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OBSERVATIONS ON THE FOOD OF EEL (*ANGUILLA* ANGUILLA L.) IN LAKE BALATON

PÉTER BIRÓ

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

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First eel stocking in Lake Balaton took place in 1890 (VÁSÁRHELYI, 1962). The question of intensive eel stocking of Lake Balaton was raised on SCHÄPERCLAUS's suggestion in 1955. According to his statement "with mass eel stocking of Lake Balaton certainly a valuable, in their stock a regulable fish could be reared in the present fauna" (RIBIÁNSZKY, 1965). Starting from this fact, experimental stockings were made in Lake Balaton and in some natural waters (Lake Velence, Lake Szelidi, Lake Belső of Tihany, Lake Cseke, etc.), during 1961–62. Stockings became permanent as the result of favourable experiences obtained during these two years (RIBIÁNSZKY, 1965; 1968; 1969; 1970; TÖLG, 1962 b; 1963 c). First mass plantings were followed by new ones (from 1961 to 1970 there were planted 25 857 740 larvae i. e. 243 individual per cadastral yoke (HORVÁTH, 1971)), but simultaneously with these, the food, growth, etc. had not been studied in details. Since, this species was planted in Lake Balaton with the sheer purpose of more intensive exploitation of food-supply in deep waters there ought to have been extensive investigations concerning the following topics: how the eel can accomodate to the biocenose of the lake, what kind of effect it has on the feeding, growth, stock density of other fish species and in which depth, whether it is a significant food-competitor, or not? (BIRÓ and ELEK, 1970). In some occasions electric catching techniques attempted to the recovery of eels inhabiting open waters were applied. At environs of Szigliget and Badacsony weirs were set up (SCHLUMPBERGER, 1962). Later an eel-rack was built in the mouth of Sió-canal at Siófok, to recover the sexually mature, migratory eels (KŐVÁRY, 1971). The fishing by hooks, a very effective means of eel catching was reported in details by RÁCZ (1969). In the meantime the yearly planted material decreased because doubts arose in connection with the insufficient knowledge of the life history of eel in Lake Balaton, and that of the quantitative changes taking place in fish fauna. Parallel with this, observations on the food of eel were started. An answer was searched to what kind of difference exists between food composition of eels inhabiting the littoral zone and the open water, and how it is related to the exploitation of the natural food-supply of the lake.

The present study summarizes the observations on the food composition of eel in Lake Balaton, made during 1970–73.

Material and methods

The majority of material have been collected by using the electric fishing machine along the northern shore line of Lake Balaton in the environs of Tihany peninsula. Fisheries were made from boat and the collected eels (their number changed seasonally and regionally, even at any time of the day), were anaesthetized by using MS-222 (Sandoz) and then transferred to the laboratory, where they were stored in deep freezer till dissection. In the laboratory, the length in millimetres and the weight in grams were recorded, following the dissection of the abdominal cavity, the visceral organs were separated and fixed in 4—5 per cent formaldehyde solution, then stored in sealed nylon bags. Based on the macroscopic structure of gonads (BERTIN, 1956) the sex of individuals were determined. In Petri-dish containing 4 per cent formaline the stomach and guts were separated, and their content was entirely isolated. Stomach and gut contents were analysed under binocular microscope and the digested particles were determined to species. The percentual composition of food was calculated according to the frequency of occurrence of the respective species, during several months of observation. During three years of observations (1970—1972), the stomach and gut contents of 596 eels of different size have been studied. In order to catch a great number of eels an attempt was made to use the electric trawl at open water areas, however, the experiments were unsuccessful, although the Balaton Fishing Company cooperated in the work, during June—July, 1972. Nevertheless, fishermen carried out successful trials by applying this method in September, 1972. Later, during November—December, the electric fishing machine could no longer be operated with success along the shore line of Lake Balaton, where the eels occurred in great numbers during summer months.

In 1973, studies were continued to distinguish the food composition amongst eels inhabiting the littoral zone and the open water. Therefore, further collectings were made by using the electric fishing machine along the shores of Tihany peninsula. The alimentary canals of 205 specimens were analysed in this material, caught between 1—17 August. In September, fishermen of the Balaton Fishing Co. collected more than 1000 eels with electric trawl at 2—2.5 m deep waters of which material 811 specimens were investigated. Collections on 13th September 1000—1500 m off shore at areas of Gyenesdiás and Szentmihálykápolna were carried out, however, collections in the environs of Szentmihálykápolna and Balatongyörök in the same distance at 2.5 m depth took place on 28th September. The fishermen collected at night and the samples after preparation were fixed in 4 per cent formaline (procedure as described above). We received these samples for examination completed with length and weight data of the specimens, which were usually well preserved, and the food-animals were only slightly digested, so their determination in the majority of cases meant no difficulties. Hence, the wide-scale collections in 1973 were carried out during August and September, because the previous observations showed that at this time the eels are catchable in great numbers and still feed intensively. Altogether 1016 eel stomach and gut contents were thoroughly analysed in 1973. The present study summarizes the observations on the food composition of 1612 eels, made during 1970—73.

Results

Data on number, size and sex-ratio of eels collected during 1970—73 are summarized in *Table I*. From these data it can be seen that the average length of eels caught at the littoral zone of Lake Balaton with the electric machine is mostly between 30—40 cm, but smaller ones (usually males) are also frequent. Among of small-sized eels the sexual character of numerous fish has not yet developed, and their weight was usually between 50—70 g.

TABLE I

Data on eel-materials investigated during 1970—73 (number of specimens, sexual ratio, measurements)

Time of collection		N	F	E	♀	♂	Juv.	L	W
May	1970	21	13	8	15	6	—	350—682	67—632
June	1971	60	48	12	52	1	7	250—517	36—384
July		70	63	7	65	5	—	335—430	78—200
Sept.		55	54	1	46	4	5	202—380	30—120
Nov.		50	47	3	45	—	5	180—480	30—200
Total:		235	212	23	208	10	17		
March	1972	16	12	4	10	—	6	245—620	35—400
April		28	22	6	22	4	2	272—672	30—420
June		58	44	14	44	2	12	310—625	70—440
July		142	115	27	82	—	60	200—995	48—700
Sept.		39	38	1	37	1	1	267—726	38—460
Oct.		57	56	1	29	3	25	135—530	8—250
Total:		340	287	53	224	10	106		
3—7 Aug.	1973	53	37	16				310—720	60—770
13—17 Aug.		152	127	25				310—700	50—700
13 Sept.		477	461	16				235—824	85—1290
28 Sept.		334	326	8				356—800	122—1055
Total:		1016	951	65					

N = total number of investigated eels; F = number of alimentary tracts containing food; E = number of empty alimentary tracts; ♀ = females; ♂ = males; juv. = juvenile; L = total length in mm (limits); W = weight in g (limits).

