Verh. Internat. Verein. Limnol.	28	273–278	Stuttgart, February 2002

Fish species assemblages in inflowing waters of Lake Balaton (Hungary)

Péter Bíró, András Specziár and Katalin Keresztessy

Introduction

Northern and southern inflows with diversified hydrological characteristics around Lake Balaton (Hungary) seem to be refugia for self-sustaining stocks of a number of fish species. This was observed during the intensive eutrophication, and/or as a consequence of overstocking of alien species, e.g. eel (*Anguilla anguilla*). Inflowing rivulets provide living areas for a number of endangered and rare fish species (habitats, nursing and feeding areas). Following the dredging of the natural bays and marshy areas in the past (with the exception of the River Zala), the inflowing rivulets provided replacement habitats for these rare species (Bíró 2000). Przybylski et al. (1991) first described the occurrence and feeding of fish species inhabiting northern inflows. Keresztessy (1993, 1996) contributed to the knowledge of fish distribution in various rivulets; Bíró (1978, 1983, 1997) and Specziár et al. (1997) studied the population dynamics and trophic relationships of fish assemblages in Lake Balaton. The ratio of most fish species in the outlet of Héviz Spa and in Lake Balaton, as well as in its inflowing waters, has changed as the result of area modifications. In the Kis–Balaton Water Reservoir and in its adjacent rivulets, the presence of 20–27 fish species could be observed (Bíró & Paulovits 1994). Various studies on faunistics, ecology and population dynamics during the last few years (1995–2000) have established the occurrence of 26 fish species in these water bodies, in varying densities. Due to intensified tourism, water quality deterioration, commercial and sport fisheries and habitat modifications, most species became endangered. Independent of season, the majority of small-sized, endangered and protected species occasionally immigrate into Lake Balaton from the variable biotopes of inflowing rivulets and backwaters.

The aim of the present study, conducted during 1995–2000 in various biotopes of Lake Balaton, was to review the species assemblages and size structure of fish stocks inhabiting the littoral zone and the open water areas, and their temporal–spatial changes.

Methods

Studies were carried out at 13 littoral and open water areas along the northern and southern shorelines, in parallel with the longitudinal axis of Lake Balaton (Balatonfüzfő, Balatonalmádi, Csopak, Sajkod, Zánka, Keszthely: *Phragmites* stands, stony shores, and 200- and 1500-m offshore areas). Based on biweekly collections, the distribution, food and feeding, as well as the growth of fish species, were analyzed. Samples were collected with the aid of an electric shocker (Smith–Root Inc., Model 12 B, max. 400 W, 300–700 V, 60–80 Hz, 0.5–2 ms impulse width), and a multi-mesh gillnet (5, 6.25, 8, 11, 14, 18, 24, 30, 40, 50, 65 and 80-mm mesh sizes). The 5- to 14-mm panels were 1.5 m deep, and those of 18- to 80-mm were 3 m deep. Data were standardized for net (12 pc 10-m long panel) and active fishing time units with the help of the PASGEAR software (Kolding 1997, Specziár et al. 2000). During recent years, monthly studies were focused on fish species assemblages, their area of distribution (habitat overlaps), migration, biomass (kg/ha), production and spawning conditions (reproductive guilds) in 14 northern and southern inflows (Fig. 1). Samples were taken with an electric shocker using direct current (Noviki, HF-205, 1,5–2,5 A, 110 V pulsing direct current), and with a framed net (60 × 90-cm size and 2 × 3-mm mesh size). Water temperature, depth, width, flow rate, pH (HANNA ATC Piccolo-2 pH tester) and conductivity of water were measured (WTW 03-type oxymeter) and the surface coverage with reed-grass stands was assessed. The standard length and weight of specimens were measured, and their total biomass for 100 m^2 was assessed. Biomass estimates for Lake Balaton and KBWR were obtained from Bíró (1997) and Bíró & Paulovits (1994).

