Chapter 17
Fishes of the Drava River

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Abstract The chapter presents the fish fauna of the Croatian-Hungarian section of the river by overview the fish faunistic literature of studies conducted between 1992 and 2016, provides an example for littoral fish assemblages, and evaluates the ecological status of a river reach on this basis. It seems that 66 fishes, most of them belong to the family Cyprinidae and one cyclostomata species occur in the studied river section. However, the number of species regularly inhabiting the Croatian-Hungarian section could be about 51, because some species require different habitat type than the main channel of the studied section, or they are not able to reach the studied section due to migration barriers. There are also some taxa with unclear taxonomic status. Twenty-two species are listed in one of the annexes of the European Union Habitats Directive. The ratio of native to non-native species is 52:15. Monkey goby (*Neogobius fluviatilis*) and western tubenose goby (*Proterorhinus semilunaris*), two non-native Ponto-Caspian gobies, appear to be among the most abundant fishes in the littoral zone. Recently, other goby species (*Ponticola kessleri*, and *N. melanostomus*) formerly not known from the Drava have been found at the lower end of the studied river section and results anticipate their potential future spreading upstream. Fish assemblages tend to mirror an overall good ecological status and the rich fish fauna is of considerable nature conservation value due to the minimum alteration of habitats and the relative geographical proximity of the Danube. Therefore, for an effective conservation of the fish fauna the actual seminatural status of the Drava riverscape is to be maintained.

Keywords Biodiversity · Fish faunistics · Non-native species · Ecological connectivity · Ecological status

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17.1 Introduction

Fish play a great socio-economic role in our life. In addition to recreational and fishery interests, the structure of fish assemblages can be used as an indicator of the environmental status of rivers. To monitor fish in a river system, researchers usually make faunistic stock surveys in the field. However, it is very challenging to compile a 'scientifically valid and relevant' species list since the spatial distribution of species is dynamic, some species can appear in and disappear from a focal stream system due to natural spreading and/or anthropogenic activity. For example, the spectacular upstream spreading in the Danube catchment and colonization of the Rhine basin by Ponto-Caspian gobies experienced since the last decades of the 20th century is probably a result of an interaction of a quasi-natural range expansion and human-aided distributions (Roche et al. 2013; Manné et al. 2013). In contrast, the disappearance of native anadromous sturgeon species from the middle Danube catchment could be attributed primarily to the construction of the Iron Gate Barrages on the Danube.

Alongside the dynamic nature of the geographical range of species, evolution of scientific methodology could be another relevant issue in faunistics. The molecular techniques used more and more frequently in taxonomy tend to reveal diverse, hidden phylogenetic relationships within species that can be considered as a single taxonomic unit on the basis of morphology (e.g. Mendel et al. 2008; Takács 2012; Takács et al. 2014; Antal et al. 2016). Changes in taxonomy and nomenclature induced by molecular phylogeny generally originate from how biologists interpret the species concept (Agapow et al. 2004). Fish taxonomists operated mainly with morphological characters before the flourishing era of molecular biology, but nowadays molecular biotechnology has deeply penetrated into systematics and taxonomy too and make biologists reconsider what a species is and what relationships exist among taxa.

Nature conservation legislation generally lags behind the frontiers of taxonomy and use names no longer valid in the light of modern taxonomy. Meanwhile, the fishes living in the focal stream system themselves are the same, but the enumeration and nature conservation evaluation of the fauna members could rarely be complete or correct because of all these above mentioned facts.

Comprehensive information on the fauna of a stream system is not sufficient to assess the quantitative characteristics of the fish stocks in detail. Naturally, if a species is frequently caught in faunistic surveys, it suggests us that the species is probably common in terms of abundance. However, different faunistic studies usually use different or even combined methods to catch fish (e.g. electrofishing by wading, from the riverbank or a boat; seine netting) in order to being able to sample most of the habitats in the study area. Moreover, authors can also incorporate additional information, like anglers' reports to make their species list 'complete'. Despite multifaceted sampling, data on the number of the individuals caught are hardly numerically comparable, sometimes even within a single faunistic study, not to mention cross-study comparisons. A simply reason for the lack of comparability is that the probability of detection of a fish species also depends, among other factors, on sampling method. Therefore, corresponding to the type of the water body to be surveyed and the region (i.e. country), various standardized sampling protocols allow the quantitative investigation of fish assemblages.

The application of standardized fish sampling protocols combined with data on the abiotic environment of the habitats help elaborate environmental bioassessment methods (Karr 1981, 1991). Actually, fish are among the five groups of organisms which are suggested as biological quality elements for the classification of ecological status of rivers by the Water Framework Directive of the European Union (European Commission 2000).