In the majority of introduced eels the sexual character definitely distinguishable above 100 g individual weight in Lake Balaton. Females can be determined by their yellow, ripple lobated ovaria, while the males by their white, tubular testis. In fresh waters, such as Lake Balaton, during sexual differentiation, it is characteristic that females become predominant against the males reaching 25—45 cm body length. Sex ratio of the caught eels was not investigated separately, in 1973. Length and weight limits of fish collected this year are summarized in *Table I*. In August, the length varied between 31 and 72 cm, while the weight between 50 and 770 g, and in those specimens collected at open waters during September the same were 23.5—82.5 cm, and 85—1290 g.

About one-third of the larger individuals inhabiting stony shores escaped the effect of electric power, when collections from boat were carried out along

shore line. The habitat of eels, chiefly in warm summer months, is among the stones of beetling cliffs and of well-aerated shore sections, and parallel with the drop in water temperature they hide in the mud of open waters. In reed-grass stands they occur in seasonally variable ratios, but at areas covered by *Phragmites* the collections remained unsuccessful. It is possible that they may also occur in great numbers in the mud of these areas, too.

After the structure of the head, a broad- and a sharp-nosed eel can be distinguished which differ in feeding habits. The broad-nosed form is stated to be piscivorous. The feeding pattern of eels having either of the two head forms has only revealed the real content of stomach and gut. The feeding pattern of Balaton eels could not be decided undoubtedly after the external, morphological features, i. e. whether they are omnivorous or piscivorous. The majority of them might be omnivorous, and they consume food usually during night hours.

Food composition of eels

The stomach content of 21 eels collected from littoral zone during May' 1970 was primarily represented by small-sized invertebrates *(Table II, Fig. 1)*. Among them *Asellus aquaticus* occurred in 81 per cent, Chironomid larvae and pupae followed them in 8.5 per cent, and *Corophium curvispinum* f. *devium*

TABLE II

Occurrence of prey-animals in the food of eel in Lake Balaton during May, 1970

Food-items	
Asellus aquaticus	417
Chironomida larvae and pupae	44
Corophium curvispinum	24
Trichoptera spp. larvae	5
Amphipoda sp.	4
Ephemeroptera sp. larvae	3
Mollusca spp.	3
Alona sp.	1
Fish	16
Total:	517

was the next in line with 4.6 per cent. Other items remained below one per cent, except fish. Fish species gave three per cent represented of ruff *(Acerina cernua)*, bleak *(Alburnus alburnus)*, yearlings of bream *(Abramis brama)* and that of sichel *(Pelecus cultratus)*, as well as of older breams. The majority of stomachs contained water-weed fragments, too. Amongst the mud-inhabiting Chironomids *Cryptochironomus* sp., *Limnochironomus* sp., *Tanypus punctipennis* were determined among Trichoptera spp. larvae the species of Hydroptilidae were found. Among Ephemeroptera sp. larvae chiefly *Cloeon dipterum*, while the Amphipods were represented by Gammarids *(Dicerogammarus haemobahpes, D. villosus)*.

In 1971, during two summer (June—July) and autumn (September—November) months, the stomach content of 235 eels were studied and the

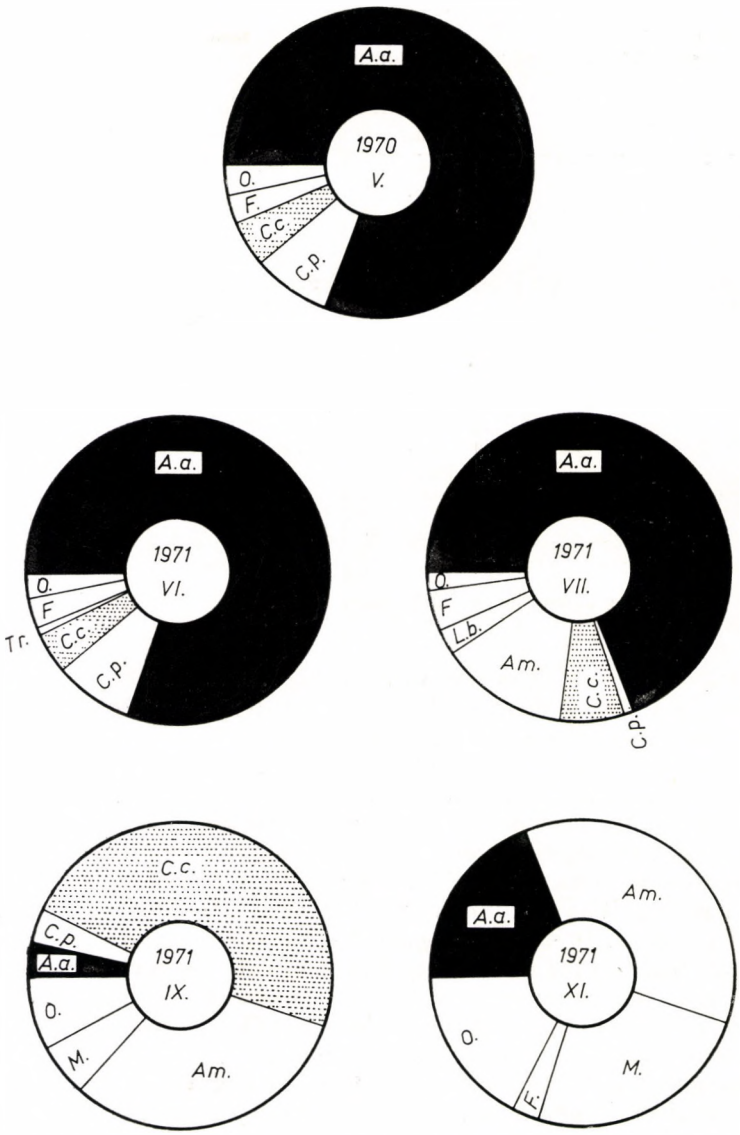

Fig. 1. Food spectrum of eels collected in the littoral zone of Lake Balaton, during 1970—71. A. a. = *Asellus aquaticus;* Am. = *Amphipoda* sp.; C. p. = *Chironomus* ex gr. *plumosus*; C. c. = *Corophium curvispinum* f. *devinum;* L. b. = *Limnomysis benedeni;* Tr. = Trichoptera sp.; M. = mollusca; F = Fish; O = others