0368-0770/02/0028-000273 $ 1.50

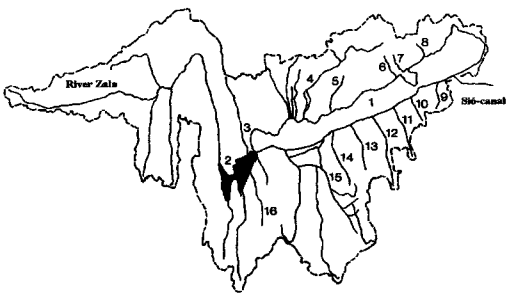

Fig. 1. The drainage area of Lake Balaton with location of the Kis–Balaton Water Reservoir (KBWR) and sampling sites in the northern and southern inflowing waters. 1, Lake Balaton; 2, Kis–Balaton Water Reservoir; 3, Hévíz Spa and its outflow; 4, Eger-víz; 5, Burnót Brook; 6, Örvényesi-séd; 7, Aszófői-séd; 8, Lovasi-séd; 9, Endrédi Brook; 10, Kőröshegyi-séd; 11, Büdösgáti-víz; 12, Nagymetszés Brook; 13, Tetves Brook; 14, Jamai Brook; 15, Keleti-bozót Canal; 16, Marótvölgyi Canal.

Results

Table 1 summarizes the presence/absence and estimated biomass of fish species in Lake Balaton and its drainage area. Altogether 34 native and 10 alien species are known to occur in the lake and adjacent water bodies. The number of native fish species varied from three to 24 in different localities, and only one inflowing water body (Aszófői-séd) did not contain any fish.

In 2000, observations were made as follows. In the Marótvölgyi Canal, a new area of occurrence, the European mud-minnow (*Umbra krameri*) formed a dense population (3.1 kg/ha), and in the Keleti-bozót Canal, the brown bullhead (*Ictalurus nebulosus*) also appeared in great masses. The brown bullhead is a recent immigrant in Lake Balaton, having shown an explosion-like appearance in the vicinity of Balatonlelle during 2000.

In *Phragmites* stands of Lake Balaton, where an electric shocker was used, according to their biomass, common carp (*Cyprinus carpio*) – 35.9%, common bream (*Abramis brama*) – 13.4%, eel (*Anguilla anguilla*) – 10.1%, Prussian carp (*Carassius auratus gibelio*) – 9.5%, amur (*Ctenopharyngodon idella*) – 9.2% and roach (*Rutilus rutilus*) – 7.8%, were significant components. Predators (excluding eels) constituted 3.6%. No defined trend was observed in CPUE values along the longitudinal axis of the lake; however, minor differences in species composition were due to the special structure and characteristics of reed-grass stands (sedimentation). Altogether, 24 fish species occurred in these habitats. Based on gillnetting at 200 m offshore, and excluding the eel, the most common species were common bream – 32.0%, razor fish (*Pelecus cultratus*) – 14.6%, white bream (*Blicca bjoerkna*) – 13.2%, common carp – 8.6%, roach – 8.3%, bleak (*Alburnus alburnus*) – 7.5% and Prussian carp – 6.1%. The ratio of predators (excluding eels) was 6.8%. CPUE values in Keszthely Bay were 1.5 times higher than on the other areas of the lake. Altogether, 24 species occurred in these biotopes. A total of 19 fish species were collected in areas 1500 m offshore. Here the biomass ratio of common bream – 48.4%, razor fish – 27.8%, bleak – 6.7%, white bream – 6.1% and roach – 5.5% appeared to be significant. The ratio of predators was 4.1%. The highest biomass values (recalculated from Bíró 1997) were characteristic of common bream (169–177 kg/ha), bleak (36.8–59.5 kg/ha), and other cyprinids (roach, rudd (*Scardinius erythrophthalmus*), white bream). In the middle of the 1990s, European eel was still present at ca. 22 kg/ha, being fished intensively after its mass mortality in 1991. In the 1980s, in the Kis–Balaton Water Reservoir, usually very high fish biomass could be observed, with the dominance of Prussian carp (11–890 kg/ha) and European mud-minnow (in a restricted area, 38–328 kg/ha).

Fourteen inflowing waters along the southern and northern shorelines of Lake Balaton differed greatly in their fish species composition. Some of them showed peculiar characteristics especially in the number of their common species and in those occurring only in one or two inflows. The richest brooks and canals were the outflow of Hévíz Spa (18 species), Nagymetszés Brook (11 species) and Eger-víz, Lovasi-séd and Keleti-bozót Canals (seven to eight species) with occurrences of one to three alien species,

Table 1. Estimated biomass (kg/ha) of fish species occurring in the drainage area of Lake Balaton, in its northern and southern inflows (modified after BÍRÓ 1997).

