv.	Average no. of indiv. stomach
Balatonfüred – Tihany	11 – 20	29	0.08	*Diaphanosoma*	51	1.76
				Eudiaptomus	16	0.55
5th VI.				*Mesocyclops*	16	0.55
				Leptodora	2	0.08
	41 – 50	7	1.23	*Diaphanosoma*	483	69
				D. cucullata	153	21.86
				Leptodora	82	11.71
				Eudiaptomus	82	11.71
		36		*Mesocyclops*	49	7
Balatonalmádi – Balatonfűzfő 23rd VI.	11 – 20	21	0.08	*Eudiaptomus*	73	3.48
				Diaphanosoma	72	3.43
				D. cucullata	15	0.71
				Leptodora	14	0.67
				Mesocyclops	8	0.38
				Limnomysis	2	0.10
				Oligochaeta	1	0.05
	21 – 30	138	0.25	*Diaphanosoma*	1883	13.64
				Eudiaptomus	1139	9.25
				D. cucullata	167	1.22
				Mesocyclops	143	1.04
				Limnomysis	79	0.57
				Leptodora	63	0.46
				Chironomus sp.	1	0.01
	31 – 40	13	0.45	*Diaphanosoma*	419	32.23
				Eudiaptomus	184	14.15
				D. cucullata	36	2.77
				Leptodora	26	2
				Mesocyclops	14	1.09
		172		*Limnomysis*	9	0.69
Akali 10th VII.	31 – 40	20	0.76	*Eudiaptomus*	864	43.20
				Diaphanosoma	822	41.10
				D. cucullata	640	32
				Leptodora	38	1.90
				Mesocyclops	17	0.95
				Nematodas	4	0.20
				Chironomu sp.	3	0.15
				Fry	1	
	41 – 50	28	1.18	*Diaphanosoma*	1372	49
				D. cucullata	1356	48
				Eudiaptomus	1034	37
				Leptodora	211	8
				Limnomysis	24	0.86
				Mesocyclops	11	0.40
				Nematoda	5	0.18
				Chironomus sp.	4	0.14
				Fry	4	

TABLE I *(continued)*

Site and date of collection in 1970	Standard length (mm)	No .of samples	Mean weight (g)	Food organisms		
				Item	Total no. of indiv.	Average no. of indiv. stomach
Akali 10th VII.	51 – 60	3	1.89	*D. cucullata*	232	77.33
				Eudiaptomus	168	56
				Diaphanosoma	107	35.60
				Leptodora	13	4.30
				Limnomysis	3	1
				Chironomus sp.	2	0.66
		51		Fry	2	
Bozsai Bay 24 th VII.	31 – 40	50	0.75	*Mesocyclops*	711	15.40
				Diaphanosoma	365	7.30
				Limnomysis	322	6.40
				Eudiaptomus	83	1.70
				D. cucullata	38	0.80
				Chironomus sp.	24	0.50
				Nematoda	10	0.20
				Leptodora	4	0.10
				Oligochaeta	3	0.06
				Fry	18	
	41 – 50	272	1.25	*Diaphanosoma*	6357	23
				Eudiaptomus	3378	12.40
				D. cucullata	2683	10
				Limnomysis	1789	6.50
				Mesocyclops	1057	3.90
				Leptodora	342	1.30
				Chironomus sp.	186	0.70
				Nematoda	62	0.20
				Oligochaeta	30	0.10
				Fry	63	
	51 – 60	109	2.03	*Limnomysis*	1730	15.80
				Diaphanosoma	1362	12.50
				D. cucullata	923	8.50
				Eudiaptomus	353	3.20
				Mesocyclops	155	1.42
				Leptodora	92	0.80
				Chironomus sp.	89	0.80
				Nematoda	27	0.30
				Oligochaeta	7	0.06
		431		Fry	26	

In the stomachs of pike-perch fry of 41 – 50 mm, increased individual number of *Diaphanosoma* (34.1 per cent), *Daphnia* (33.8 per cent), as well as *Leptodora* (18.9 per cent) were found, as compared to previous size-group *(Fig. 4b)*. The large-sized *Limnomysis benedeni* have also appeared in the meal of pike-perch fry, altough in a small number (0.6 per cent). Larvae and pupae of *Chironomus* sp. also occur in the food spectrum of this size-group (0.1 per cent). Ctenoid scales and epithelial tissue as well as muscle remains of ruff were observed in the stomachs of pike-perch fry in four instances. It means that about 14 per cent of the individuals in this size-group apart from invertebrates of larger body dimensions also feeds on fish.