result supported our previous, sporadic investigations *(Table III, Fig. 1).* On an average of four months, *Asellus aquaticus* yielded the greatest number (average 58 per cent), Corophium occupying the second place (15 per cent), while Amphipods was the third in line (12 per cent). In the majority of stomachs, water-weed fragments were found, too. Among Chironomid larvae (average 5.8 per cent) the three most abundant littoral species of Lake Balaton

TABLE III

Quantitative occurrence of prey-animals in the food of eel during June—November, 1971

Food-items	June	July	Sept.	Nov.	Total
Asellus aquaticus	417	110	8	7	542
Chironomida larvae + pupae	44	2	8	—	54
Corophium curvispinum	24	11	107	—	142
Trichoptera spp. larvae	5	—	—	—	5
Amphipoda sp.	4	22	70	13	109
Ephemeroptera sp. larvae	3	—	—	—	3
Lithoglyphus naticoides	—	—	13	7	20
Dreissena polymorpha	—	—	2	2	4
Limnomysis benedeni	—	4	1	2	7
Alona sp.	1	—	—	—	1
Fish	16	7	2	1	26
Total:	517	156	211	32	917
Other fragments	—	2	5	4	11
Water-weed fragments	—	1	—	—	1
Trematoda + Cestoda spp.	—	—	7	—	7**

Note: ** Parasitic worms in the alimentary canal.

were present, also reported in the previous year. The quantity of Trichoptera (*Rhyacophila* sp.) and Ephemeroptera *(Cloeon dipterum* and *Caenis horaria)* larvae remained below 0.5 per cent. Fish species occurred in variable quantities between 0.9—4.4 per cent (average 2.8 per cent), amongst them ruff *(Acerina cernua)*, bleak *(Alburnus alburnus)*, roach *(Rutilus rutilus)*, bream *(Abramis brama)* and yearlings of sichel *(Pelecus cultratus)* were determined. Molluscs, living in the mud and periphyton, were consumed in significant but seasonally variable quantities (from zero to 19.4 per cent). The amount of *Lithoglyphus naticoides* snails *(Table III)* changed between 0.6—19.4 per cent, on an average 2.1 per cent. *Dreissena polymorpha* and shell-fragments of some other species (small *Unio* and *Anodonta* spp.) were found in some alimentary canals. Their frequency in the food reached 5.6 per cent (average 0.4). In autumn, the significance of Corophium and Amphipods in the food of eels sharply increased, while that of *Asellus aquaticus* and of Chironomid larvae diminished by autumn. *Limnomysis benedeni* amounted to 0.4—5.6, on an average 0.7 per cent, although previously they were not found. Like other food-animals, except one or two invertebrates, the latter species is also periphytic in habit.

During March—June, 1972, altogether 102 eel stomachs were examined, and 76.5 per cent of them contained food, while 23.5 per cent were at the time of examination empty. Length of the examined specimens ranged between 26 and 67 cm. Data on the food composition are summarized in *Table IV* and in *Fig. 2*. According to these data it is evident that the animal food-items of the eels inhabiting the littoral zone comprise several invertebrates. Among them *Asellus aquaticus, Corophium curvispinum* f. *devium*, and from Amphipods the *Dicerogammarus* sp. are predominate. Their ratio in different months changed parallel with the length of eels, and so the invertebrates of greater sizes predominated. Chironomid larvae (chiefly *Tanypus punctipennis), Limnomysis*

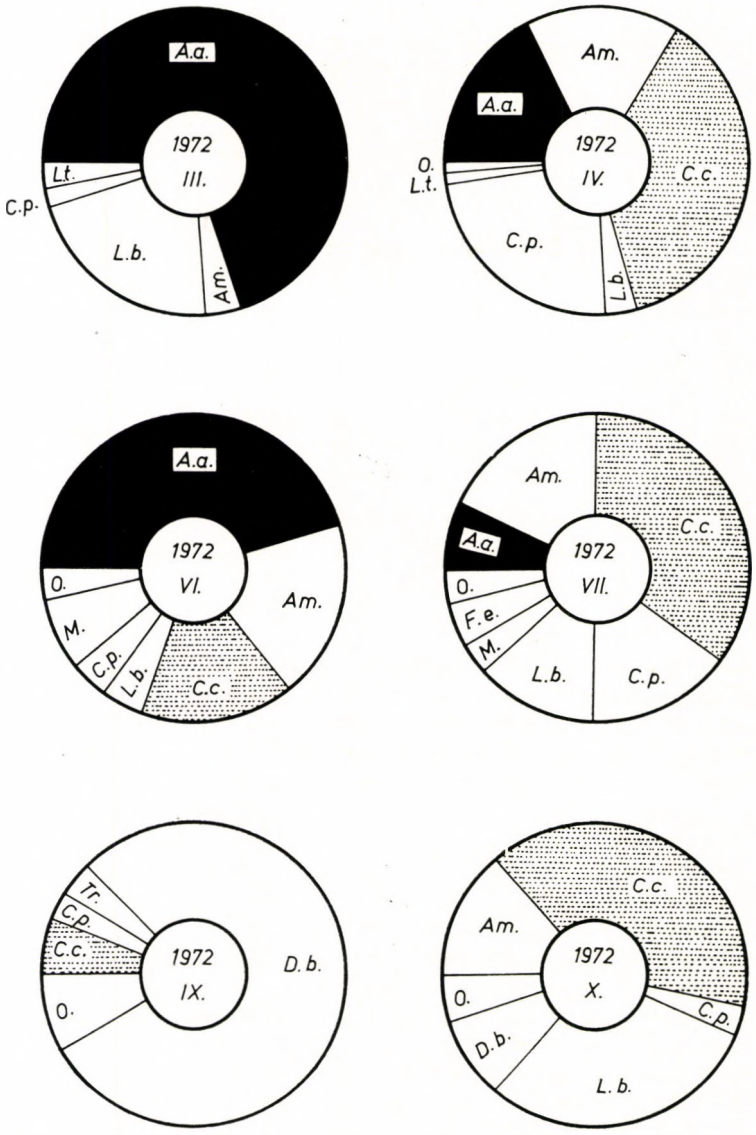

Fig. 2. Food spectrum of eels collected in the littoral zone, during 1972 (explanation as in *Fig. 1*, and in addition L. t. = *Lumbricus terrestris;* F. e. = fish eggs; D. b. = *Diaphanosoma brachyurum*)