As a major right-bank tributary of the Danube River, the Drava River has a rich fish fauna. Along the upper course of the river in Austria, Slovenia and Croatia, a series of hydropower plants alter natural hydromorphological connectivity (see Chap. 9 in this volume). Above the dams, reservoirs are highly unfavorable for rheophilic riverine fish species, often utilized by fishery, so game fish species are usually introduced. Dams prevent potamodromous and diadromous fishes from migrating between their upstream spawning and downstream feeding, overwintering habitats (Baxter 1977). Although fish passes are usually built in barrages to mitigate the unwanted effects of river impoundment, hydropower plants modify riverine fish fauna. The Croatian-Hungarian section of the Drava River is much less modified. In this chapter, the fish fauna of the Croatian-Hungarian section is presented.

17.2 Faunistic Literature

Harka (1992) surveyed the fish fauna between two Hungarian settlements, Őrtilos and Gordisa, at five locations, in July 1990. On the basis of his own samples and inspection of anglers' catches, he reports the presence of 48 species.

Majer (1995) collected data on the fish fauna between Őrtilos and Drávaszabolcs (Hungary) at seven locations. Unfortunately, he does not mention the date of the field surveys, and he does not distinguish the species recorded by him in the field from the species reported in the literature. Majer (1998) reports the occurrence of 47 fish species after surveying the main channel, side-arms and oxbow lakes at 14 locations, inspecting anglers' catches between 1995 and 1997.

Croatia planned to build a new hydropower plant near Novi Virje, but it has not been realized to date. As a baseline environmental assessment conducted before the potential building started, Majer and Bordács (2001) had sampled the river upstream of the barrage site, between Őrtilos and Zákány villages (Hungary) and downstream, between Bélavár and Vízvár (Hungary) at altogether ten sites. They report 40 species but only 39 are listed in Table 3. Moreover, because the pumpkinseed (*Lepomis gibbosus*) is mentioned twice in the table, the actual number of the species they found must be 38.

Until now, the most detailed fish faunistic survey of the Croatian-Hungarian Drava section has been completed by Sallai (2002a, b). He sampled a wide variety of habitats, for example, gravel bars and rip-rap banks in the main channel, side-arms and oxbow lakes. Unfortunately, it is not easy to identify the exact number of the sampling locations from the report. Nonetheless, it seems that samples were taken at about 19 locations between Őrtilos and Matty, from 11 April 2001 to 19 October 2001. Synthesizing his own field data and anglers' reports verified by photo documentation, Sallai (2002b) proves the presence of 57 species in the studied section, although there are only 52 denoted in Table 5 as occurring in the Drava. Among the species with proved occurrence, eight had been unknown from the studied Drava section. Considering literature and his own data, Sallai (2002b) suggests a total of 64 fish species of occasional or regular occurrence.

The possible construction of the new, aforementioned hydropower plan near Novi Virje, Croatia, motivated Sallai (2004) to review the literature and his own data on fish fauna of the Drava River. Apart from the Eurasian minnow (*Phoxinus phoxinus*), the species listed in this study are actually the same as those enumerated by Sallai (2002b).

Soon after, Sallai and Kontos (2005) report the faunistic results from 11 monitoring sites on the Hungarian bank between 1999 and 2004. In fact, this study includes the report of Sallai (2002a, b), supplemented with new information. Contrary to Sallai (2002b), in this study 63 fish species are presumed to occur occasionally or regularly in the study region. The occurrence of the Eurasian minnow was not confirmed.

The fish monitoring of the Croatian Drava sections started in 2007 and the data were presented by Sallai and Kontos (2008). The monitoring sites were located between Őrtilos and Barcs, but their exact number is difficult to reconstruct, because the resolution of the site map is poor and no coordinates are indicated. Authors report field data obtained not only from the 2007 monitoring but from 2004 as well. All in all, they report the direct observation of 40 fish species, including the Eurasian minnow form the Croatian section.

Jelić et al. (2012) conducted a faunistic survey near Donji Miholjac (Croatia) at 18 sampling sites in 2006. They sampled the main types of habitats, such as the main channel, side-arms, backwaters and artificial channels, and also obtained information from local anglers. Authors give a species list in Table 1 with the species from their field research and literature since 1985. In this list, 46 species are denoted as a species recorded in their study, but, strangely, they report a total of only 44 species in the English summary of the article. The occurrence of six species was based on information from anglers. Compared to the previously mentioned faunistic studies, Jelić et al. (2012) mention the presence of the Kessler goby (*Ponticola kessleri*) for the first time.

