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Freshwater resources and fisheries in Hungary

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Abstract

This paper shortly reviews the present state of Hungarian fisheries including commercial and recreational activities in natural waters, along with aquaculture production. Major threats to natural fish production are the degradation of habitats, the introduction of non-indigenous species, the overexploitation of native fish populations and improper stocking strategy. Priorities, recent developments and future recommendations in fisheries managements are discussed.

Key words: angling; aquaculture; common carp; fisheries management; habitat degradation; native species; non-indigenous species; stocking.

NATURE AND STATUS OF FRESHWATER FISHERIES

Surrounded by large mountain ranges, such as the Carpathians and the Alps, and situated in the Carpathian Basin, which is the collector of submontane streams and rivers, Hungary receives 96% of its running waters from abroad. Of these, Europe's second largest river, the Danube (2860 km) and its second largest tributary the Tisza (962 km at present) are the most important rivers which flows 417 and 597 km, in Hungary. Historically, these large alluvial floodplain rivers provided excellent habitats for a diverse fishery culture to flourish. The importance of the traditional floodplain fishery declined significantly when large scale water regulations started in the 19th century. At present, habitats utilized by freshwater fisheries are Lake Balaton (59 600 ha), Lake Velence (2 300 ha; only angling is allowed), Lake Fertő (Neusiedler See; 7 500 ha), River Danube, River Tisza and its reservoir Lake Tisza (*c*. 6 400 ha), all other rivers, irrigation canals, most of streams, most of oxbow lakes, reservoirs, natural and artificial lakes and ponds. The total area of freshwater habitats with fisheries activities is 140 402 ha. Besides there are many fish farms including both valley dammed reservoirs and artificial ponds (23 639 ha).

Fisheries management rights for natural habitats may be leased from the state for 15 years. Artificial lakes can also be in private ownership. Some of the natural habitats (*e.g.* some oxbow lakes, Little Lake Balaton Reservoir II., parts of Lake Fertő and Velence) are under strict protection where fisheries including angling is forbidden.

Basically, three types of fisheries can be distinguished in Hungarian freshwater habitats. At present, the most important fisheries activity is angling. There are *c.* 332 000 registered anglers in the country. Anglers are allowed to use only rod and line for fishing, but a lift net of maximum 1×1 m area may also be used for capturing bait fishes. Daily catches are limited at country level (maximum three individuals per species and altogether five individuals of high value fishes, and maximum 10 kg of other fishes may be caught daily), but local regulations may be stricter.

Commercial fisheries (large gear fisheries) used to be important until the second half of the 20th century, but the recent trend is to confine it and to produce all market fishes by aquaculture. This type of fisheries is now restricted to Lake Balaton, and to main rivers and some of their oxbow lakes. A commercial fishery uses a series of fishing gears including seines, trawls (only in Lake Balaton), different traps, gillnets, trammel nets and direct current electrofishers. The use of electrofisher machines, however, is restricted (*e.g.* its use is forbidden between 1 May and 30 September), and there is a strong pressure from the anglers to prohibit it at all. A similar concern is rising against the gillnet, which is the most preferred gear of illegal fisheries and considered to 'torture' captured fishes. Nevertheless, electrofishing and gillnetting are important in research, and for example, they are used for evaluating the diversity and ecological status of fish assemblages according to the guidelines of the Habitat Directive and the Water Framework Directive of the European Union (Erős, 2007; Specziár *et al.*, 2009).

The third type of fisheries is the so called 'little gear fisheries' that is used individually, and has a long tradition in the Carpathian basin. By now, this type of fishery has become insignificant and only limited number of licences is allocated annually for specific locations. The main gear of this activity is the lift net with a maximum 3×3 m net area. Other gears used are various traps, gillnets, trammel nets, fyke nets, cast nets and a specific traditional towed net called 'kece', which is on rivers only. Their use depends on local regulations and daily catch limits are generally the same as for anglers.