benedeni, and the small-sized *Lithoglyphus naticoides* snails may also be considered very important food-items. *Dreissena polymorpha*, Chironomid pupae (after swarming there were found some exuvia), *Valvata piscinalis* snail and *Lumbricus terrestris* (drifted probably in the lake with rainwater) may be regarded occasional foods in the given period. Insect- and fish-eggs, then fish remains were found in insignificant quantities in the eel stomachs, although in some

TABLE IV

Quantitative occurrence of prey-animals in the food of eel during March—June, 1972

Food-items	March	April	June	Total
Asellus aquaticus	72	32	304	408
Amphipoda sp.	4	30	126	160
Corophium curvispinum	—	68	108	176
Limnomysis benedeni	22	6	30	58
Chironomida larvae + pupae	2	44	26	72
Dreissena polymorpha	—	—	4	4
Lithoglyphus naticoides	—	—	50	50
Valvata piscinalis	—	—	8	8
Lumbricus terrestris	3	2	—	5
Insecta eggs	—	1	—	1
Fish-eggs	—	—	5	5
Alburnus alburnus	—	—	4	4
Abramis brama	—	—	1	1
Total:	103	183	666	952
Water-weed fragments	—	4	6	10*
Trematoda + Cespoda spp.	4	4	18	26*
Pulpy stomach-content	4	4	13	21*

Note: * occurrence in stomachs of given number.

shore sections their ratio may be higher during the spawning period. Among fish remains, smaller bleak *(Alburnus alburnus)* and fry of bream *(Abramis brama)* were found, and water-weed fragments, probably getting into the stomachs by chance, were also common.

During July—October, 1972, stomach content of further 238 eels were analysed *(Table V, Fig. 2.)* In comparison with spring and early summer data a more significant difference was observed in the frequency of occurrence of species comprising the food, however, it was consisted of invertebrates already reported earlier. In July, *Corophium curvispinum* f, *devium* dominated besides Amphipoda crustaceans (*Dicerogammarus* sp.), and Chironomid larvae. Participation of *Limnomysis* in the food increased significantly (by 12.7 per cent). Parallel with this, the ratio of *Asellus aquaticus* declined to 1/6 of its previous value (7.1 per cent). The consumption of *Dreissena* (3.3 per cent) and of fish-eggs (4.7 per cent) became intensive. The amount of fish *(Acerina cernua, Alburnus alburnus, Abramis brama, Rutilus rutilus)* reached 1.9 per cent. In the majority of stomachs, variously shaped and digested plant-fragments and debris were found at that time, too. In the food of 39 examined eels during September, *Diaphanosoma brachiurum* and a species of Cladocera were predominant (79.5 per cent). Earlier observations did not reveal any dominance of eels feeding on plankton, so their high ratio is remarkable. Here we should point out that *Diaphanosoma* occurred in the stomachs of some small-sized eels only, but there in large quantities, and in this case, its high ratio is understandable. A significant part of the food consisted of Corophium, Chironomids and Trichoptera larvae. Fish consumption amounted to three per cent only. During the given period, only one eel stomach was empty (2.6 per cent). During October, *Corophium curvispinum* f. *devium* (39.5 per

TABLE V

Quantitative occurrence of prey-animals in the food of eel during July—October 1972

Food-items	July	Sept.	Oct.	Total
Asellus aquaticus	144	12	—	156
Amphipoda sp.	366	16	153	535
Corophium curvispinum	711	53	441	1205
Chironomida larvae + pupae	312	27	33	372
Ephemeroptera sp. larvae	3	—	—	3
Trichoptera sp. larvae	18	32	9	59
Lymnomysis benedeni	258	—	341	599
Alona sp.	—	—	2	2
Diaphanosoma brachyurum	—	716	98	814
Diptera sp. imago	6	—	2	8
Araneida sp. *(terrestris)*	—	1	—	1
Dreissena polymorpha	66	—	—	66
Lithoglyphus naticoides	6	—	2	8
Fish-eggs	96	—	—	96
Alburnus alburnus	15	1	1	17
Acerina cernua	—	11	1	12
Abramis brama	6	1	—	7
Lucioperca lucioperca	—	4	—	4
Rutilus rutilus	18	1	—	19
Cyprinida sp.	—	9	1	10
Other fish remains	—	1	—	1
Other fragments	—	—	33	33
Total:	2025	882	1117	4024
Water-weed fragments	+	+	+	+
Nematoda sp. (parasitic)	—	1	—	1
Trematoda + Cestoda spp.	18	17	3	38
Pulpy stomach content	—	11	7	18

cent), and *Limnomysis benedeni* (30.5 per cent) became predominant, but a significant part of the food consisted of Amphipods (13.6 per cent) and of the plankton-living *Diaphanosoma* (8.8 per cent). Fish consumption reached 0.27 per cent only, and this value exceeded by ratio of Chironomids (2.9 per cent) and of Trichoptera larvae (0.8 per cent), though, the amount is insignificant. During spring, early summer and then in summer-autumn, the seasonal variance of food components unanimously show the different role of several food-items. It may well be in close connections with their density, availability and population dynamics. In order to recognize these problems in details, extensive studies on the benthos and periphyton-living invertebrate populations, and the exploration of their feeding relations are imminent problems awaiting solution. By these means we could obtain data on the real food-supply, and on the exploitation of the most important littoral zone being the main feeding and spawning ground of fish, as it also appeared from these investigations. During collections carried out in the littoral zone between 1 and 17 August, 1973, a considerable quantity of eels was collected, but only a part of this material (205 specimens) was investigated. At the beginning of August, from the 53 alimentary tracts 37 contained food (16 were empty), however, by the middle of the month, only 25 were empty out of 152 eel stomachs and intestines. The