Stomach content analyses of the 3 specimens belonging to 51 – 60 mm size-group showed that only *Limnomysis* occurred in the stomachs. Nevertheless, pupae of chironomids were found in two of the three specimens. In addition to this, the amount of plankton-crustaceans primarily *Daphnia* and *Eudiaptomus* is henceforth significant *(Fig. 4c)*.

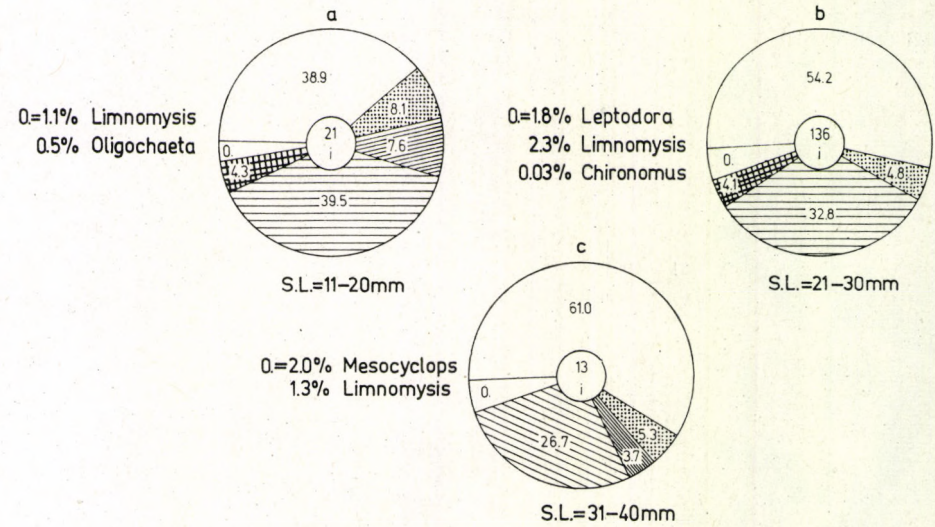

Fig. 3. Percentual composition of stomach content of pike-perch fry (Balatonalmádi—Balatonfűzfő, 23rd June, 1970) (Explanation as in *Fig. 2*)

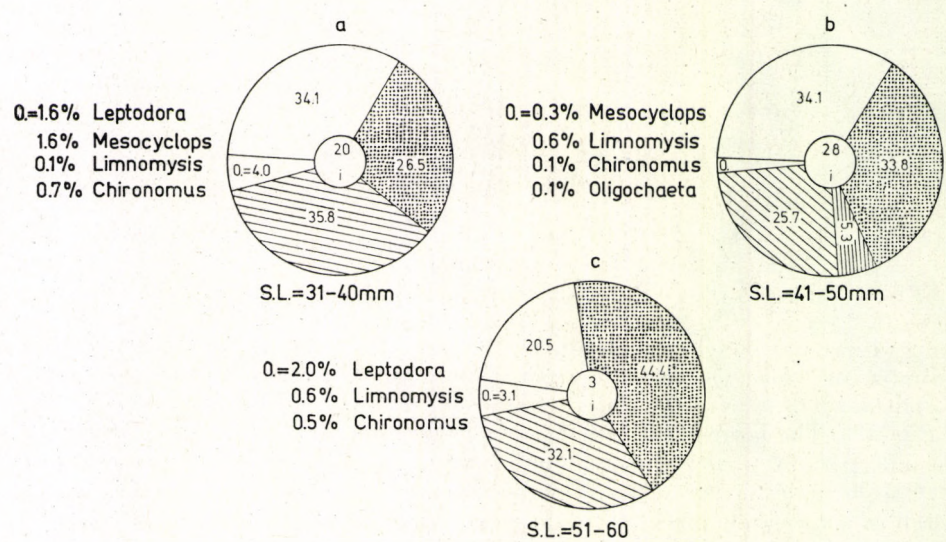

Fig. 4. Percentual composition of stomach content of pike-perch fry (Balatonakali, 10th July, 1970) (Explanation as in *Fig. 2*)