Practically all larger-bodied native species, except those under protection, are harvested by fisheries and captured by anglers. In addition, several non-indigenous fish species have been introduced to increase the diversity of utilizable fishes. The common carp *Cyprinus* *carpio* is definitely the most preferred fish species, especially for anglers. It is stocked in high numbers to most waters and even to those ones which may be unsuitable for the species. Piscivores are also preferred species, and of these the pikeperch *Sander lucioperca*, pike *Esox lucius*, European catfish *Silurus glanis* and the asp *Leuciscus aspius* are the most commonly caught. The silver carp *Hypophthalmichthys molitrix* and the grass carp *Ctenopharyngodon idella* are the most preferred introduced species. Nevertheless, the larger part of the catches is comprised of so-called 'other fishes'. The most frequent caught in standing waters are common bream *Abramis brama*, white bream *Blicca bjoerkna*, roach *Rutilus rutilus* and gibel *Carassius gibelio*. Beside these species ide *Leuciscus idus*, common nase *Chondrostoma nasus* and chub *Squalius cephalus* are also harvested in running waters.

During the period of 2006-2010, the mean total catch from natural fresh waters including both commercial fisheries and angling was 6908 t year^{-1}. *Cyprinus carpio* (3537 t year^{-1}) comprised more than half of the catches. Other valuable fishes with higher share were the *C. idella* (5.7%), *H. molitrix* and bighead carp *Hypophthalmichthys nobilis* (7.6%), *S. lucioperca* (2.6%), *S. glanis* (2.4%) and *E. lucius* (3.0%). Less valuable cyprinids comprised 24.8% of the fisheries production (Table I).

The trend of two decades shows a continuous decrease in the total catch (Table I), which is a common consequence of decreasing abundance of native fish species and the decrease of commercial fisheries effort in natural habitats. Due to intensive stockings, catches of the most preferred species (*e.g. C. Carpio* and *C. idella*) are stable. Native piscivores, such as *S. glanis*, *E. lucius* and *L. aspius*, seem to maintain stable populations mainly *via* natural recruitment supported with some stockings in most important angling waters. In contrast, catches of other valuable native species, especially of those preferring river habitats are decreasing rapidly (*S. lucioperca* and barbel *Barbus barbus*) or have even collapsed (Volga pikeperch *Sander volgensis* and sterlet *Acipenser ruthenus*). The catches of some reophilic cyprinids (*e.g. C.*

nasus, *L. idus* and *S. cephalus*) are decreasing as well. Catches of European eel *Anguilla anguilla*, *H. molitrix* and *H. nobilis* are also decreasing. These three species do not reproduce in Hungarian waters, but were intensively stocked to large water bodies from the 1960s. Note that *A. anguilla* may be considered as an indigenous species, but it was extremely rare in Hungarian waters before the introductions begun. In the near past, the intensively stocked *A. anguilla* played a significant role in he commercial fishery in the three largest lakes of Hungary. The stocking of *A. anguilla*, however, was first stopped in Lake Velence (in 1973) and then its stocking was prohibited country-wide in 1991 following the two massive fish kills in 1991 and 1995, in Lake Balaton. *Anguilla anguilla* catches strongly depend on the annual precipitation and the operation of the eel trap at the outlet of Lake Balaton. Nowadays, the stocking intensity of *H. molitrix* is considerably decreasing in other natural waters as well, but this fish may also recruit by escapes from fishponds.

Exploitation rate of fish stocks is not known exactly, and sustainable production has not been assessed since the 1980s (Bíró, 1997). The exploitation rate, however, is probably very high in some species, and the stability of many fish stocks, which depend upon natural recruitment, may be in jeopardy. For example, tagging experiments showed that 90% of stocked *C. carpio* is exploited within 1 year in Lake Balaton (Specziár, 2010). Consequently, without regular stockings the *C. carpio* stock of the lake would rapidly collapse. The same is true for most natural habitats with *C. carpio* oriented angling. Tagging experiments also showed that the annual exploitation rate of the *S. lucioperca* population is *c*. 56% of the number of catchable fish (legal size is ≥30 cm standard length) in Lake Balaton. Considering that the recruitment of this fish depends substantially on natural reproduction and the annual stocking rate is < 1% compared to the natural recruitment, the present rate of exploitation seems to risk population stability (Specziár, 2010). Exploitation rate of other valuable fishes is also generally high, and there is also clear evidence that some populations are instable and can be endangered. One of the most documented examples is the overfishing caused collapse of the razor fish *Pelecus cultratus* population in Lake Balaton during the 1970s. Fortunately, the population recovered successfully after intensive fishing was given up (Specziár, 2010). More recently, stocks of *A. ruthenus* and *S. volgensis* have suffered the most drastic decrease in Hungarian waters.