Species	Lake Balaton**	KBWR***	Hévíz Spa and its outflow	Eger-víz	Burnót Brook	Örvényesi-séd	Aszófői-séd	Lovasi-séd	Endrédi Brook	Kőröshegyi-séd	Büdösgáti-víz	Terves Brook	Jamai Brook	Nagymetszés Brook	Keleti-bozót Canal	Marórvölgyi Canal
1. Roach *Rutilus rutilus*	1.4–23.4	+	+	3.9	16.8	27.5	–	23.4	1.2	0.9	11.8	+	8.4	+	20.5	–
2. Sunbleak *Leucaspius delineatus*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.1
3. Chub *Leuciscus cephalus*	+	–	+	2.3	–	0.9	–	–	–	–	–	–	–	–	–	–
4. Ide *Leuciscus idus*	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
5. Minnow *Phoxinus phoxinus**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
6. Rudd *Scardinius erythrophthalmus*	8.6–31.3	+	+	0.7	–	–	–	–	–	0.3	+	0.8	2.1	+	5.4	8.5
7. Asp *Aspius aspius*	+	+	+	–	–	–	–	–	–	–	10.4	20.5	–	22.0	–	–
8. Tench *Tinca tinca*	+	+	–	–	–	–	–	–	–	–	0.8	0.8	–	0.4	–	7.5
9. Gudgeon *Gobio gobio*	+	+	+	6.7	–	–	–	1.2	–	–	–	–	–	+	–	–
10. 'White-fin' gudgeon *G. albipinnatus*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
11. Bleak *Alburnus alburnus*	36.8–59.5	+	+?	26.3	2.9	29.1	–	6.1	14.0	6.6	61.1	48.3	+	44.9	7.3	1.5
12. Spirlin *Alburnoides bipunctatus*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
13. White bream *Blicca bjoerkna*	3.1–19.6	+	–	–	–	–	–	–	–	–	0.7	0.1	–	–	–	–
14. Common bream *Abramis brama*	169–177	+	+?	+	5.7	12.5	–	10.7	1.2	0.6	2.6	0.9	–	2.3	11.2	–
15. White-eyed bream *A. sapa*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
16. Blue bream *A. ballerus*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
17. Razor fish *Pelecus cultratus*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
18. Bitterling *Rhodeus sericeus amarus*	+	+	+	+	0.5	+	–	0.8	6.5	3.4	20.3	3.6	+	5.2	1.5	–
19. Crucian carp *Carassius carassius*	+	+	–	–	–	0.3	–	–	2.1	–	–	–	–	–	–	14.8
20. Prussian carp *C. auratus gibelio*	0.23–8.36	11–890	+	–	4.5	–	–	7.6	5.5	+	9.2	1.2	–	7.5	6.1	–
21. Common carp *Cyprinus carpio*	+	+	+	–	–	–	–	–	–	–	–	–	–	–	+	–
22. Stone loach *Barbatulus barbatulus*	–	+	–	0.8	–	–	–	–	–	–	–	–	–	–	–	–
23. Weatherfish *Misgurnus fossilis*	+	+	+	–	–	–	–	–	–	–	0.5	–	–	0.9	1.3	–
24. Spined loach *Cobitis taenia*	–	+	+	0.6	–	–	–	–	–	–	–	–	–	–	–	–
25. Wels *Silurus glanis*	0.72	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
26. European eel *Anguilla anguilla*	21.97	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 1. *contd.*