4. In the stomachs of 31 – 40 mm sized fry originating from Bozsai Bay *Limnomysis* in much greater number was observed (20.0 per cent) in contrast to previous collecting places *(Fig. 5a)*. It is important to note that pupae and larvae of *Chironomus* sp., as well as Oligochaetes were found in the stomachs of every second fry. The ratio of secondary food consisted of species of crustacean-plankton, however, is much less compared to other collecting places (Tihany – Balatonfüred, Balatonalmádi – Balatonfűzfő) *(Table I)*.

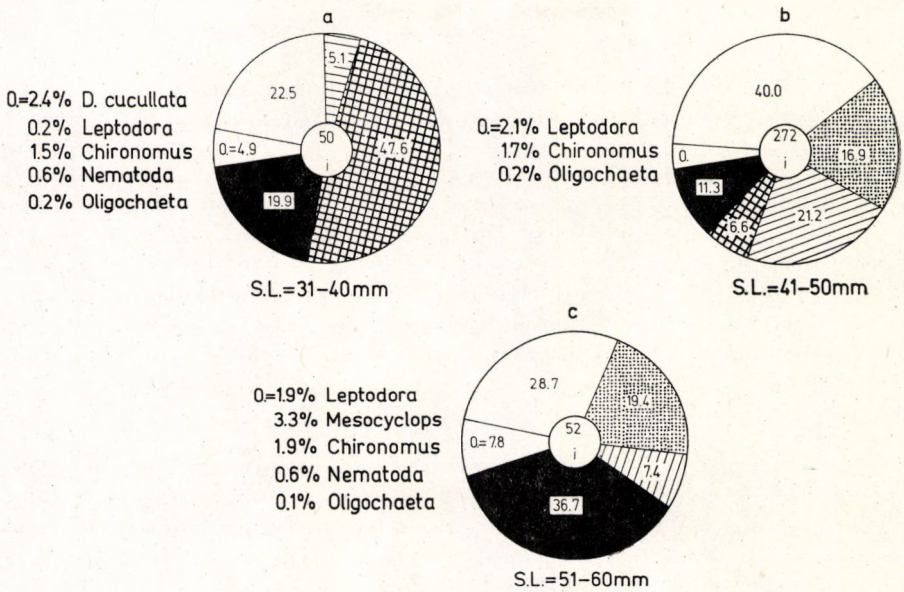

Fig. 5. Percentual composition of stomach content of pike-perch fry (Bozsai Bay, 24th July, 1970) (Explanation as in *Fig. 2*)

Infestation of the digestion tract by nematodes was most intensive in this size-group; i.e. almost every fifth specimen was infected.

In every third digestion tract studied (33 per cent) heavily digested tissues, as well as fragments of the body of ruff and pike-perch fry were observed.

Most of the stomach analyses were made on specimens of 41 – 50 mm. The ratio of *Limnomysis* in the stomach-content further increased compared to the previous group. The number of larvae and pupae as well as oligochaetes per one fish has also increased. The number of plankton-crustaceans in a stomach has further decreased. In spite of this fact, the occurrence of *Diaphanosoma*, *Eudiaptomus* and *Daphnia* cannot be ruled out *(Fig. 5b)*.

The intensity of infestation by nematodes is about the same as in the previous group.

Fish (ruff, pike-perch) and more or less digested organs of them were found in 63 stomachs of the 272 analyzed. On an average almost every fourth pike-perch fry consumed fish-food.