AQUACULTURE

Aquaculture has a long tradition and plays a significant role in fish production in Hungary. It provides 70% of culinary fish production and provides stocking fishes for natural and intensive angling waters. The total production of fish ponds was 18 559 t (net production 466 kg ha^{-1}), in 2010 (Dankó & Bardócz, 2011). Aquaculture mainly utilizes natural water resources by capturing the water of streams in valley dammed reservoirs and artificial pond systems (23 639 ha). Unfortunately, many fishpond systems are age-worn and especially their sluicing is inappropriate to prevent the escape of cultured fishes into natural habitats. The major fish species produced in aquaculture is *C. carpio* (15,080 t, 81%) and the most important supplementary species are *H. molitrix* (1 502 t) and *C. idella* (734 t). Species with relatively low contribution are *S. lucioperca* (87 t), *E. lucius* (92 t), *S. glanis* (19 t), tench *Tinca tinca* (12 t), *H. nobilis* (16 t) and some other species (25 t).

There are also a few high-level intensive recirculation piscicultures in Hungary. Their total fish production was 2114 t, in 2010 (Dankó & Bardócz 2011). Here, mainly non-native species are reared, mostly North African catfish *Clarias gariepinus* (1930 t) and in smaller amount barramundi *Lates calcarifer* (in progress, with an estimated capacity of 80 t) and some dominantly non-indigenous and hybrid acipenseroids (92 t) and salmonids (84 t).

THREATS TO FISHERIES PRODUCTION

Fish communities are threatened by direct or indirect effects of past or recent anthropogenic activities in Hungarian natural waters. The three most important groups of threats are habitat alteration, introduction of non-indigenous fish species and intensive exploitation of fish stocks.

Human induced degradation of habitats is characteristic for nearly all water bodies in the region. All rivers have been regulated and channelized to a various extent. River bends were cut through, and most of the inundation areas and riparian zones were lost due to the building of flood control dikes and subsequent deepening of riverbeds. Parts of the riverbanks were stabilized with ripraps and several barrages were constructed. The reefs of large rivers are dredged locally. The water of many streams is utilized for irrigation, to feed artificial ponds and as drinking water. Valley dam reservoirs interrupt connectivity relationships of upstream and downstream habitats in the stream network and largely constrain migration dynamics of fishes (Erős *et al.*, 2011). Fragmentation of upstream habitats is a serious threat, which can lead to the extinction of populations. This can happen during droughts and in cases of chemical pollution events, when extirpated populations cannot be substituted from downstream migrating individuals. Banks of lakes were also largely stabilized with ripraps, concrete buildings and dams, and the stabilization of the water level resulted in the loss of riparian zones and temporal connections to nearby wetland areas. Finally, most wetland areas were dredged and transformed into drain-canals. These activities significantly decreased the total habitat area of natural fish populations and resulted in the loss of majority of reproduction sites.

The second major threat for the native fish fauna is the introduction and continuous recruiting of non-indigenous fishes. How to increase species diversity and total exploitable fish biomass has long been one of the key issues of fisheries management in Hungary. This led to the introduction of many exotic fish species from the 19th century, mainly from North-American and east-Asian regions. The most influential introductions started in the 1960s when *H. molitrix*, *H. nobilis*, *C. idella* and *A. anguilla* stockings begun. Some fishes were introduced accidentally (*e.g*. topmouth gudgeon *Pseudorasbora parva*). Based on long-term experiences, it can be concluded that none of the introduced species generated net benefit either financially or ecologically. In contrast, most introduced species impaired native aquatic communities. *Hypophthalmichthys molitrix* invaded all larger water bodies and competed with native planktivores and early life stages. *Anguilla anguilla* was stocked in huge number to the three largest lakes of the country and competed with native species, preyed on their eggs and juveniles, and may also caused the collapse of populations of several fish and amphibian species (Specziár, 2010). Smaller sized exotics compete with indigenous species and some of them (e.g. pumpkinseed sunfish *Lepomis gibbosus* and black bullhead *Ameiurus melas*) prey on their eggs and fry. Moreover, *A. anguilla* and *H. molitrix* also caused problem for tourisms by their slowly putrescible, floating carcases in Lake Balaton.