Species	Lake Balaton**	KBWR***	Hévíz Spa and its outflow	Eger-víz	Burnót Brook	Örvényesi-séd	Aszófői-séd	Lovasi-séd	Endrédi Brook	Kőröshegyi-séd	Büdösgáti-víz	Tetves Brook	Jamai Brook	Nagymetszés Brook	Keleti-bozót Canal	Marótvölgyi Canal
27. European perch *Perca fluviatilis*	+	+	+	0.8	–	–	–	5.8	–	0.5	–	0.2	–	2.9	4.2	–
28. European mud-minnow *Umbra krameri*	–?	38–328	+	–	–	–	–	–	–	–	0.9	–	–	–	–	3.1
29. Pike *Esox lucius*	0.48–3.1	+	–	8.5	–	12.9	–	0.8	3.8	–	+	2.4	+	+	1.3	–
30. Pikeperch *Stizostedion lucioperca*	1.7–50	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
31. Volga pikeperch *S. volgensis*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32. Ruffe *Gymnocephalus cernuus*	+	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–
33. Marmored goby *Proterorchinus marmoratus*	–?	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
34. Burbot *Lota lota*	–?	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Total number of native species	24	21	18	8	4	3	–	7	5	4	5	6	4	11	8	6
35. Chinese rasbora *Pseudorasbora parva*	+	+	–	1.9	3.5	2.6	–	1.5	56.7	7.3	4.5	1.5	+	1.5	3.0	–
36. Pumpkinseed *Lepomis gibbosus*	+	+	–	+	–	–	–	–	–	–	–	–	–	+	8.6	–
37. Monkey goby *Neogobius fluviatilis*	0.48–5.02	+	–	+	–	–	–	–	–	–	–	–	–	+	–	–
38. Brown bullhead *Ictalurus nebulosus*	+	–	–	+	–	–	–	–	–	–	–	–	–	2.7	3.1	–
39. Silver carp *Hypophthalmichthys molitrix*	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
40. Gass carp *Ctenopharyngodon idella*	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
41. Bighead carp *Aristichthys nobilis*	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
42. Mosquito fish *Gambusia affinis holbrooki*	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
43. Largemouth bass *Micropterus salmoides*	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
44. Cichlid fish *Herotilapia multispinosa*	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Total number of alien species	6	5	2	5	1	1	–	1	1	0	1	1	1	3	2	–

*Earlier occurrence in Gerence Brook (Bakony Mountains at Bakonybél); ** estimated during 1995–1997 (Bíró 1997); *** estimated during 1990–1993 (the majority of biomass estimates refer to all fish present) (Bíró & Paulovits 1994).

respectively. Roach was common in about 50% of inflowing waters, varying from 0.9 to 27.5 kg/ha. Asp (*Aspius aspius*) was present in three inflows between 10.4 and 22 kg/ha. Bleak used to be a widely distributed element, with biomass values varying between 1.5 and 61.1 kg/ha. Common bream exceeded 10 kg/ha biomass in Örvényesi- and Lovasi-séd and Keleti-bozót Canals. An extreme biomass of bitterling (*Rhodeus sericeus amarus*) has been observed in

Büdösgáti víz (20.3 kg/ha). Crucian carp (*Carassius carassius*) formed a dense stock only in the Marótvölgyi Canal (14.5 kg/ha). The perch (*Perca fluviatilis*) proved to be significant in the Lovasi-séd and the Keleti-bozót Canal. A dense population of pike (*Esox lucius*) was observed in the Örvényesi-séd (12.9 kg/ha). Among alien species, Chinese rasbora (*Pseudorasbora parva*) formed an extraordinarily dense population in the Endrédi Brook (56.7 kg/ha), pumpkinseed (*Lepomis gibbosus*) in the Keleti-bozót Canal (8.6 kg/ha), and brown bullhead in the Nagymetszés Brook and Keleti-bozót Canal (2.7 and 3.1 kg/ha, respectively).

Discussion

Comparative investigations showed about one order of magnitude difference in fish productivity between the littoral and the open water biotopes, and that the littoral communities are especially sensitive to internal and external effects, as well as to the food-stuff of these habitats (SIMONIAN et al. 1995, SPECZIÁR & BÍRÓ, 1998, SPECZIÁR et al. 2000).

Due to eutrophication, water quality deterioration, water level regulation, and the systematic introduction of exotics, the inflowing brooks serve as refugia for a number of native fish (BÍRÓ 1997). Their varied bottom profile, drop and flow rate and their chemical characteristics also result in well-defined differences in the fish fauna composition. Qualitative and quantitative compositions of fish stocks in various inflows showed varying distributions during the last 5 years. With the exception of the River Zala, only smaller brooks and waters flow into Lake Balaton. These small-sized inflowing rivulets are highly significant: they act as spawning and nursing areas, as well as feeding places for the natural recruitment of the majority of fish. At the same time, shoals of small-sized common individuals form a prey base for the lake predators. Due to the special characteristics of Hévíz Spa, only a few fish species can adapt to the 'tropical' conditions; however, in the components of fish species assemblages in its outflow, further modifications are highly probable. A high number of diversified biotopes of the Hévíz–Páhok Canal system, and the ditch system with marshy waters surrounding the Kis–Balaton Water Reservoir, are the main areas of distribution of rare, protected and endangered fish species (BÍRÓ & PAULOVITS 1994).