According to analyses of digestion tract of pike-perches belonging to size-group of 51 – 60 mm the following was established: *Limnomysis benedeni*

occurred in the greatest number (36.7 per cent) in this group *(Fig. 5c)*. As compared to the previous size-group, the frequency of occurrence of larvae and pupae of *Chironomus* sp. has increased further, and almost all pike-perch stomachs contained one specimen of each. The ratio of plankton-crustaceans in the food-spectrum is insignificant. As compared to the previous size-group the intensity of predation in fish did not change; about 25 per cent of fry consumed prey-fish.

Discussion

The primary question is whether the specimens caught with the otter-trawl suitably represent the entire stock of fry originating partly from the reed-grass zone having rich food-supply, and partly from open water areas without vegetation. Due to its structure the otter-trawl cannot be used within the extensive, dense reed-grass. At most it can adequately be used between reed-grass spots. Consequently, specimens usually caught at water areas far-off the reed-grass zone and more deficient in fish food were studied. TÖLG (1959) made no mention of such a case that *Limnomysis* or any other Amphipoda had been observed in the stomach, although at this time the large-sized *Limnomysis* have already been observed in great quantities in the entire littoral reed-grass zone *(Myriophyllum)* of Lake Balaton (PONYI, 1956). Some hundreds of pike-perch fry feeding on the relatively rich fauna of the littoral area covered by reed-grass were also caught. An example from our studies: the food composition of the 31—40 mm long pike-perch fry collected at open water areas in the environs of Balatonalmádi—Balatonfűzfő (23rd July, 1970) according to the number of food organisms was as follows: 61 per cent of *Diaphanosoma*, 27 per cent *Eudiaptomus*, 5 per cent of *Daphnia cucullata*, 4 per cent of *Leptodora*, 2 per cent of *Mesocyclops* and 1 per cent of *Limnomysis*. At the same time, in the case of the same-sized specimens collected at areas with more available food for fish: 38 per cent of *Mesocyclops*, 22 per cent of *Diaphanosoma*, 20 per cent of *Limnomysis*, 5 per cent of *Eudiaptomus* and 5 per cent of miscellaneous items *(Daphnia cucullata, Leptodora, Chironomus,* Nematoda, *Tubificids)*. These data refer to the fact that inshore areas covered by reed-grass provide better possibility for pike-perch fry to turn over the consumption on larger invertebrates after their plankton-feeding stage. It is also proved by literature data (ENTZ, 1947; BÍRÓ and GULYÁS, 1974) that the reed-grass stands are abundantly inhabitated by differently sized members of the fauna.

In evaluating the food-spectrum the individual weight of various organisms is indispensable. Although, during the analyses *Limnomysis* was present in a smaller quantity compared to plankton-crustaceans, still its biomass may be relatively more significant. For instance, in the stomach of a 31—40 mm sized fry about 25 plankton-crustaceans and 6 *Limnomysis* were present. Simultaneously, their biomass assessed in dry weight were 0.02 mg and 0.96 mg, respectively.

Lastly we gather from the results that only a certain part of the fry stock is able to inhabit the relatively narrow zone with rich food-supply, while the other part is driven out to water areas deficient in appropriate food. As a result of this, one part of the population is well developed, while the other is stunted in growth. This can be an explanation for the phenomenon of "diverse growth"

in length of pike-perch fry (BIRÓ, 1972). The same phenomenon was observed in Soviet reservoirs (i.e. Kujbishev Reservoir) (SHARONOV, 1963). Similar observation was also made among invertebrates. In the case of *Bosmina longirostris* it was found (WEGLENSKA, 1964) that the measurement of animals inhabiting the littoral zone with rich food supply was larger (290 μ) compared to members of the population living in open water areas (250 μ). Time factor also plays a part in this, because three–four weeks may pass between the birth of specimens. To settle this question further studies are needed.