In their short communication, Csipkés et al. (2012) report the first known occurrence of the western three-spined stickleback, *Gasterosteus gymnurus* Cuvier, 1829, in the Drava River. They caught one specimen near Matty on 7 September 2010. The taxonomic identification was based on the incomplete armoration of the fish. Formerly, the less armored form of the three-spined stickleback was considered as a subspecies, *G. aculeatus gymnurus*, however, this taxon was raised to species level rank (FishBase).

As a most recent faunistic result, Sallai (2016) reports the presence of the Kessler goby and round goby (*Neogobius melanostomus*) from Matty. The gobies were caught on 22 September 2015. To our knowledge, this is the first detection of round goby in the Drava.

17.3 Methods

We compiled a list on fish species known to occur in the Croatian-Hungarian section of the Drava River on the basis of the relevant faunistic literature published between 1992 and 2016 (Harka 1992; Majer 1998; Majer and Bordács 2001; Sallai 2002a, b; Sallai 2004; Sallai and Kontos 2005, 2008; Jelić et al. 2012; Csipkés et al. 2012; Sallai 2016). The literature written before 1992 on the fish fauna of the Drava is overviewed by Sallai and Kontos (2005). Fishes were classified according to Nelson et al. (2016), and the nomenclature of the species used in FishBase (www.fishbase.org), an ichthyological database, was followed. Only observations made directly by the authors of the faunistic studies or made by a third person and reported to the authors with photodocumentation, or data obtained from fishery database by the authors were considered as valid.

The biogeographical status of the species in the Drava River was characterized as follows. A species was considered native if the Drava belongs to its natural range; endemic if the Drava belongs to the natural range of the species, and the species is a biogeographic endemism of the Danube catchment, or in other words, the natural range of the species is restricted to the Danube River Basin; and non-native if the Drava does not belong to the original native range, so the presence of the species in the Drava River is highly supposed to be the result of some kind of human intervention. To highlight conservation importance, we indicated if a species is included in any of the annexes of the European Union Habitats Directive (European Commission 2000). Annex II lists species of community interest whose core habitats are included in the Natura 2000 network (Natura 2000 indicator species). Annex IV lists species of community interest in need of strict protection across their entire natural range within the EU. Annex V lists species of community interest whose taking in the wild and exploitation must be compatible with maintaining their favorable conservation status.

To illustrate the relative abundances and densities of the fishes, we present an example for a rank abundance distribution of fish assemblage of the Drava littoral zone using formerly unpublished original data from Sály et al. Data were collected by boat electrofishing of three 500 m reaches (subsamples) along the Hungarian bank of the river, near Barcs (between the endpoints of 45.950053°N, 17.432136°E and 45.942783°N, 17.484209°E), daytime, on 19 October 2016, in accordance with the suggested sampling protocol for the Hungarian lowland rivers (Sály and Erős 2016).

The width of the effective zone of the electrofishing gear (Hans Grassl EL 64II, SDC, 300 V, 10 A) was about 2 m, hence the sampled area can be roughly estimated at $1500 \times 2 = 3000$ m^2. The effectiveness of electrofishing, however, is generally influenced by several factors (e.g. conductivity, water level of the river, depth, current velocity, turbidity). Rank abundance distribution was constructed from the full sample, i.e. the pooled data of the three 500-m-long subsamples.

Finally, the ecological status of the sampled Drava section was assessed. We applied the Hungarian Multimetric Fish Index (Sály and Erős 2016), a recently developed biotic index family for evaluating the ecological status of surface running waters on the basis of fish assemblages in Hungary in accordance with the EU Water Framework Directive, to the above mentioned data of Sály et al. Assessment was made for the three subsamples separately, and, to obtain a more solid picture, also for the full sample data. The Hungarian Multimetric Fish Index provides two kinds of relevant information. The first one is an Ecological Quality Ratio (EQR), ranging from zero to one, a standardized quantitative indicator of ecological status; the closer to one, the better the ecological status is. The second information is the so-called Ecological Quality Class, which can be bad, poor, moderate, good or high, determined according to a conversion rule (not presented here) of the EQR.

17.4 Results and Discussion

17.4.1 Faunistics

The overview of the above-cited faunistic studies shows that representatives of 11 orders and 17 families have been known from the Croatian-Hungarian Drava section. The number of species occurring regularly or occasionally in the region seems to be about 67, including one cyclostomata (*Eudontomyzon mariae*) too. The fauna is dominated by the members of the Cyprinidae family (32 species, ca. 48%), which is a common characteristic for European lowland rivers. Altogether, there are 22 species of community interest. Eighteen species are listed in Annex II, one in Annex IV, and ten in Annex V. Seven species out of the 22 are listed in two annexes. A slightly more than three-fourths of the 67 species are native, including four Danubian endemisms. There are 15 non-native species (Table 17.1).