Legal, and especially illegal, non-native introductions has been reawakened recently, mainly by irresponsible angling collectives. Owners of many private ponds and pit lakes stock non-indigenous fishes, including endangered and critically endangered Red Book acipenseroids to attract trophy hunting anglers. Since these lakes generally are not fully isolated, the escape of fishes from these habitat to natural water systems is common. For example, recently individuals of Siberian sturgeon *Acipenser baeri*, American paddlefish *Polyodon spathula* and hybrid bass *Morone saxatilis* × *M. chrysops* have been observed in the River Danube.

Unfortunately, several non-indigenous species have been acclimatized in Hungarian waters and established self-sustaining stocks, which are hard to confine anymore. Stocks of some species that evidently are not able to reproduce in Hungarian waters, however, seem also to have continuous recruitment. Sources of these recruits are from illegal stocking and mainly from fishes escaping from fish farms (*e.g. H. molitrix* and *C. idella*) and intensive angling ponds.

The third general threat is the overexploitation of native fish species coupled with unbalanced stocking. Recruiting harvested populations by stockings might trigger a further threat. To save and strengthen some endangered or overexploited fish populations by stocking artificially reproduced specimens is a common tool of fisheries management and biological conservation. Unless they are executed with the outmost care, these stockings may induce adverse population genetic processes (loss of genetic diversity and genetic drift). Generally, the same 'mother' stocks and reproduction procedures are used in aquaculture for stocking natural waters as those used for rearing fishes for the market. These 'mother' stocks consist of relatively few and strongly selected specimens. For example, the River Danube subpopulation of *C. carpio* has drastically declined due to overexploitation and loss of nursery areas in the last two centuries. By now, this subpopulation has reached the critically endangered status (IUCN Red Book). For stocking, however, mostly the domesticated strains are used. Moreover, natural habitats are often stocked with offspring originating from other areas. Consequently, there is a real threat that stockings deteriorate the genetic integrity and diversity of natural fish populations and special attention should be given for selecting mother fishes (*i.e*. origin and abundance) for conservation and reintroduction of threatened species.

Although both diffuse and point source pollution still influence the ecological integrity of natural waters, many rivers and streams that used to be strongly polluted even some decades ago, with a strongly deteriorated fish fauna, have started to recover *(e.g.* the Rivers Hernád and Sajó). The decreasing use of fertilizers and chemicals in the agriculture and the accomplishment of sewage systems also positively influenced lake eutrophication processes.

For example Lake Balaton is also recovering from hypertrophy along with other lakes. Nevertheless, industrial catastrophes still threat aquatic habitats. Recent ecological catastrophes include the River Tisza (cyanide produced by a gold mine in Romania, in 2000) and the River Marcal (red sludge produced by an aluminium corporation, in 2010).

Europe-wise spread of cormorants *Phalacrocorax carbo* and the immigration of Ponto-Caspian gobiids (e.g. bighead goby *Ponticola kessleri*, round goby Neogobius melanostomus and racer goby *Babka gymnotrachelus*) into the River Danube drainage system also might impact the native fish community of some habitats, however, the level of these threats has not been assessed.

MANAGEMENT ACTIVITIES

Despite the above problems, fisheries research and management are under development and with a new approach in Hungary. Although this progress is still in an initial phase, several promising developments have been achieved, especially in the fields of habitat re-naturalization, species and biodiversity conservation and establishment of a more sustainable fisheries practice. Objectives for the future are that commercial fisheries should be banned from natural habitats, native biodiversity should be conserved but may be used for recreational fisheries, for angling, and all market fishes should be produced in aquaculture, preferably in closed recirculating systems.

Although some private lake owners still use exotic species in their stocking strategy, there is a dynamically increasing need for re-establishing and improving previously neglected native fish stocks. Fisheries management of several natural waters has recently shifted toward the stocking of native fish species and also to use authentic strains over domesticated races (*e.g. C. carpio*). This tendency initiated a progress in breading of native fish species in aquaculture (*e.g. T. tinca*, *Carassius carassius* and *L. aspius*). Similarly, the biological conservation action launched to save threatened biodiversity of aquatic systems promoted the development of artificial propagation and intensive rearing procedures of small endangered fish species that are not directly important for fisheries (Demény *et al.,* 2012). There is also some progress in preventing the further spread of non-native fishes in natural habitats, but still mainly at a local scale. For example, the primary task of the commercial fishery now is to deplete the non-indigenous fish stocks in Lake Balaton.