The food of pike-perch fry driven out to open water theoretically is partly the curstacean-plankton, and above 25 mm body length, partly the various species of larger-sized macrozoobenthos (LJASHENKO, 1961). In the case of Lake Balaton these studies unanimously show that for pike-perch fry the open water chironomids are unavailable. The food analysis of ruff (PONYI et al., 1972) also proves the occurrence of Diptera in a required number. The light deficiency at the mud surface is the probable reason why the pike-perch fry is unable to consume this type of food. TÖLG's (1959) and our results show that Diptera and Oligochaeta occurred in the digestion tract of 30—50 mm sized specimens originating from the open water areas in an insignificant number. They probably reached the upper layers of the water when the lake was troubled and so they became available for the fish. The ratio of chironomids in the food of fry inhabiting the reed-grass zone is much higher (2.4—3.9 mg in dry weight per stomach; Bozsai Bay).

The food supply of pike-perch fry in the open water are exclusively the species of crustacean-plankton. Comparing the qualitative and quantitative composition of crustacean-plankton samples *(Table II)* being at our disposal

TABLE II

Average number of individuals per litre of crustacean-plankton samples collected during June and July of 1967 and 1972 (PONYI, *1975)*

Crustacean plankton	Standard sections		
	"E"	"A"	"G"
Diaphanosoma brachyurum	7.28	6.12	4.73
Daphnia cucullata	1.22	1.37	1.46
Leptodora kindtii	0.07	0.08	0.15
Eudiaptomus gracilis	4.31	5.75	3.26
Mesocyclops leuckarti	4.72	3.32	4.69
Cyclops sp.	1.97	1.14	1.17
Total:	19.57	17.78	15.46

and originating from areas near to the collecting places of fry, it is clear that the food supply cannot be ranked as a rich one. On the basis of individuum per litre values the *Leptodora kindtii* occurred in a small number. Consequently, it did not play a significant role in the food of pike-perch fry.

Having compared the percentual composition of gut contents and crustacean-plankton samples taken from three collecting sites at the open water areas *(Table III)* it was established that *Diaphanosoma* (body length of ♀ = about 1 mm) occurring in high percentage every time was also present

TABLE III

The percentual distribution of crustacean-plankton along the "E" section (Balatonalmádi—Balatonfűzfő) and in the stomach content of pike-perch fry

Food animals	Section "E"	Pike-perch fry		
		11—20 mm	21—30 mm	31—40 mm
Diaphanosoma brachyurum	41.4	40.0	54.2	61.0
Daphnia cucullata	6.9	8.1	4.8	5.2
Leptodora kindtii	0.4	7.6	1.8	3.7
Eudiaptomus gracilis	24.5	39.5	37.8	26.7
Mesocyclops leuckarti	26.8	4.3	4.1	2.0

in a high ratio in the food of fish, as well. As regards the frequency of occurrence of *Eudiaptomus* (length of ♀ = 1—1.5 mm) it occupies the second or third place in the plankton and accordingly it can also be found in a high percentage in the food of pike-perch fry. Simultaneously, the relatively same sized *Mesocyclops* (length of ♀ = 1.3 mm) occurring in great numbers can hardly be found in the gut. According to out data the occurrence of *Leptodora* varies between 0.4 and 1.0 per cent, at the given areas of the lake, nevertheless, in the gut amounts to its manifold value *(Tables II* and *III)*. In summing up our observations it can be stated that pike-perch fry selectively consumes the plankton-crustaceans in the open water; though for the final solution of this question simultaneous investigations are needed.

Having compared our and TÖLG's (1959) data it was found that the amount of plankton-crustaceans observed in the digestion tract of 11—20 mm long pike-perch fry had decreased to its half.

While in 1958 *Eudiaptomus* occupied the first place of the food spectrum, during our studies it was replaced by *Diaphanosoma*. This can be explained by those results (PONYI et al., 1975) according to which the biomass of *Eudiaptomus* population has greatly decreased probably due to the high density of fish. We suppose that the habitat of pike-perch fry is concentrated to about a 500 m wide littoral zone. Considering the density of fry of various fish species inhabiting the littoral zone of Lake Balaton, an overgrazing of the crustacean-plankton food supply is an existing problem. It may well be true, because all species of fish inhabiting Lake Balaton feed on zooplankton during a certain phase of their juvenile stage. This insufficiency of planktonic food afflicting the pike-perch fry also proves that the biomass of zooplankton and their consumers are balanced in Lake Balaton. Obviously this should not be increased with new consumers.