Here some remarks are due on changes in nomenclature and taxonomy to help understand the nature conservation interest of some species.

Leuciscus aspius is listed as its synonym, *Aspius aspius*, in the Annexes of the EU Habitats Directive.

Rhodeus amarus is listed as a subspecies, *R. sericeus amarus*, in Annex II, however, this taxon has been raised to species level rank (FishBase).

Romanogobio vladykovi was listed as *Gobio albipinnatus* in earlier studies (see e.g. Harka 1992; Sallai 2002b; Sallai and Kontos 2005), and in Annex II. However, according to the FishBase, the presence of *Romanogobio albipinnatus* (a synonym

Table 17.1 Fish species with verified occurrence in the Croatian-Hungarian Drava section, 1990–2016. Biogeographical status refers to the nativeness of the species. Habitats Directive denotes if the species is listed in any annexes of the European Habitats Directive. See the Methods section for details

No. of species	Taxon	Common name	Biogeographical status	Habitats directive
	ordo Petromyzontiformes	**lampreys**		
	familia Petromyzontidae	**northern lampreys**		
1	[a]*Eudontomyzon mariae* (Berg, 1931)	Ukrainian brook lamprey	Native	Annex II
	ordo Acipenseriformes	**paddlefishes and sturgeons**		
	familia Acipenseridae	**sturgeons**		
2	*Acipenser nudiventris* Lovetsky, 1828	fringebarbel sturgeon	Native	Annex V
3	*Acipenser ruthenus* Linnaeus, 1758	sterlet sturgeon	Native	Annex V
	ordo Anguilliformes	**eels**		
	familia Anguillidae	**freshwater eels**		
4	*Anguilla anguilla* (Linnaeus, 1758)	European eel	Native	
	ordo Cypriniformes	**carps, loaches, minnows**		
	familia Cyprinidae	**carps, loaches, minnows**		
5	*Abramis brama* (Linnaeus, 1758)	freshwater bream	Native	
6	*Alburnoides bipunctatus* (Bloch, 1782)	schneider	Native	
7	*Alburnus alburnus* (Linnaeus, 1758)	bleak	Native	
8	*Ballerus ballerus* (Linnaeus, 1758)	zope	Native	
9	*Ballerus sapa* (Pallas, 1814)	white-eyed bream	Native	
10	*Barbus barbus* (Linnaeus, 1758)	barbel	Native	Annex V
11	*Blicca bjoerkna* (Linnaeus, 1758)	white bream	Native	
12	*Carassius carassius* (Linnaeus, 1758)	Crucian carp	Native	
13	*Carassius gibelio* (Bloch, 1782)	Prussian carp	Non-native	
14	*Chondrostoma nasus* (Linnaeus, 1758)	common nase	Native	
15	*Ctenopharyngodon idella* (Valenciennes, 1844)	grass carp	Non-native	

(continued)

Table 17.1 (continued)

No. of species	Taxon	Common name	Biogeographical status	Habitats directive
16	*Cyprinus carpio* Linnaeus, 1758	common carp	Native	
17	[b]*Gobio obtusirostris* Valenciennes, 1842	gudgeon	Native	
18	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	silver carp	Non-native	
19	*Hypophthalmichthys nobilis* (Richardson, 1845)	bighead carp	Non-native	
20	*Leucaspius delineatus* (Heckel, 1873)	belica	Native	
21	*Leuciscus aspius* (Linnaeus, 1758)	asp	Native	Annex II, V
22	*Leuciscus idus* (Linnaeus, 1758)	ide	Native	
23	*Leuciscus leuciscus* (Linnaeus, 1758)	common dace	Native	
24	*Pelecus cultratus* (Linnaeus, 1758)	sichel	Native	Annex II, V
25	*Phoxinus phoxinus* (Linnaeus, 1758)	Eurasian minnow	Native	
26	*Pseudorasbora parva* (Temminck & Schlegel, 1846)	stone moroko	Native	
27	*Rhodeus amarus* (Bloch, 1782)	European bitterling	Native	Annex II
28	*Romanogobio kesslerii* (Dybowski, 1862)	Kessler's gudgeon	Native	Annex II
29	*Romanogobio uranoscopus* (Agassiz, 1828)	Danubian longbarbel gudgeon	Endemic	Annex II
30	*Romanogobio vladykovi* (Fang, 1943)	white-finned gudgeon	Native	Annex II
31	*Rutilus rutilus* (Linnaeus, 1758)	roach	Native	
32	*Rutilus virgo* (Heckel, 1852)	Danubian roach	Endemic	Annex II, V
33	*Scardinius erythrophthalmus* (Linnaeus, 1758)	rudd	Native	
34	*Squalius cephalus* (Linnaeus, 1758)	chub	Native	
35	*Tinca tinca* (Linnaeus, 1758)	tench	Native	
36	*Vimba vimba* (Linnaeus, 1758)	vimba bream	Native	