TABLE VI

Quantitative distribution of prey-animals representing the stomach and intestine content o eels in the littoral zone and in the open water of Lake Balaton during August—September, 1973

Food-items	Littoral zone			Open water		
	3—7. Aug.	13—17. Aug.	Total	13. Sept.	28. Sept.	Total
Leptodora kindtii	—	—	—	116	—	116
Asellus aquaticus	58	1	59	—	—	—
Amphipoda sp.	525	598	1 123	1	1	2
Corophium curvispinum	787	3 645	4 432	—	4	4
Limnomysis benedeni	524	709	1 233	—	—	—
Ephemeroptera sp. larvae	—	54	54	—	—	—
Odonata (Anisoptera) larvae	3	—	3	—	—	—
Odonata (Zygoptera) larvae	1	—	1	—	4	4
Chironomida spp. larvae + pupae	40	298	338	19 917	15 227	35 144
Diptera spp. imago + larvae	—	3	3	—	6	6
Trichoptera sp. larvae	26	514	540	—	—	—
Hymenoptera spp. imago	—	—	—	—	7	7
Cicadidae spp.	—	—	—	—	3	3
Gyrinus natator	—	—	—	—	1	1
Argyroneta aquatica	—	—	—	1	16	17
Ancylus fluviatilis	—	—	—	—	1	1
Planorbis sp.	10	—	10	—	—	—
Pisidium sp.	—	1	1	—	—	—
Valvata sp.	—	1	1	—	—	—
Lithoglyphus naticoides	201	166	367	58	20	78
Dreissena polymorpha	3	54	57	67	70	137
Unio + *Anodonta*	—	—	—	—	2	2
Rutilus rutilus	—	1	1	—	3	3
Scardinius erythrophthalmus	—	—	—	—	5	5
Abramis brama	—	—	—	2	2	4
Alburnus alburnus	—	—	—	3	20	23
Pelectus cultratus	—	—	—	1	—	1
Neogobius fluviatilis	—	3	3	—	—	—
Cyprinida spp.	1	—	1	11	12	23
Lucioperca lucioperca	—	2	2	13	2	15
Lucioperca volgensis	—	—	—	2	—	2
Acerina cernua	—	—	—	25	23	48
Percida spp.	—	3	3	21	32	53
Total fish:	1	9	10	78	99	177
Total prey-animals:	2 179	6 053	8 232	20 238	15 461	35 699
Nematoda spp. (parasitic)	5	24	29	—	—	—
Trematoda + Cestoda spp.	7	46	53	388	103	491
Other fragments	21	42	63	168	152	320

analysis of stomach and intestine content showed that the food mainly comprises invertebrates inhabiting the littoral zone, such as crustaceans, insect larvae, and molluscs *(Table VI, Fig. 3)*. Compared to the spring food (see data of 1972, *Tables IV—V)*, a markedly smaller amount of *Asellus aquaticus* (0.7 per cent) was found. The ratios of *Dicerogammarus* sp. and of *Limnomysis benedeni* were practically equal 13.6—15 per cent). By frequency of occurrence, the main food-item, *Corophium curvispinum* f. *devium* amounted to 36—60 (an average of 53.8 per cent) *(Fig. 4)*. Trichoptera *(Ecnomus tenellus)* larvae

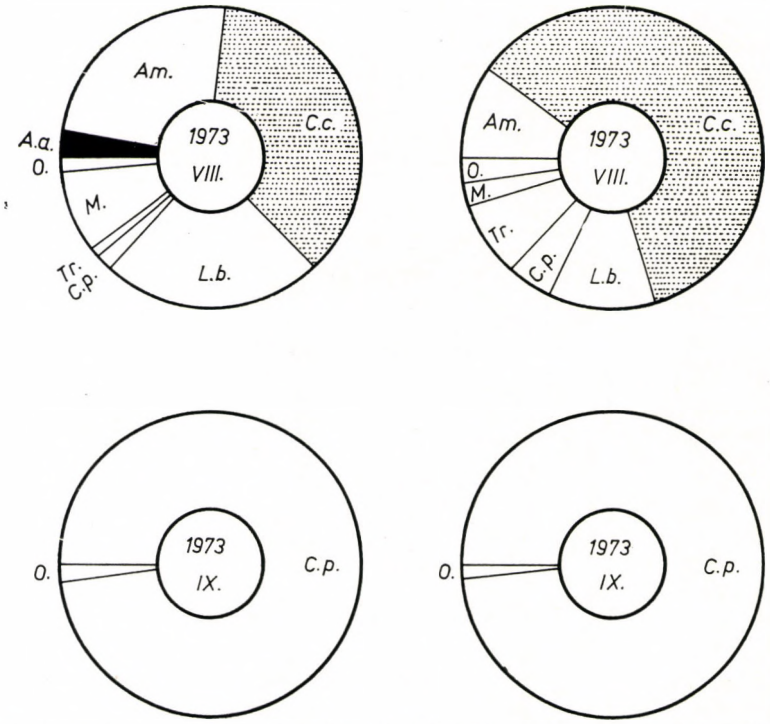

Fig. 3. Food spectrum of eels collected in the littoral zone (August, 1973) and in the open water (September, 1973)

(6.6 per cent) *(Fig. 5)*, Chironomus larvae and pupae *(Tanypus punctipennis* and *Chironomus* ex gr. *plumosus)* (4.1 per cent), while *Lithoglyphus naticoides* snails (4.5 per cent) occurred in considerable quantities. Besides the enumerated species, predominating in the food, Ephemeroptera *(Cloeon dipterum)* larvae were found in 0.6 per cent and *Dreissena polymorpha* in 0.7 per cent. According to frequency of occurence, the amount of fish was only 0.1 per cent. Totally 10 fish remains (*Rutilus rutilus*, *Neogobius fluviatilis*, fry of *Stizostedion lucioperca*, undetermined Cyprinids and Percids) were found in the alimentary tracts, which means that fish consumption of the given sized eels is not significant in the littoral zone which was also established by our previous observations. Since, in littoral waters the food is chiefly consisted of periphytic invertebrates, and in formation of their ratios seasonal variations can be observed. At the same time, the regularities of population dynamics of the animal in question are also remarkable. From this point of wiev, the decrease of the individual number of *Asellus aquaticus* during the summer-autumn period, or just the high number of Chironomids during autumn is most characteristic. The number of food animals consumed by one eel was very variable, and the maximum number of consumed animals showed the following distribution:

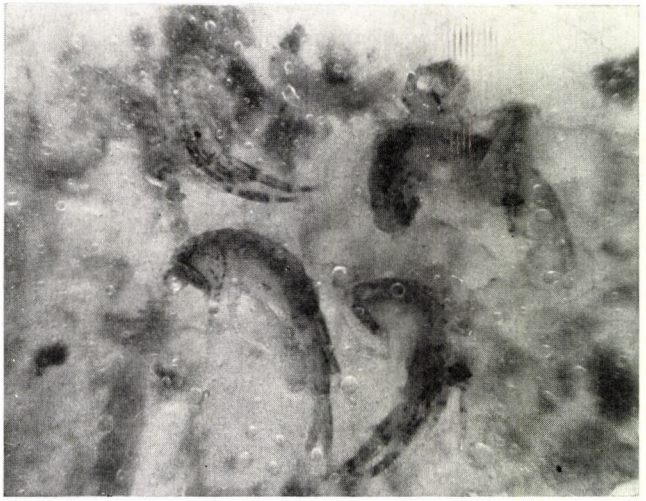

Fig. 4. Corophium curvispium f. *devium* is one of the main food animals in the littoral zone

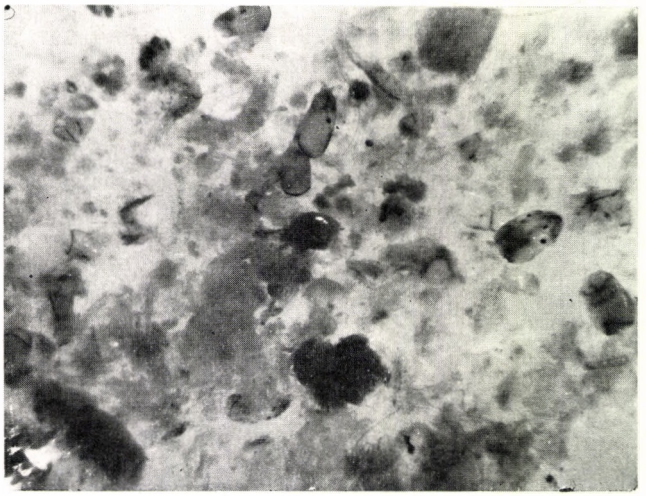

Fig. 5. Ecnomus tenellus (Trichoptera) is a common food in the littoral zone. The head-capsule remains intact for a long time during digestion

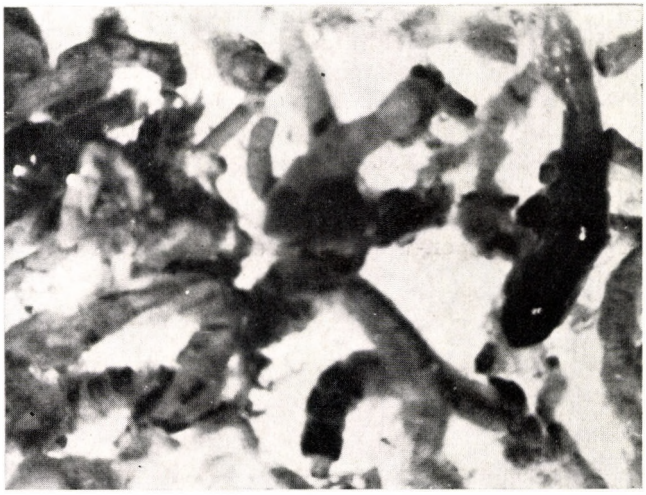

Fig. 6. The predominant food-items in the open water are the larvae and pupae of *Chironomus* ex gr. *plumosus*

	3—7, Aug.	13—17, Aug.
Corophium curvispinum	87	276
Limnomysis benedeni	132	112
Chironomida spp.	8	26
Trichoptera sp.	14	102
Amphipoda spp.	45	38
Lithoglyphus naticoides	92	88
Dreissena polymorpha	3	25
Fish	1	3

Comparing the food of eels caught in the littoral zone, with that originating from open waters, a surprisingly sharp difference was found in the stomach and intestine content. From 811 eels, 24 alimentary tracts were empty, and in the others a fairly unvaried food was found. Among the food-components the larvae and pupae of *Chironomus* ex gr. *plumosus* were almost exclusive (average 98.4 per cent) *(Fig. 6)*, and parallel with this, the other food-items suddenly dropped. Amphipods (*Dicerogammarus* sp.), and *Corophium curvispinum* f. *devium*, species occurring in great masses in the littoral zone, practically disappeared, and only a few specimens (1—4) were found. As compared to observations in the littoral zone, the frequency of occurrence of *Lithoglyphus naticoides* diminished, but that of *Dreissena polymorpha* increased. However, it is very interesting that certain typical littoral forms *(Gyrinus natator, Argyroneta aquatica)* were found only in the stomachs of eels caught in open water, but food-animals of allochthon origin occurred in greater quantities at the same place, as well as Cicadidae spp., Hymenoptera spp. imago. Although their percentual ratios are insignificant, their appearance in the alimentary tracts of eels from open waters is remarkable. During September, in the food of eels collected at open water areas of the lake, the ratio of fish sharply increased. While during August, only 10 fish were found in the alimentary tracts of eels from the littoral zone, in the collections carried out in open waters during September, 177 partly digested fish remains were found. Although their

percentual occurrence is insignificant (all fish was about 0.5 per cent), nevertheless, these data verify the greater importance of fish as food for eels in the open waters than in the littoral regions. Naturally, the living biomass of 177 fish is about twice greater than that of about 35 000 Chironomid larvae. Fish consumption in open waters is mostly characteristic of eels above 60 cm body length. Specimens having exceeded 1 kg of weight may entirely become piscivorous. Besides feeding on fish, they eat large quantities of invertebrates. An interesting comparison can be made if the maximum number of food animals consumed by one open-water eel is compared to that from the littoral zone (see above):

	13 Sept.	28 Sept.
Corophium curvispinum	—	1*
Limnomysis benedeni	—	—
Chironomus ex gr. *plumosus*	298	248
Trichoptera sp.	—	—
Amphipoda spp.	1*	1*
Lithoglyphus naticoides	32	3
Dreissena polymorpha	4	4
Fish	3	6

(figures marked with an asterisk mean the occurrence in only one stomach).