Summary

Stomach contents of 690 pike-perch fry caught at four collecting sites in Lake Balaton during the summer of 1970 were analyzed by the authors and the following were established.

Specimens of 11—20 mm length consume *Diaphanosoma brachyurum* in 60 per cent and *Eudiaptomus gracilis* in 18 per cent, while this ratio was 50—50 per cent in 1958.

As compared to data of 1957—58, the amount of total crustacean-plankton in the stomach content had decreased to its half. It means that the deterioration of feeding possibility of fry (10—20 mm size-class) continued.

According to the quality of food consumed a part of pike-perch fry surpassing 20 mm body length inhabit water areas free from reed-grass stands. This results in a displacement from the relatively narrow reed-grass stands having rich food-supply. The other part consuming rich macrofauna grows faster and change to predation in time. The "diverse growth" of pike-perch fry in Lake Balaton can be explained by this phenomenon.

Based on the present studies we came to the conclusion that the bulk of previous analyses were made on groups of fry displaced to the open water. With the use of collecting technique applied in earlier the fry inhabiting open water areas were chiefly caught because of the dense reed-grass. Owing to this an inaccurate statement was put forth saying that large-sized organism is lacking in Lake Balaton being necessary during the changing period of feeding habit.

According to data of the summer period of 1967 and 1972, *Leptodora kindtii* amounted to 0.4—1.0 per cent only in the crustacean-plankton of Lake Balaton. This is why it occurred only in an insignificant quantity in the food of fry inhabiting the open water.

Authors are anxious concerning the density of fry in the littoral zone of Lake Balaton, since it is unfavourable, consequently a sharp competition may occur there.

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A FOGASSÜLLŐ-IVADÉK (*STIZOSTEDION LUCIOPERCA* L.) TÁPLÁLÉKA A BALATONBAN 1970-BEN

Tátrai István és *Ponyi Jenő*

Összefoglalás

A szerzők 1970. év nyarán a Balaton négy gyűjtőhelyéről befogott 690 db süllő-ivadék gyomortartalmát vizsgálták és a következőket állapították meg.

A 11—20 mm-es példányok 60%-ában *Diaphanosoma brachyurum*-ot és 18%-ban *Eudiaptomus gracilis*-t fogyasztanak, míg 1958-ban ez az arány 50—50% volt.

Az össz-Crustacea plankton mennyisége a gyomortartalomban az 1957—58-as adatokhoz képest a felére csökkent. Ez azt jelenti, hogy a 10—20 mm-es ivadék táplálék-feltétele tovább romlott.

A 20 mm feletti fogassüllő-ivadék egy része — a felvett táplálék minősége alapján — továbbra is hínármentes vízben él, melynek oka a viszonylag keskeny, táplálékban gazdagabb hínármezőből való kiszorulás. A másik része a gazdag makrofaunát fogyasztva gyorsabban nő, és át is tér a halragadozásra. Ezzel a jelenséggel magyarázható a balatoni süllőivadék ún. szétnövése is.

Vizsgálataink alapján arra a következtetésre jutottunk, hogy a korábbi analízisek kizárólag a nyíltvízre kiszorult ivadékcsoportokon történtek. Ugyanis az eddigiek során alkalmazott gyűjtési technika segítségével, a hínármező miatt főleg a nyíltvízi ivadékot foghatják ki. Ennek következtében született az a nem pontos megfogalmazás, miszerint a Balatonból hiányzik egy nagytestű szervezet, amely az ún. táplálékváltási periódusban szükséges.

Az 1967., 1972. évek nyári átlag adatai alapján a Balaton Crustacea-planktonjában a *Leptodora kindtii* csupán 0,4—1,0%-ban szerepelt. Ez az oka annak, hogy a nyíltvízi ivadék táplálékában kis mennyiségben fordult elő.

A szerzők kifejtik azon aggodalmukat, hogy a Balaton parti övében a halivadékok sűrűsége kedvezőtlen, így éles táplálékkonkurrencia esete állhat elő.