(continued)

Table 17.1 (continued)

No. of species	Taxon	Common name	Biogeographical status	Habitats directive
	familia Cobitidae	**loaches**		
37	*Cobitis elongatoides* Băcescu & Mayer, 1969	spined loach	Native	Annex II
38	*Misgurnus fossilis* (Linnaeus, 1758)	weatherfish	Native	Annex II
39	[c]*Sabanejewia aurata* (De Filippi, 1863)	golden spined loach	Native	Annex II
	familia Nemacheilidae	**stone loaches**		
40	*Barbatula barbatula* (Linnaeus, 1758)	stone loach	Native	
	ordo SILURIFORMES	**CATFISHES**		
	familia Siluridae	**sheatfishes**		
41	*Silurus glanis* Linnaeus, 1758	wels catfish	Native	
	familia Ictaluridae	**North American catfishes**		
42	*Ameiurus melas* (Rafinesque, 1820)	black bullhead	Non-native	
43	*Ameiurus nebulosus* (Lesueur, 1819)	brown bullhead	Non-native	
	ordo SALMONIFORMES	**TROUTS, SALMONS, AND WHITEFISHES**		
	familia Salmonidae	**trouts, salmons, and whitefishes**		
44	*Hucho hucho* (Linnaeus, 1758)	huchen	Endemic	Annex II, V
45	*Oncorhynchus mykiss* (Walbaum, 1792)	rainbow trout	Non-native	
46	*Salmo trutta* Linnaeus, 1758	brown trout	Native	
47	*Salvelinus fontinalis* (Mitchill, 1814)	brook trout	Non-native	
48	*Thymallus thymallus* (Linnaeus, 1758)	grayling	Native	Annex V
	ordo ESOCIFORMES	**PIKES AND MUDMINNOWS**		
	familia Esocidae	**pikes**		
49	*Esox lucius* Linnaeus, 1758	northern pike	Native	
	familia Umbridae	**mudminnows**		
50	*Umbra krameri* Walbaum, 1792	European mudminnow	Native	Annex II
	ordo GADIFORMES	**CODS AND HAKES**		
	familia Gadidae	**cods**		

(continued)

Table 17.1 (continued)

No. of species	Taxon	Common name	Biogeographical status	Habitats directive
51	*Lota lota* (Linnaeus, 1758)	burbot	Native	
	ordo Gobiiformes	**gobies**		
	familia Gobiidae	**gobies**		
52	*Neogobius fluviatilis* (Pallas, 1814)	monkey goby	Non-native	
53	*Neogobius melanostomus* (Pallas, 1814)	round goby	Non-native	
54	*Ponticola kessleri* (Günther, 1861)	bighead goby	Non-native	
55	*Proterorhinus semilunaris* (Heckel, 1837)	western tubenose goby	Non-native	
	ordo Perciformes	**perches**		
	familia Centrarchidae	**sunfishes**		
56	*Lepomis gibbosus* (Linnaeus, 1758)	pumpkinseed	Non-native	
57	*Micropterus salmoides* (Lacepède, 1802)	largemouth bass	Non-native	
	familia Percidae	**perches**		
58	*Gymnocephalus baloni* Holčík & Hensel, 1974	Danube ruffe	Native	Annex II, IV
59	*Gymnocephalus cernua* (Linnaeus, 1758)	ruffe	Native	
60	*Gymnocephalus schraetser* (Linnaeus, 1758)	schraetzer	Endemic	Annex II, V
61	*Perca fluviatilis* Linnaeus, 1758	European perch	Native	
62	*Sander lucioperca* (Linnaeus, 1758)	pikeperch	Native	
63	*Sander volgensis* (Gmelin, 1789)	Volga pikeperch	Native	
64	*Zingel streber* (Siebold, 1863)	Danube streber	Native	Annex II
65	*Zingel zingel* (Linnaeus, 1766)	zingel	Native	Annex II, V
	ordo Scorpaeniformes	**mail-cheeked fishes**		
	familia Gasterosteidae	**sticklebacks**		

(continued)

Table 17.1 (continued)