From the above grouping it is seen that the main food animals in open waters are chiefly the larvae and pupae of *Chironomus* ex gr. *plumosus*. According to the latest observations, their population density at the environs of Keszthely Bay amounts to 1000—1500 ind/m^2 (in dry weight it is about 1.6—1.7 g/m^2) (FRANKÓ, personal communication). Owing to their size they are available food for eels, and their dense population makes them an indispensable food-stuff.

Discussion

According to the investigations on the content of eel stomachs and intestines, carried out during 1970—73, it can be established that 30—40 cm long eels are not yet significant competitors of mature, indigenous predatory fish of Lake Balaton. However, Cyprinids and fry, besides prey-fish for predators, a sharp competition against eel may develop. One of the aims of our investigations was besides recognizing the composition of food to elucidate the effect on the biota of the lake. To answer this question on the basis of the material investigated in 1970—72 was not entirely possible. Eels in these investigations were collected from the littoral zone, which in contrary to the open waters, has a more important role for the fish fauna (fry of Cyprinids and young predators), since the food-supply of the lake is mostly concentrated here. The role of the rich periphyton is usually underestimated here. If competition is sharpened, its effect is first felt in the littoral zone which in contrast to the open water areas may heavily influence the feeding of Cyprinids and fry of any fish species. Accordingly, a certain competition cannot be ruled out in the case of eel. Our observations yielded such results which could explain the role of eel in the food-chain, both in the littoral zone and in the open water of Lake Balaton. We should beware of heavily taxing and exploiting the lit-

toral zone by consumers, because recent hydrobiological and ichthyological studies drew attention to the fact that the littoral zone plays a decisive role in the ecosystem of Lake Balaton with its rapidly changing water quality. The main food for fry and Cyprinid stock of the lake are represented of seasonally variable zoocenosis of periphyton developing on stones along the shoreline, and on the macrophytic stands of littoral, shallow waters. Beside these, the biocenosis of reed-grass stands and the zooplankton are also important as food. In the past years, from the fisheries' point of view a very limited attention was directed to the survey of natural food-supply. In this line research must continue since we scarcely know anything about the real food-supply of the lake and population dynamics of invertebrates. Results of pike-perch *(Stizostedion lucioperca)* food investigations carried out in 1971—72 (Biró, 1973) focused our attention to facts that the food organisms most frequently consumed chiefly inhabit the littoral zone. The number of plankton organisms is relatively small in the open water which may explain the slow growth of some fish species there (Biró, 1970a, b; 1971; 1972). In those species, which in older age feed mainly on the benthic macrofauna at open water areas, usually a more rapid growth is observable. This is demonstrated by recent comparative investigations made on the bream stock of Lake Balaton (Biró and Garádi, 1974). It is also a practical experience that eel grows rapidly in Lake Balaton (Tölg, 1962 a; 1963 a), which indicates the seasonally favourable composition and amount of food. Its omnivorous feeding pattern makes fast growth possible (Horváth, 1971; Tölg, 1962a; 1963 b). Still the growth rate is faster here, as compared to other European data (compare with Deelder, 1970) thus, a ready explanation is offered eels found better living circumstances. However, this fact makes us to be more careful concerning further stockings, because the inhomogenous distribution of food-supply consisting of qualitatively and quantitatively greatly variable species, and their extreme exploitation by fish (such as overstocking of eel) may bring about unfavourable consequences. Attention was already called to this danger in a previous paper (Biró and Elek, 1970).

Pollution (oil, detergents) the influx of toxic materials (pesticides), furthermore the destruction of Phragmites stands along the shores (Tóth, 1972), and the accumulation of the former in the food-chain can also decrease the number of food organisms. Investigating the food of ruff *(Acerina cernua)* in Lake Balaton (Ponyi et al., 1972) we concluded that the ratio of Chironomids in their food suddenly increased from 8—9 to 23—58 per cent, as compared to the previous years (Tölg, 1960). Such a high quantitative change of Diptera (compare with Entz, 1965) refers unanimously to the eutrophication of the lake. This benthic food-supply gains increasing importance.

In 1973, investigating the food of eels in open water against the littoral zone, conspicuous differences were observed in which sharp seasonal and annual changes were recorded. Different seasonal role of food organisms and the difference of food composition of eels inhabiting the littoral zone and open water areas can be followed in *Fig. 7*. Since the stomach and intestine of specimens from open waters were full with Chironomid larvae, so their quantitative exploitation and that of other macrobenthic organisms should be elucidated with further investigations. The alimentary canal of Chironomid larvae is suitable for the reception of a considerable amount of mud rich in organic detritus (Entz, 1964) with which they were full without exception.