Since most of the natural waters in Hungary are strongly modified and impacted by human activities and especially the spawning and nursery sites have been affected, it is very important to secure the stability and recruitment of fish populations. Accordingly, country-wide minimum legal size and catch limits along with fishing ban periods for the most effected fish species, which have been in operation for a long time, are now being adjusted to be more flexible to spatio-temporal variations in recruitment and stock status.

Problems of the modified and regulated habitats are being recognized now not only by conservation biologists but increasingly by fisheries managers as well. Several small-scale re-naturalization projects have been launched, especially in streams and small rivers of Vas-county, aiming mainly to re-establish longitudinal habitat connectivity of floodable riparian zones and wetland systems. In Hungary, the first 'nature-like' fish pass have been built at Denkpál in 1998 on the River Danube. Recently, however, several fish passes have been planned or already been constructed to ensure habitat connectivity in dammed stretches of the Rivers Pinka and Rába. There are also proposals to re-establish the meandering of some stream stretches by re-annexation of previously isolated streambeds. Some previously drained wetland systems have already been re-inundated, and the re-naturalization of other sites are under discussion. For example, the Kis-Balaton, which was drained in the 1920s, has been re-established since 1985, and now it is inhabited by a diverse and dense fish community. The completion of two fish passes on the River Zala, will hopefully provide a reproduction habitat for Lake Balaton fish populations.

Water resource utilization strategy and climate change increase the probability of periods of drought in the region. Streams and wetlands are especially affected, although these unique ecosystems provide primary habitats for several rare and endangered fish species. Natural flow regime of streams is strongly affected by the water requirements of fish ponds and reservoirs (Erős *et al.*, 2012). Fish ponds often retain water during droughts. In these periods several stream reaches regularly dry up, and consequently lose their native fish communities. Unfortunately, there is no care taken to determine at least the minimum flow requirements of streams in Hungary, although this would be especially important for conserving native stream fish assemblages.

Finally, in order to reach a sustainable fisheries practice that also supports the conservation of the native fish communities, first the education of fisheries experts and water engineers should be widened with ecological and nature conservation issues. The education of anglers should be also improved. Ecologists and conservation biologist should have a leading role in this process.

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TABLE 3.9.3. A summary of fisheries statistics of Hungarian natural waters for the last 20 years

Period	1991-1995	1996-2000	2001-2005	2006-2010	
Catch (t $year^{-1}$)	Mean±S.D.	Mean±S.D.	Mean±S.D.	Mean±S.D.	Trend
Common carp *Cyprinus carpio*	3413±511	2968±472	3033±448	3537±297	Stable
Grass carp *Ctenopharyngodon idella*	348±34	325±25	366±37	396±36	Stable
Silver carp *Hypophthalmichthys molitrix* (with bighead carp *Hypophthalmichthys nobilis*)	1192±365	855±447	794±276	526±169	Strongly decreasing
Pikeperch *Sander lucioperca*	224±12	190±27	194±3	179±19	Decreasing
Volga pikeperch *Sander volgensis*[1]	116±0	29±40	13±2	10±1	Collapsed
European catfish (wels catfish) *Silurus glanis*	172±35	137±39	141±17	166±3	Stable
Pike *Esox lucius*[2]	148±63	185±90	192±6	205±42	Stable, fluctuating
European eel *Anguilla anguilla*[3]	344±149	228±201	29±26	100±79	Strongly decreasing,

					fluctuating
Asp *Leuciscus aspius*	40±12	37±9	33±12	41±6	Stable
Sterlet *Acipenser ruthenus*	21±9	21±13	11±1	7±2	Collapsed
Barbel *Barbus barbus*	49±15	45±13	44±5	31±4	Strongly decreasing
Other fishes	2185±157	2360±128	2112±214	1710±146	Decreasing
Total catch	8126±537	7378±201	6955±455	6908±597	Decreasing

References: summarized annual fisheries statistics are published yearly in the journal Halászat, in Hungarian.

[1]Data are available from 1995.

[2]Year class strength fluctuates depending on the success of the natural reproduction.

[3]Annual catches strongly depend upon the precipitation and the water level of Lake Balaton.