No. of species	Taxon	Common name	Biogeographical status	Habitats directive
66	*Gasterosteus gymnurus* Cuvier, 1829	western three-spined stickleback	Non-native	
	Familia Cottidae	**sculpins**		
67	*Cottus gobio* Linnaeus, 1758	bullhead	Native	Annex II

[a]Some ichthyologists tend to consider the lampreys living in the Drava River as *E. vladykovi* (Oliva & Zanandrea, 1959), a distinct species from *E. mariae* (see e.g. Povz 2011). In fact, *E. vladykovi* has been considered as a subspecies of *E. mariae*. Hence, further studies are expected to clear the taxonomical status of the lampreys of the Drava. If results support *E. vladykovi* being a distinct species, it should be considered as an endemism of the Danube catchment

[b]Takács et al. (2014) argue that gudgeons in the Central and Southern Transdanubia region, including the Drava catchment too, in Hungary are genetically different from gudgeons identifiable as *G. obtusirostris* living in Northern Transdanubia. However, the differences are probably not enough to make a species-level distinction

[c]See Faunistics section in Results and Discussion

for *Gobio albipinnatus*) in Central Europe and Germany is questionable, and the species is denoted as native to Russia and Kazakhstan. Furthermore, FishBase denotes *R. vladykovi* as native to Austria, Hungary, and Romania. Consequently, *R. vladykovi* should also be considered a species of community interest. (The reference to gudgeons in the FishBase is Kottelat and Freyhof (2007), a not peer-reviewed handbook.)

Harka (1992) listed the spined loach as *Cobitis taenia*. Likewise, Annex II also contains the name *C. taenia*. Actually, the species *C. elongatoides* was formerly considered a subspecies of *C. taenia*. In accordance with this, *Cobitis taenia elongatoides* is denoted as a synonym for *C. elongatoides* in the FishBase. Thus, *C. elongatoides* is another species of community interest (see e.g. Sallai 2002b; Tóth et al. 2007).

Formerly, it was accepted that the golden spined loach, *Sabanejewia aurata,* has two subspecies, *S. a. balcanica* and *S. a. bulgarica*. However, it has become more and more widely accepted that these subspecies are actually two distinct species on the basis of colouration pattern. Correspondingly, Sallai and Kontos (2005, 2008) report *S. bulgarica* (Drensky 1928), and Jelić et al. (2012) report *S. balcanica* (Karaman 1922). But the phylogenetic relationships of *Sabanejewia* has not been fully clarified yet. It could be possible that *S. balcanica* and *S. bulgarica* are really distinct from *S. aurata*, but they are probably members of a species complex (Danubian Balkanian complex) rather than being two fully distinct species (see Perdices et al. 2003, 2016; The PLOS ONE Staff 2016). Because of this taxonomic uncertainty, we listed golden spined loaches as *S. aurata* in Table 17.1. Whatever the real taxonomic relationships between the golden spined loaches living in the Drava are, they should be considered as community interest fishes.

Although faunistic investigations suggest 67 fish species, the number of species actually living and reproducing in the Croatian-Hungarian Drava section can be supposed to be about 51. For the sake of simplicity, these regularly occurring species can be considered as the core of the fish fauna, and other occasionally appearing species function as colorizing satellite species of the fauna. The occurrence of species can be occasional because, for instance, they are not able to reach this section from downstream habitats (diadromous fishes like sturgeons and European eel [*Anguilla anguilla*]) due to migration barriers. Some fishes, like Salmonid species, natives and non-natives as well, and probably the Danubian longbarbel gudgeon (*Romanogobio uranoscopus*) too, find more suitable habitats on the upper reaches of the Drava, hence they have a naturally rare occurrence in the lower section. Although the regular downstream drift of some of their individuals is probably also negatively affected by barrages, and these species would likely be detected a little more frequently in the Croatian-Hungarian section as they are now if the upstream dams did not exist.

It is widely accepted that some non-native species, such as grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*H. molitrix*), do not have self-sustaining populations in the Drava or other rivers in the region. Therefore, their occurrences depend primarily on the human stocking activities directly into the main channel and/or fishponds from where they can escape into the main channel via inflow streams. The populations of another non-native species, the largemouth bass (*Micropterus salmoides*), although assumed to reproduce in the Drava (Povž and Šumer 2005; Sallai and Kontos 2008), typically have low density. A possible reason for this could be the extreme daily fluctuation of water level due to the operation of the upstream hydropower plants, which makes the main channel an unfavorable habitat for reproduction to the largemouth bass.