During the last 20 years, the density and biomass of fish populations varied in parallel with the longitudinal trophic gradient of Lake Balaton (yields: 7.6–46.3 kg/ha). On analyzing the percent distribution of different species in the commercial catches, a significant increase in the ratio of alien species (eel, silver carp, Prussian carp) was apparent, in contrast to the native species. Modified parameters of the population dynamics of pikeperch, common bream, asp, razor fish and bleak indicated basic changes.

Acknowledgements

Studies were financially supported by OTKA (# T029960), MEH-MTA and OVIBER. The authors would like to thank GÁBOR PAULOVITS, ISTVÁN BÁTHORY, GÉZA DOBOS, BÉLA SZECSŐDI and ISTVÁN VARANKA for their help provided in the field.

References

BÍRÓ, P., 1978: Exploitation of fishery resources of Lake Balaton. – *Verh. Internat. Verein. Limnol.* **20:** 2146–2149.

BÍRÓ, P., 1983: On the dynamics of fish populations in Lake Balaton. – *Rocz. Nauk Rolniczych H* **100:** 55–64.

BÍRÓ, P., 1997: Temporal variation in Lake Balaton and its fish production. – *Ecol. Freshwater Fish.* **6:** 196–216.

BÍRÓ, P., 2000: Changes in Lake Balaton and its fish populations. – In: ROSSITER, A. & KAWANABE, H. (eds): *Biology of Ancient Lakes: Humans, Culture and Biodiversity. – Adv. Ecol. Res.* 31 – Academic Press, London. pp. 599–613.

BÍRÓ, P. & PAULOVITS, G., 1994: Evolution of fish fauna in Little Balaton Water Reservoir. – *Verh. Int. Verein. Limnol.* 25(4): 2164–2168.

KERESZTESSY, K., 1993: Faunistical research on Hungarian protected fish species. – *Landscape Urban Plann.* 27: 115–122.

KERESZTESSY, K., 1996: Threatened freshwater fish in Hungary. – In: KIRCHHOFER, A. & HEFTI, D. (eds): *Conservation of Endangered Fish in Europe.* – Birkhauser Verlag Basel/Switzerland. pp. 73–77.

KOLDING, J., 1997: *PASGEAR – A Database Package for Experimental Fishery Data from Passive Gears.* – Department of Fisheries and Marine Biology, University of Bergen, Bergen, pp. 52.

PRZYBYLSKI, M., BÍRÓ, P., ZALEWSKI, M., TÁTRAI, I. & FRANKIEWICZ, P., 1991: The structure of fish communities in streams of the northern part of the catchment area of Lake Balaton (Hungary). – *Acta Hydrobiol.* (Kraków) **33(1/2):** 135–148.

SIMONIAN, A., TÁTRAI, I., BÍRÓ, P., PAULOVITS, G., TÓTH G-., L. & LAKATOS, GY., 1995: Biomass of planktonic crustaceans and the food of young cyprinids in the littoral zone of Lake Balaton. – *Hydrobiologia* **303**: 39–48.

SPECZIÁR, A. & BÍRÓ, P., 1998: Spatial distribution and short-term changes of benthic macrofauna in Lake Balaton (Hungary). – *Hydrobiologia* **389**: 203–216.

SPECZIÁR, A., TÖLG, L. & BÍRÓ, P., 1997: Feeding strategy and growth of cyprinids in the littoral zone of Lake Balaton. – *J. Fish Biol.* **51**: 1109–1124.

SPECZIÁR, A., TÖLG, L. & BÍRÓ, P., 2000: A Balaton halfaunájának vizsgálata (Investigation of Lake Balaton's fish fauna). – *Halászatfejlesztés* **24**: 115–125.

Authors' addresses:

P. BÍRÓ, A. SPECZIÁR, Balaton Limnological Research Institute, Hungarian Academy of Sciences, H-8237 Tihany, Hungary.

K. KERESZTESSY, St. István University, Dept. of Animal Husbandry, H-2103 Gödöllő, Hungary.