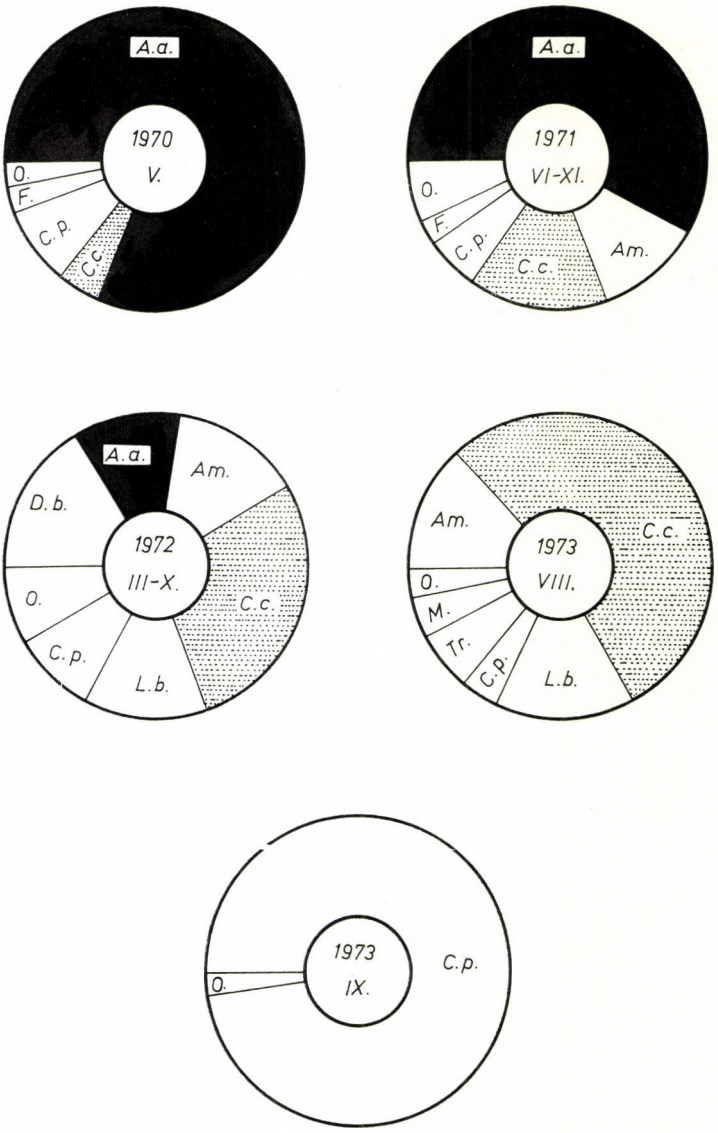

Fig. 7. Comparison of eel food spectrums in Lake Balaton. Percentual changes in food composition in the littoral zone and open water, during 1970—73

From this we conclude that the eel production in the open water of Lake Balaton is decisively based on the mud. Bacteriological, phytoplankton and benthos researches carried out during last years contributed to this problem (Oláh, 1973a, b; Tamás, 1971; Herodek and Tamás, 1973).

Our investigations show the food composition of eels in Lake Balaton in full details in the littoral zone and in the open water, too. These results are in agreement with observations carried out on the food of eel in various European

waters (see DEELDER, 1970; MORIARTY, 1972). Drawing conclusion from the quantity of food, it is evident that the prey-animal populations are intensively utilized by eels both in the littoral and in the open water areas. The significant variances observed in the density of invertebrates, similar to the decrease of some animal (such as *Astacus leptodactylus* crab) and of fish species (*Perca fluviatilis, Acerina cernua, Gobio fluviatilis)* suggest great circumspection. Eel stockings should be reduced chiefly in the north-eastern basin of Lake Balaton until we obtain correct data on the natural food-supply of Lake Balaton. Parallel studies on the eel population of Lake Balaton may give essential data to a better understanding of the niche of this fish species.

Summary

From the investigations on stomach and intestine contents of eels carried out during 1970—73, the following have been established:

1. The main food items of eel are sharply distinguished in the littoral zone and in the open water areas. In the former, among the periphyton-living animals various crustaceans *(Asellus aquaticus, Dicerogammarus* spp., *Corophium curvispinum* f. *devium, Limnomysis benedeni)* yield the main food, whereas they have no practical importance in the open water (1000—1500 m off shore). They are replaced by larvae and pupae of *Chironomus* ex gr. *plumosus* representing a sigificant biomass, and besides these the ratios of molluscs *(Lithoglyphus naticoides, Dreissena polymorpha)* and fish are also increased. Eel production at open water is decisively based on mud of high organic detritus content by the mud-consuming Chironomids.

2. Eel in Lake Balaton grows rapidly even in European respects, it is an intensive food-utilizer owing to its omnivorous feeding pattern.

3. No sharp competition between eel and other predatory fish (pikeperch, pike, etc.) was found, however, the food-supply in the littoral zone was of decisive importance from the viewpoint of the development of Cyprinids and fry. Slight food pauperisation of this region was observed, consequently, we must beware of overstocking the lake with eels.

4. The discovered feeding relations press for a quantitative survey of food-supply of Lake Balaton, which is yet inadequately known.

Acknowledgements

During 1970—73, our eel-food studies under the subject of "Investigations on natural waters to develop more productive fish fauna" were financially supported by Fish Culture Research Station (Szarvas) and by National Fishery Inspectorate (Budapest). Balaton Fishing Company (Siófok) provided us with eels caught in the open water areas. I should like to express my gratitude to the above Organisations. I am personally grateful to M. RIBIÁNSZKY (Budapest) and to Dr. J. PONYI (Tihany) for organizing the subject, to I. BÁTHORY and Miss. B. HORVÁTH assistants (both from Tihany) for performing the littoral collections and for their help offered during laboratory treatments.

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AZ ANGOLNA (*ANGUILLA ANGUILLA* L.) TÁPLÁLÉKÁNAK VIZSGÁLATA A BALATONBAN

Bíró Péter

Összefoglalás

1970—73 években végzett angolna gyomor- és béltartalom vizsgálataink során a következő főbb megállapításokat tehettük:

1. A parti övben és a tó nyílt vízi területein az angolnák fő táplálékbázisa élesen elkülönül. A parti övben a bevonatlakó állatok közül a különböző rákok *(Asellus, Dicerogammarus* spp., *Corophium, Limnomysis)* jelentik a fő táplálékot, míg ezzel szemben a partvonaltól 1000—1500 m-re a nyílt vízben gyakorlatilag nincs jelentőségük. Szerepüket a tekintélyes élő biomasszát képviselő *Chironomus* ex gr. *plumosus* lárva és báb alakjai veszik át, mellettük a puhatestűek *(Lithoglyphus, Dreissena)* és a halak részaránya is nő. A nyílt vízben az angolna produkciója az iszapfaló Chironomida-k révén, döntő mértékben a tó szerves törmelékben gazdag iszapján alapul.

2. Az angolna a Balatonban európai viszonylatban is gyorsan fejlődő, intenzív táplálékhasznosítású faj, mindenevő.

3. Éles táplálék-konkurrenciát eddig az angolna és más ragadozó halak (fogassüllő, csuka) között nem találtunk, a békés halak és halivadék fejlődése szempontjából a parti öv táplálékkészlete viszont döntő jelentőségű. E régió táplálékbeli elszegényesedésére több jel is mutat, ezért a tó angolnákkal történő túlnépesítésétől minden körülmények között óvakodni kell!

4. A feltárt táplálkozási kapcsolatok a Balaton mennyiségileg mindeddig ismeretlen természetes táplálékkészletének mielőbbi felmérését sürgetik.