Other species require for their entire life-cycle habitats remarkably different from those in the main Drava channel. The Eurasian minnow can typically be found in fast flowing, cool, sub-mountainous brooks and clear, gravel, and stony-bottomed lakes. The crucian carp (*Carassius carassius*) and belica (*Leucaspius delineatus*) prefer slow-flowing and still water, so they are most likely to occur in densely vegetated oxbow lakes and backwaters. For them the main channel of high current velocity functions as a matrix habitat through which they can disperse among their real habitat patches (see Erős and Campbell Grant 2015). Hence, they are usually also regarded occasionally occurring species in the main channel.

The ongoing spreading of the Ponto-Caspian gobies in the Danube catchment could lead not only to the enrichment of the local fauna but the remarkable alteration of the fish abundances both in the offshore zone (Szalóky et al. 2015) and, especially, in the littoral zone of the rivers (Erős et al. 2005). The results of the faunistic surveys point to the forthcoming upstream expansion of the Ponto-Caspian gobies in the Drava as well. This prediction is supported by the following observations. The Kessler goby was first found at Donji Miholjac, Croatia, the most downstream location investigated in the studies reviewed here, and furthermore, this species or any other new goby species was not detected upstream of Donji

Miholjac until 2015. Subsequently, Sallai (2016) found the Kessler goby along with the round goby, a new species to the fish fauna of the Drava, upstream of Donji Miholjac at Matty, but he did not recover either of them more upstream, at Drávakeresztúr-Révfalu, Hungary. Along with the upstream spreading of the goby species already present in the Drava, other goby species, for example the racer goby (*Babka gymnotrachelus* [Kessler 1857]), also could colonize the Drava from the Danube.

17.4.2 Qualitative Aspects and Ecological Assessment

Turning to the quantitative aspect, the sample of Sály et al. contains 474 individuals of 22 fish species. The rank abundance distribution (Fig. 17.1) constructed from the data shows that the bleak (*Alburnus alburnus*), the most abundant species in the assemblage, represents two fifths of all individuals (41.6%), while the second most abundant chub (*Squalius cephalus*) only one fifth of the specimens (18.6%). Eight species show a relative abundance between ten and one percent. It is less fortunate, that among these species the three most abundant are non-native (Prussian carp [*Carassius gibelio*], monkey goby [*Neogobius fluviatilis*] and western tubenose goby [*Proterorhinus semilunaris*]), although there are three species with community interest (European bitterling [*Rhodeus amarus*], white-finned gudgeon [*Romanogobio vladykovi*], barbel [*Barbus barbus*]). The relative abundance of the remaining 12 species is less than 1%. Among them, there are four species with community interest (spined loach, zingel [*Zingel zingel*], Ukrainian brook lamprey [*Eudontomyzon mariae*], and Danube streber [*Zingel streber*]), and two non-native ones (stone moroko [*Pseudorasbora parva*] and pumpkinseed [*Lepomis gibbosus*]).

The ecological assessment of the three 500-m-long subsamples and that of the full sample containing the pooled data (i.e. 3 × 500 m) with the Hungarian Multimetric Fish Index (HMMFI) resulted in EQR values of 0.42, 0.47, 0.64, and 0.69. These figures correspond to the ecological classes of moderate, moderate, good, and good, respectively. Out of the three subsamples, the third (EQR = 0.64) was located the most downstream, the farthest from the built-up area of Barcs, whereas the other two subsamples were much closer to the inhabited region. This may, at least in part, explain the higher EQR value for the third subsample.

The HMMFI index applicable to lowland rivers like the Croatian-Hungarian Drava is primarily sensitive to the species number of the sample to be assessed. However, pooling the three subsamples into a single full sample can increase the robustness and information content of the data. Therefore, it appears that the ecological status of the assessed section near Barcs could fit in with the ecological status of the surface water bodies of the Hungarian Drava, which were estimated as good and high (see the coloured map in Sály and Erős 2016, Appendix 3).

Certainly, the analysis of this example data set provides only a snap-shot illustration on the abundances of the fish species and on the ecological status of the sampled habitat. Because many species are represented in this sample only by one

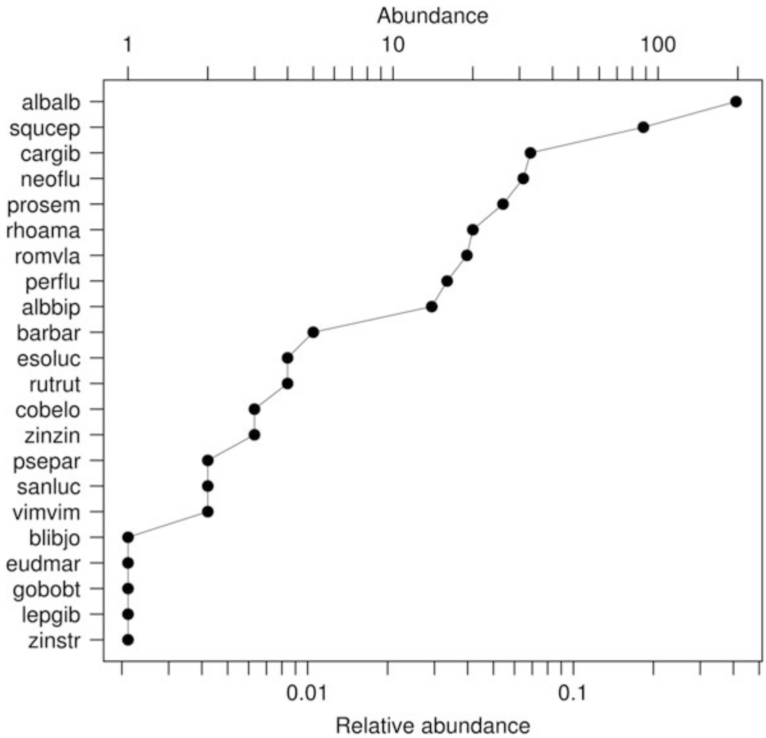

Fig. 17.1 Rank abundance distribution of the fish assemblage in the littoral zone of the Drava (original data of Sály et al.). The total number of the individuals caught was 474, which belonged to a total of 22 species. Upper x-axis represents the number of individuals (abundance), and the lower x-axis shows the relative abundance. Note that both the x-axes are logarithmic to the base of 10. Albalb, bleak (*Alburnus alburnus*); squcep, chub (*Squalius cephalus*); cargib, Prussian carp (*Carassius gibelio*); neoflu, monkey goby (*Neogobius fluviatilis*); prosem, western tubenose goby (*Proterorhinus semilunaris*); rhoama, European bitterling (*Rhodeus amarus*); romvla, white-finned gudgeon (*Romanogobio vladykovi*); perflu, European perch (*Perca fluviatilis*); albbip, schneider (*Alburnoides bipunctatus*); barbar, barbel (*Barbus barbus*); esoluc, northern pike (*Esox lucius*); rutrut, roach (*Rutilus rutilus*); cobelo, spined loach (*Cobitis elongatoides*); zinzin, zingel (*Zingel zingel*); psepar, stone moroko (*Pseudorasbora parva*); sanluc, pikeperch (*Sander lucioperca*); vimvim, vimba bream (*Vimba vimba*); blibjo, white bream (*Blicca bjoerkna*); eudmar, Ukrainian brook lamprey (*Eudontomyzon mariae*); gobobt, gudgeon (*Gobio obtusirostris*); lepgib, pumpkinseed (*Lepomis gibbosus*); zinstr, Danube streber (*Zingel streber*)

or two specimens, it can be assumed that additional species would have been caught if further effort had been made to sample. Yet, the survey is informative because sampling was made by using a single method. On the other hand, further effort probably would yield rare species, which could not profoundly modify the relative abundance of the more common species.

However, in the light of abundance the evaluation of commonness and rarity could be misleading when one uses a single sampling method only in case of large rivers. For instance, Szalóky et al. (2014) highlight the importance of offshore sampling to evaluate the abundance of benthic fish species in large rivers. Compared to shoreline boat electrofishing, a sampling method used commonly in lowland rivers, they detected the sterlet (*Acipenser ruthenus*) and caught much more individuals of the Danube streber by sampling with an electrified benthic frame trawl offshore in the Danube. Similarly, sampling with this recently developed method, Szalóky et al. (2015) point out the intense and somewhat species differentiated offshore habitat use of the Ponto-Caspian gobies. Therefore, the application of such formerly not used methodological approaches to sample the fishes of the Drava could refine our picture on the abundance structure and maybe even on the presence of some species in the Drava as well.

17.5 Conclusions

The Croatian-Hungarian section of the Drava River seems to have a reasonable good ecological status and provides home for a rich fish fanua, valuable for nature conservation. This richness is mainly due to that this river section has not been subjected to such large-scale human modifications as other Drava sections. Another control of its fish fauna and the density of the fish populations is the proximity to the Danube as a source region. Primarily potamodromous species can move between the two rivers. Consequently, the cornerstone of successful conservation of fish fauna could probably be the prevention of any further anthropogenic alteration of the Drava and its banks. In addition, improving longitudinal connectivity not only on the upper Drava but on the lower Danube too, a more frequent appearance of occasional satellite fauna members and the possible re-emergence of indigenous diadromous fishes could be achieved.

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